June 14, 1949. W. WATSON 2,473,183

ELECTRICALLY CONDUCTIVE FABRIC

Filed July 16, 1947

FIG.1.

FIG.3.

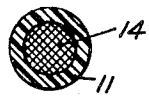


FIG.2.

FIG.4.

FIG.5

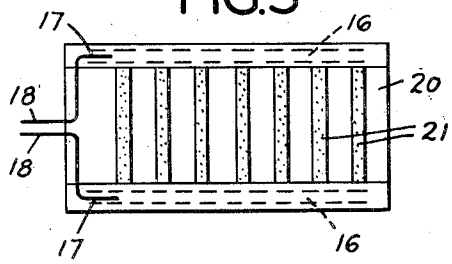


FIG.7.

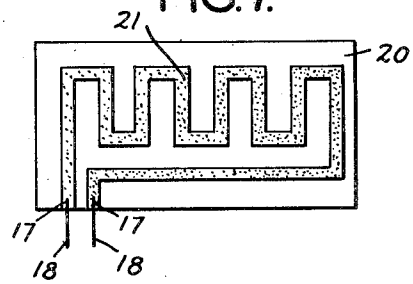


FIG.6.

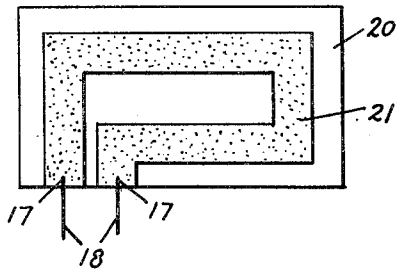
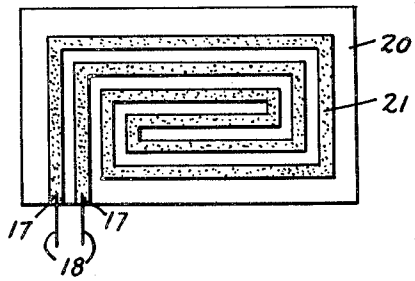


FIG.8.



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ELECTRICALLY CONDUCTIVE FABRIC

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10 Claims. (Cl. 219—46)

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The present invention relates to electrically conductive fabrics that are flexible, resilient and have many other desirable properties inherent in their structure as well as to covering material provided with an electrically conductive fabric or film.

Products such as electrically heated blankets and the like have been on the market for a number of years. These blankets are formed by imbedding or sealing within them wires of a conductive metal such as copper. They possess a number of disadvantages, among which are the inability of the wires to withstand repeated bending, as when the blankets are folded and unfolded, the opportunity for broken ends of wires to pierce the insulation and thus give a shock to any person coming in contact with the portion or portions of the blankets containing such broken ends and the general fragility of such blankets when subjected to rough handling in laundering or dry cleaning operations.

The present invention involves a radical departure from the art relating to electrically heated blankets in that it contemplates the use, on or within a fabric, of a film of electrically conductive material as a medium to convey an electrical current and thereby supply heat.

The fabrics and covering materials of the present invention are useful not only as electrically heated blankets but also as bedspreads, draperies, rugs and carpets as well as chauffeurs', truck-drivers' and pilot uniforms and the like. Some of the more unconventional uses to which these fabrics may be applied are as heating elements for mattresses, wall panels and floors, and the like.

The film that is used to convey electrical current through or over fabrics or covering materials of this invention is an electrically conductive composition comprising a plasticized resin and containing a carbon black.

The resin may be any resin having the general properties possessed by co-polymers of vinyl chloride and vinyl acetate. The most useful of these has been found to be a co-polymer of vinyl chloride and vinyl acetate having a molecular weight of 18,000 to 30,000 or higher, as determined by Staudinger's method, and having a vinyl chloride content of from about 85% to 95% by weight.

The resin may be rendered plastic at room temperatures by the addition of any plasticizer that is relatively non-volatile and is compatible with the resin. The plasticizer may be a natural or synthetic material such as a natural oil or a

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synthetic poly ester resin. An example of a natural plasticizer is stabilized oiticia oil. An example of a synthetic plasticizer which has been found to give particularly good results is a saturated poly ester resin, believed to be a glycol sebacate of the general formula

$$(—CH_2CH_2OCO(CH_2)_8COO—)_n$$

which possesses high resistance to oils, gasoline and heat, is readily soluble in esters, ketones, aromatic hydrocarbons and chlorinated hydrocarbons and is supplied in the form of a soft, tacky, viscous liquid. Other suitable plasticizers are ester type plasticizers such as esters and polyesters of acids such as sebacic, phthalic and phosphoric acids, e. g., ethylhexyl phthalate and tricresyl phosphate, as well as complex oleates, ricinoleates and sebacates, glycolates, e. g., triethylene glycol di-2-ethyl-hexoate, and nitriles.

The carbon blacks suitable for use in the electrically conductive composition are acetylene blacks, devolatilized channel blacks and lamp blacks having a particle size ranging from about 30 to about 100 millimicrons. Although any of these blacks may be used, acetylene blacks having a particle size of the order of about 43 millimicrons have been found to yield the best results.

It has been found that a particularly good combination of low resistivity and excellent pliability and elasticity is obtained when the essential ingredients of the conductive composition comprise from 90 to 100 parts by weight of acetylene black and from about 60 to about 110 parts by weight of plasticizer to 100 parts by weight of resin. Experiments have shown that the electrical resistance of the composition comprising these ingredients in the proportions named is equal to about 176 ohms per cm. at 25° C. when it is applied to a fabric in the form of a film having a thickness of one mil and a width of one centimeter.

The thickness of the composition as it is applied to the fabric in the form of a film may vary within wide limits depending upon the particular uses for which the fabric is designed. Excellent results have been obtained with films having a thickness of as little as one to three mils.

The composition may be applied in a number of ways. Some or all of the yarns that go to make up the fabric can be coated and/or impregnated with the composition before or after the weaving operation or the woven fabric can have applied to it a film of the composition by means of a coating machine, a brush, a calendering process

or by spraying. Strips of fabric coated and/or impregnated with the composition are, in a preferred embodiment of the invention, sewn or otherwise applied to the covering material. Furthermore, a free film of the conductive composition may be formed and sewn to or placed between two layers of fabric.

One method of applying the composition to fabric or yarns includes dissolving the ingredients of the composition in a volatile solvent, such as a volatile ester, ketone, aromatic hydrocarbon or chlorinated hydrocarbon. It has been found particularly desirable to use solvents such as cyclohexanone, methyl ethyl ketone, methyl isobutyl ketone, isophorone, mesityl oxide and toluene or combinations thereof to dissolve the ingredients of the conductive composition, to apply them to the yarns or fabrics by spraying, brushing, calendering or dipping and then to subject the yarns or fabrics to sufficient heat to volatilize the solvent.

The amount of solvent used temporarily to dissolve the essential ingredients of the composition varies widely and depends upon the particular solvent or solvents used, the thickness of the film desired, and upon the method of applying the composition to the fabric or yarn. If the fabric or yarn is to be dipped into a solution containing the essential ingredients of the composition, relatively large quantities of solvents should be used to obtain a uniform distribution of the film-forming ingredients on or within the fabric or yarn. The more solvent is used, the thinner will be the final film. If the composition is to be applied to the fabric in the form of a film by means of a calendering operation, the solution can be quite viscous so that considerably less solvent can be used.

It was found, for example, that a solution of 60 parts by weight of a plasticizer believed to be a glycol sebacate, 100 parts by weight of a copolymer of vinyl chloride and vinyl acetate having a vinyl chloride content of about 90% by weight and 100 parts by weight of balled acetylene black having a particle size of 43 millimicrons, in 740 parts by weight of a solvent comprising 75% by weight of cyclohexanone and 25% by weight methyl ethyl ketone, could be spread coated on a fabric with a knife coater to form a film having a thickness of the order of only one mil.

It is, however, not necessary to use a solvent if precautions are taken to mix the resin, the plasticizer and the carbon black thoroughly so as to obtain a homogeneous plastic mass that can then be extruded or calendered to produce a thin film of the conductive composition.

A film of the conductive composition, whether applied in the dry form or in the dissolved form, may be applied to a fabric in the form of a continuous sheet, a series of parallel strips, a continuous zigzag strip, a continuous single or double spiral, or in any other form so that substantially all areas of the fabric to be heated are provided with some of the electrically conductive material.

When the conductive composition is applied to the fabric or yarns in a dissolved state, it is necessary to heat the coated fabric or yarn in order to volatilize the solvent. This may be accomplished in any number of ways and can be carried out in any well known industrial drying machine.

The electrically conductive composition, after it has been applied to the fabric in the form of a film, may be and preferably is coated with a non-conductive plastic material such as a plasticized vinyl resin that does not contain a carbon black. It has been found that when a film is thus coated with a non-conductive resin, it is rendered completely incapable of transmitting an electrical shock to a person even when the coated fabric, or the skin of the person touching it, is wet and when considerable pressure is applied to the film.

Electrical energy may be supplied to the treated fabric in the form of alternating or direct current. In either event, opposite ends or corners of the treated fabric or of one or more strips of conductive film over or within said fabric are provided with electric terminals. It has been found that a terminal, i. e., an exposed end of an insulated wire, can be applied to the conductive film by electro-plating a small portion of the film with copper and soldering the terminal to the electro-plated area; sewing a strip or piece of copper wire screening directly to the coated and/or impregnated fabric before an insulating film is applied and soldering the terminal to the screening; or by heat sealing the terminal to an end of the film or strip of film. In any event the terminals and the electro-plated or other connecting portions are preferably coated with an insulating vinyl resin or are otherwise insulated as by folding the coated and/or impregnated fabric around the terminals.

The accompanying drawing is intended to illustrate by way of example several of the innumerable modifications of the present invention:

Figure 1 is a cross section, enlarged but not to scale, through a fabric provided on both sides with films of an electrically conductive composition and insulating films;

Figure 2 is a similar cross section through a fabric provided on one side with a film of an electrically conductive composition and an insulating film;

Figure 3 is a similar cross section through a yarn coated with a film of a conductive composition;

Figure 4 is a similar cross section through a fabric woven from yarns coated and/or impregnated with a conductive composition and showing one means for connecting an electrical terminal to said fabric; and

Figures 5 to 8 illustrate variations in the way the strips of conductive film may be applied to a fabric in order to act as heating elements therefor.

The cross section illustrated in Figure 1 represents a fabric 10 that is coated on both sides with films 11 of an electrically conductive composition, the latter being insulated by means of insulating films 12.

The cross section illustrated in Figure 2 represents a fabric 10 coated on one side only with a film 11 of an electrically conductive composition and an insulating film 12.

Yarn, prior to being woven into fabric, can be dipped or otherwise brought into intimate contact with the conductive composition. Depending upon the physical characteristics of the yarn and the viscosity and penetrative ability of a solution of the conductive composition, the composition will become impregnated within or coated upon the yarn or the yarn will become both impregnated and coated with the composition.

A yarn that is coated with a film of the composition has a cross section such as that illustrated in Figure 3, wherein the yarn is designated by

reference numeral 14 and the conductive coating or film formed by the composition bears reference numeral 11.

Figure 4 illustrates one of the many ways in which an end of a conductive strip may be attached to a terminal connected to a source of electrical energy. A strip of fabric 10a impregnated or coated, or both, with a conductive composition is folded over a wire screen 16 to which a terminal 17 is attached by means of soldering flux 19. An insulating film 12 is applied round the entire fold to insulate the film and connection.

Figure 5 illustrates, in a schematic plan view, one way in which parallel strips of electrically conductive fabric may be applied to a covering material such as a bedspread, blanket or the like and connected to a source of electrical energy. The material 20 is provided with a number of parallel conductive strips 21 connected by strips 16 of wire screening to which there are soldered terminals 17, all of the exposed conductive strips and screening being covered by a film of insulating material as shown in Figure 4. The lead wires 18 are insulated in the conventional manner.

Figure 6 illustrates, in a schematic plan view, another way in which a strip 21 of electrically conductive film covered by a suitable insulating film may be applied to a covering material or the like 20, the terminals 17 of lead wires 18 being attached to opposite ends of the strip 21.

Figures 7 and 8 illustrate other arrangements of a strip 21 of conductive film on a covering material or the like 20 wherein terminals 17 of lead wires 18 are attached to opposite ends of the strip.

It is, of course, within the contemplation of the present invention to connect the terminals applied to the conductive film or strips thereof to conventional cut-off or regulating switches, as well as to provide thermostats or other controls, such as a motor controller that has a thermostat control and cam arrangement which alternately closes and opens the circuit in cycles of predetermined length, to regulate the time of heating and the amount of heat dissipated in the fabric. The advantage of using such a motor controller is that it avoids the necessity of installing thermostats in the covering material to be heated.

Without intending to limit the scope of the invention in any way, the following example is included to illustrate more specifically the application of the principles of this invention to a covering material such as a bedspread.

Example

A solution of 60 parts by weight of a plasticizer believed to be a glycol sebacate, 100 parts by weight of a co-polymer of vinyl chloride and vinyl acetate having a vinyl chloride content of about 90% by weight and 100 parts by weight of balled acetylene black having an average particle size of about 43 millimicrons, in 740 parts by weight of a solvent comprising 75% by weight of cyclohexane and 25% by weight of methyl ethyl ketone, was brushed onto a 3' 8'' x 1' 4'' piece of cotton fabric which was thereupon passed over a coil of heating elements of 660 watts for a distance of five to six feet, the elements being enclosed in a box with slots at either end aligned for passage of the fabric through the box and provided with a fan to force air through the box to accelerate the drying and the carrying off

of the volatilized solvents, the temperature in the box varying between 90° and 120° C. The fabric thus coated bore a film of the conductive composition having a thickness of about three to four mils.

The coated fabric was then coated on both sides with an insulating vinyl resin comprising 100 parts by weight of a co-polymer of vinyl chloride and vinyl acetate and 60 parts by weight of a glycol sebacate plasticizer, and cut into eight 3' 8'' x 2'' strips.

The eight strips of conductive fabric were then sewn to a cotton covering material 3' 8'' wide and 5' 3'' long with the strips running across the material parallel to one another and spaced at 8'' center to center, the last two inches at each end of each strip, however, not being sewn to the material.

Sixteen 2'' squares of fine mesh, copper wire screening were then sewn to the sixteen ends of the conductive strips at a distance of about 2'' from each end, and heat sealed thereto by the application of heat and pressure.

An electrical terminal was attached to each square of copper wire screening by soldering and the eight conductive strips were connected in parallel. The free ends of the strips were then folded over the wire screening and the terminals and sewn to the covering material.

The leads were plugged into a 110 volt A. C. circuit. Within a minute or two the conductive strips became pleasantly warm to the touch. The strips were bent sharply and moistened to test the pliability and insulation. No shock was obtained even by pressing vigorously upon moistened strips or upon sharply bent folds thereof. The conductive strips were subjected to 1,077 hours of continuous heating. There were no perceptible changes in the physical and conductive characteristics of the conductive strips and no deleterious effects were observed to have occurred on the cotton covering material.

It was found that the eight conductive strips drew 1.25 amps. at 110 volts and therefor dissipated 137.5 watts.

It is to be understood that the conductive composition can be applied in the form of a thin film to other materials such as paper, wood, Masonite, asbestos and the like. Moreover, the covering material may be a finished product such as a bedspread per se or a relatively unfinished product that can be inserted into or fastened to a finished bedspread. These are but a few of the innumerable changes and modifications that will suggest themselves to those skilled in the art upon reading the present description. All such changes and modifications are intended to be included within the scope of the present invention as defined in the appended claims.

I claim:

1. Electrically conductive fabric having a film of material comprising from about 90 to about 100 parts by weight of a carbon black and from about 60 to about 110 parts by weight of plasticizer to 100 parts by weight of vinyl resin.

2. Electrically conductive fabric having a film of material comprising from about 90 to 100 parts of acetylene black and from about 60 to about 110 parts by weight of plasticizer to 100 parts by weight of vinyl resin.

3. Electrically conductive fabric consisting of yarns coated with a composition comprising from about 90 to about 100 parts by weight of a carbon black and from about 60 to about 110 parts by

weight of plasticizer to 100 parts by weight of vinyl resin.

4. Electrically conductive fabric having a resinous film comprising from about 90 to about 100 parts by weight of acetylene black and from about 60 to about 100 parts by weight of plastizer selected from the group consisting of esters and polyesters of sebacic, phthalic and phosphoric acids to 100 parts by weight of a co-polymer of vinyl chloride and vinyl acetate having a molecular weight of 18,000 to 30,000 and having a vinyl chloride content of from about 85% to 95% by weight.

5. A fabric having applied thereto a strip of electrically conductive film, said film comprising from about 90 to about 100 parts by weight of a carbon black and from about 60 to about 110 parts by weight of plasticizer to 100 parts by weight of vinyl resin.

6. Covering material provided with an electrically conductive film comprising from about 90 to about 100 parts by weight of a carbon black and from about 60 to about 110 parts by weight of plasticizer to 100 parts by weight of vinyl resin.

7. Covering material having applied thereto a plurality of parallel conductive strips, each strip comprising a web of frabric, a continuous film of material comprising from about 90 to 100 parts of acetylene black and from about 60 to about 110 parts by weight of plasticizer to 100 parts by weight of vinyl resin, and a covering film of plasticized insulating material, and each end of each strip having applied thereto a metallic conductor capable of conducting an electrical current from a lead wire to said conductive strip.

8. A method of making an electrically conductive fabric which comprises applying a resinous film comprising from about 90 to 100 parts by weight of a carbon black and from about 60 to about 110 parts by weight of plasticizer to 100 parts by weight of vinyl resin.

9. A method of making an electrically conductive fabric which comprises applying to a fabric a film comprising from about 90 to about 100 parts by weight of acetylene black and from about 60 to 110 parts by weight of plasticizer selected from the group consisting of esters and polyesters of sebacic, phthalic and phosphoric acids to 100 parts by weight of a co-polymer of vinyl chloride and vinyl acetate having a molecular weight of 18,000 to 30,000 and having a vinyl chloride content of from about 85% to 95% by weight.

10. A fabric covering adapted to be heated upon connection to a source of electricity, said fabric having at least one applied continuous strip of film covering a substantial portion of said fabric, said strip of film comprising from about 90 to 100 parts by weight of carbon black and from about 60 to 110 parts by weight of a plasticizer to 100 parts by weight of a vinyl resin, said strip of film having a covering of insulating material, connecting means attached to said fabric and to separated portions of said strip of film, and electrical conduit means attached to said connecting means whereby electrical energy may be caused to pass through said strip of film.

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