Aug. 15, 1961 H. W. HERMANCE 2,996,368

ABRASIVE FABRICS

Filed Dec. 11, 1958

FIG. 1

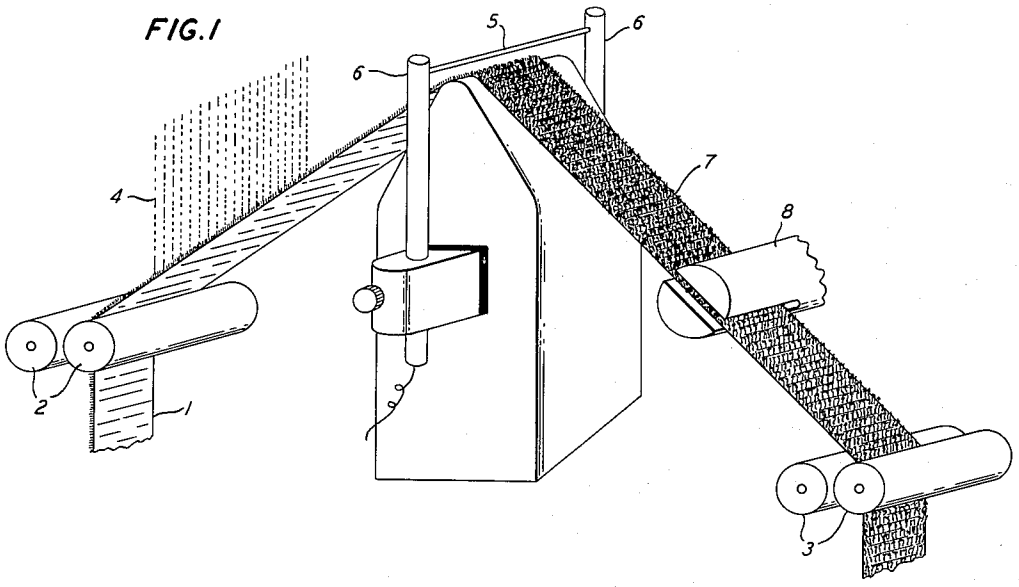


FIG. 2

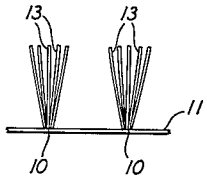


FIG. 3

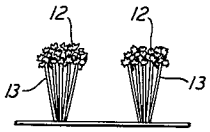


FIG. 4

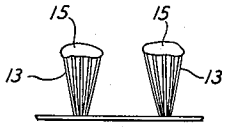
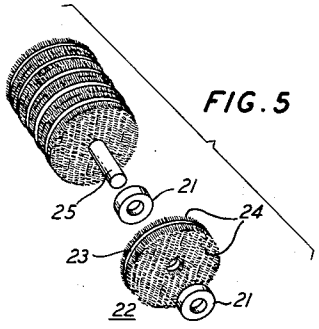


FIG. 5



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ABRASIVE FABRICS

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This invention relates to methods of producing abrasive fabrics, and to the fabrics so produced.

Abrasive fabrics are well known in the art, having been used for such diverse purposes as the cleaning of household pots and pans and also for the polishing of precision tools and instruments. Familiar examples of such materials include emery cloth, and abrasive-coated polishing cloths. Heretofore, the customary method of producing the abrasive surface consisted of bonding abrasive particles to the base material using adhesives such as glues, resins, and plastics.

In accordance with the present invention a pile fabric composed of thermoplastic fibers is coated with abrasive particles by fusing the upper portion of the pile upon which the abrasive particles had previously been deposited. The abrasive-coated materials of this invention are superior to those of the prior art by reason of their exceptional wearing and cutting properties.

In the preferred embodiment of this aspect of the present invention, a bulbous mass consisting of fiber material deformed by heating is produced at the tip of the fibers. This mass, or cap, permits bonding of a large quantity of abrasive which enhances the cutting properties of the fabric.

In accordance with a second aspect of this invention, a pile fabric composed of thermoplastic fibers is heated in a manner to deform the upper portions of the pile fibers thereby producing a bulbous mass or cap. Abrasive fabrics so constructed find special application in the cleaning of step-by-step switches.

The term "pile fabric" as used in the specification and the appended claims is intended to include such materials as terry cloth, velours, velvets, chenilles, and all tufted and/or napped fabrics which have cut or uncut loops, fibers, or tufts of fibers extending in a direction substantially normal to the plane of the warp of the fabric. The term "pile fibers" is intended to denote those fibers disposed substantially normal to the plane of the warp of the fabric.

The invention will be better understood by reference to the following drawings in which:

FIG. 1 is a schematic perspective view of an apparatus suitable for producing the abrasive fabrics of this invention;

FIG. 2 is a front elevational view of a portion of a tufted pile fabric to be coated in accordance with this invention;

FIG. 3 is a front elevational view of the portion of the pile fabric of FIG. 2 after having been coated with abrasive in accordance with a preferred embodiment of one aspect of the present invention;

FIG. 4 is a front elevational view of the portion of the pile fabric of FIG. 2 treated in accordance with a second aspect of the present invention; and

FIG. 5 is an exploded perspective view of a rotary scrubbing unit fabricated from the abrasive fabric of this invention.

With further reference now to the drawings, FIG. 1 is a schematic view of an apparatus suitable for producing the abrasive fabric of the present invention. Shown in FIG. 1 is a pile fabric 1 which is being pulled upward through drag rollers 2 by drive rollers 3, driven by

means not shown. Pile fabric 1 is composed of any thermoplastic material which may be woven into a fabric. Examples of such materials are cellulosic esters, such as cellulose acetate; polyesters, such as Dacron, manufactured by Du Pont, which is a polyester of ethylene glycol and terephthalic acid; substituted polyolefins, such as Orlon, manufactured by Du Pont, which is a polymer of acrylonitrile, Vinyon, manufactured by Union Carbon and Carbide, which is a copolymer of vinyl chloride and vinyl acetate, and Acrilan, manufactured by Chemstrand Corporation, which is a copolymer of acrylonitrile and a vinyl derivative; and polyamides, such as nylon, manufactured by Du Pont, which is a copolymer of sebacic acid and hexamethylene diamine.

In accordance with one aspect of this invention, abrasive particles 4 are deposited on moving pile fabric 1 by means of a dusting box or other device not shown.

As discussed in detail below, the abrasive qualities of the fabric are dependent in large part on the temperatures to which the fabric is heated. The quantity of abrasive bonded to the fabric is also dependent on the heating schedule and is not affected by the presence of an excess of abrasive particles. Accordingly, it is desirable to deposit a quantity of abrasive which is in excess of that which is bonded to the fabric during the processing to permit temperature control of the abrasive qualities of the fabric.

Any of the well-known abrasives, such as alumina, silica, garnet, diamond, pumice, silicon carbide, may be used.

The range of particle size which is used is dependent in large part upon the end use of the fabric being produced. For those fabrics to be used as polishing cloths, very fine particles of the order of one micron in diameter or less are indicated.

The maximum diameter of particles which may be used is limited by the diameter of the pile fibers. If the particles are too large with respect to the fiber diameter, inadequate bonding results. However, with a tufted fabric, maximum particle size is dependent upon the number of fibers per tuft, in addition to the diameter of the fibers. A good approximation in this respect is that the largest particle which can be successfully bonded to a tufted pile fabric is one whose diameter is approximately equal to the number of fibers per tuft multiplied by the diameter of the fiber.

Pile fabric 1 including abrasive particles 4 is then passed under heating element 5 which is at an elevated temperature by reason of an electrical current passing therethrough. Element 5 is held by insulated supports 6, which also serve as the conductors through which the electrical current passes.

As the pile fabric 1 passes beneath heating element 5, the upper portions of the fibers of the pile are heated causing them to fuse. As pile fabric 1 leaves the vicinity of element 5, the fused portions of the pile cool and solidify. In this manner, the abrasive particles which were in contact with the fused portions of the pile become rigidly bonded thereto.

The term "fused" as applied to thermoplastics in this specification and the appended claims is intended to indicate that the thermoplastic is in a condition such that it wets and adheres to abrasive particles in contact therewith. The minimum temperature at which this occurs for any given thermoplastic is termed the "sticking point." Sticking points are determined by producing a temperature gradient in a metal body and moving a block of thermoplastic along the body from the cooler to the hotter end until the thermoplastic sticks or adheres to the bar and leaves a residue when removed therefrom.

The approximate sticking points of some of the more common fibers are as follows:

	°F.
Cellulose acetate	375
Nylon	480
Vinyon	260
Acrilan	450
Orlon	450
Dacron	480

Abrasive-coated pile fabric **7** is then passed through vacuum nozzle **8** to remove excess abrasive particles which were not bonded to the pile fibers.

FIG. 2 shows a tufted pile fabric suitable for processing in accordance with this invention. Shown in FIG. 2 are tufts **10** consisting of fibers **13**, which are attached to the body **11** of the fabric.

FIG. 3 depicts the fabric of FIG. 2 after it has been coated with abrasive particles in accordance with the preferred embodiment of this aspect of the present invention. In this embodiment, following the deposition of abrasive particles, the upper portions of the fibers **13** are heated to cause deformation, as described in detail below. As a result of such heating, a bulbous mass or cap **12** is formed atop each tuft, which upon cooling securely binds abrasive particles which had been previously deposited on the pile.

Since thermoplastic materials generally do not have a sharply defined melting point, but, rather, exhibit a gradual decrease in viscosity with increasing temperature, the upper portions of the fibers must be heated in accordance with a prescribed schedule to obtain the deformation desired. A partial list of the approximate temperatures, termed "deformation temperatures" to which the fibers should be heated in accordance with the preferred embodiment of this invention follows:

	°F.
Cellulose acetate	425
Nylon	485
Vinyon	290
Acrilan	480
Orlon	455
Dacron	485

Those thermoplastics, such as nylon, Dacron and Orlon, which are crystalline or semicrystalline, have fairly well-defined melting points, and, accordingly, pseudo-phase changes from solid to liquid occur for these materials within a narrow temperature range. The sticking point, deformation temperature and melting point of each of these materials are essentially equal.

The properties of the abrasive-coated cloth produced in accordance with the preferred embodiment depend to a large extent on the proportion of the fiber which is deformed. Increasing the proportion of the fiber which is deformed produces a commensurate increase in the size of the cap **12** on the end of the fiber. The quantity of abrasive which is bound to the fabric is also increased in such instance. For heavy duty service, a large cap containing a large amount of abrasive is desired. However, since the excellent cleaning properties of the cloth are, to a large extent, due to the fact that the abrasive particles are attached to the ends of flexible fibers, deforming too large a proportion of the fibers tends to eliminate the inherent advantages gained by the use of a pile fabric.

FIG. 4 is a front elevational view of the pile fabric of FIG. 2 after it has been treated in accordance with a second aspect of the present invention. Shown in FIG. 4 is cap **15** which has been produced atop fibers **13**. Although no additional abrasive action is imparted to the fabric by reason of the deformation of the pile fibers, an advantage is obtained by reason of the changed nature of the pile itself. Whereas formerly the pile consisted of tufts of thin easily pliable fibers, each tuft has been converted into a single unit which is many times less flexible than the individual fibers of which they are composed.

FIG. 5 is an exploded perspective view of a rotary scrubbing unit suitable for cleaning step-by-step switches of the type commonly found in telephone exchange offices. Such a unit comprises alternate spacers **21** and cleaning discs **22** mounted on a rigid shaft **25**. Cleaning discs **22** consist of a central supporting member **23** faced with abrasive fabric **24** of this invention. This type of scrubbing unit and its use are described in detail in U.S. Patent 2,843,869, issued to H. W. Hermance on July 22, 1958.

The maximum temperature to which the fiber may be heated in accordance with this invention is determined by the charring or decomposition point of the thermoplastic. Most thermoplastic materials based on a hydrocarbon structure begin to decompose and char when heated in air to temperatures of the order of 600° F., and this figure thus represents the upper limit for this invention.

Thus, to deform the upper portion of a fiber in accordance with this invention, a temperature gradient is introduced along the fiber length which ranges from the deformation temperature at the lower end of the portion to be melted to a temperature below the decomposition temperature at the tip of the fiber.

If deformation of the fiber is not desired, the temperature gradient in the fiber is adjusted so that it ranges from below the sticking point to below the deformation temperature. In such instances, abrasive particles will be bonded only to those portions of the fiber which are at a temperature equal to or greater than the sticking point. Fabric materials so produced are suitable for use as polishing cloths and the like.

In any event, the present invention contemplates the introduction of a steep temperature gradient along the length of the pile fibers. A simple method of accomplishing the introduction of the requisite temperature gradient is the use of a means whereby heat is transferred substantially by radiation. Energy transport by radiation varies inversely as the square of the distance between the sink and source. Accordingly, by placing a radiating means at a distance from the top of the pile, which distance is relatively small in comparison with the length of the pile fiber, a relatively high differential between the heat transfer to the upper portions of the fiber and the lower portions of the fiber is obtained. Thus, for example, if the height of the pile is approximately 65 mils, the distance of the top of the pile from the radiating means may be of the order of 5 mils. Assuming the total quantity of heat transferred from the wire to the fabric to be by radiation, such a configuration would result in almost a two hundredfold difference in the quantity of heat transferred as between the top and bottom of the fibers.

There are three parameters which may be controlled to provide for the desired temperature gradient when using a radiating means as the source of heat: the distance of the top of the pile from the means, the speed of the fabric past the means, and the temperature of the means. Variation in the last two parameters affects the quantity of heat transmitted to all portions of the fiber in the same manner. Thus, an increase in the temperature of the means increases the temperature of all portions of the fiber by increasing the rate of heat transfer.

Conversely, varying the distance of the means from the fabric has a selective effect on the temperature of the fiber. Increasing the distance tends to flatten the temperature gradient in the fiber, decreasing the distance having an opposite effect.

In view of the foregoing, the preferred methods for increasing the proportion of the fiber which is fused are either decreasing the speed of the fabric or increasing the temperature. Where a predetermined portion of the fiber is to be deformed, this is best controlled by proper ad-

justment of the distance between the radiating means and the top of the pile.

Scrubbing units for use in cleaning step-by-step switches similar to those shown in FIG. 5 were fabricated from silicon carbide coated nylon produced in accordance with the preferred embodiment of this invention. Approximately 20 percent of the pile fiber length was deformed during the processing of the nylon. Such scrubbing units were compared with those fabricated from an abrasive cloth produced by bonding silicon carbide particles to the identical nylon fabric using an adhesive material in accordance with the prior art processes. The prior art scrubbing units lost their abrasive properties after cleaning an average of only five banks of step-by-step switches, whereas fifty banks were satisfactorily cleaned with the scrubbing units employing the abrasive fabric produced in accordance with this invention. Following the above tests, microscopic examination of the scrubbing units of this invention disclosed that most of the abrasive was still effectively bonded to the nylon fibers.

It has been determined that deforming approximately 10 to 30 percent of the fiber results in an abrasive cloth which is particularly suited for use in these scrubbing units, the preferred fiber length for such use being in the range of from 50 to 75 mils.

The unforeseeable advantage of superior wearability of the abrasive fabric of this invention over that of the prior art is believed to result directly from the manner in which the abrasive cloth is fabricated. Adherence of the abrasive particles to the fabric as produced by this invention is far greater than that which could be predicted on the basis of the prior art materials which were fabricated using the strongest possible adhesive materials.

The cutting action of the abrasive material of this invention also exceeds that of the prior art materials. It is suggested that the use of an adhesive bonding method tends to cover many of the sharp cutting edges of the individual abrasive particles with adhesive material thereby decreasing the overall abrasive action of the cloth.

Cleaning step-by-step switches involves both cleaning the surface of the metal contacts and also cleaning the spaces between the contacts. Although the primary consideration in such cleaning operation is the cleanliness of the contacts themselves, sludge deposits between the contacts may at times be the source of crosstalk difficulties. Although scrubbing units fabricated from the abrasive-coated fabric of this invention remove a substantial portion of such sludge material, it has been determined that scrubbing units constructed from the abrasive-free fabric of this invention shown in FIG. 4 are far superior in this respect. Using scrubbing units constructed of a nylon fabric in which approximately 20 percent of the pile fiber length was deformed by treatment in accordance with this invention resulted in cleaning substantially all of the sludge and foreign matter from the spaces between the contacts of step-by-step switches.

The superiority of the abrasive-free material is believed to be due in large measure to the flexibility of the capped tufts of this fabric.

Excellent cleaning cloths suitable for the use described above are produced by deforming from 10 percent to 40 percent of the fiber length, the preferred fiber length being in the range of from 75 to 100 mils.

Examples of the present invention are described in detail below:

Example 1

The fabric which was coated was a nylon pile material consisting of approximately 1500 tufts per square inch, each tuft being made up of approximately 66 filaments, one mil in diameter. The filaments comprising the pile were approximately 64 mils long. No. 600 silicon carbide particles were used as the abrasive material, the particles ranging from 25 to 40 microns in diameter.

The silicon carbide abrasive was then deposited on the nylon pile material.

The nylon fabric including the abrasive particles was passed under a heated Nichrome wire at a speed of approximately 8 inches per minute. The Nichrome wire was 30 mils in diameter and was at a temperature of 680° C. The distance between the wire and the top of the pile was approximately 5 mils. Such treatment produced a fabric in which approximately 20 percent of the pile length was deformed.

The nylon fabric was then treated to remove the excess silicon carbide particles which were not bonded to the fabric.

Example 2

The fabric which was treated in accordance with this aspect of this invention was a nylon pile material consisting of approximately 1500 tufts per square inch, each tuft including approximately 66 filaments, one mil in diameter. The filaments comprising the pile were approximately 85 mils in length.

The fabric was passed under a heated Nichrome wire at a speed of approximately 8 inches per minute. The Nichrome wire was 30 mils in diameter and was at a temperature of 680° C. The distance between the wire and the top of the pile was approximately 5 mils. Such treatment produced a fabric in which approximately 20 percent of the pile length was deformed.

The examples and embodiments described above are intended merely as illustrative of the present invention. Although the description of the invention involves use of a fabric constructed entirely of fibers of one thermoplastic material, it is to be appreciated that the present invention contemplatae the use of fabrics constructed of fibers of more than one thermoplastic material and, in addition, may contain non-thermoplastic fibers.

Variations in the present invention as described above may be made by one skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. The method of producing an abrasive cloth comprising depositing abrasive particles onto the face of a pile fabric, the pile of which comprises fibers consisting essentially of a thermoplastic material, heating the fabric in a manner so as to fuse the upper portions of the thermoplastic pile fibers, and cooling the fabric to bond abrasive particles to the said upper portions.

2. The method of claim 1 in which said thermoplastic material is selected from the group consisting of cellulose acetate, polyesters of ethylene glycol and terephthalic acid, polymeric acrylonitrile, copolymers of vinyl chloride and vinyl acetate, copolymers of acrylonitrile and a vinyl derivative, and copolymers of sebacic acid and hexamethylene diamine.

3. An abrasive cloth produced in accordance with claim 1.

4. An abrasive cloth consisting essentially of a nylon pile fabric and abrasive particles fused to the upper portions of the pile fibers of the said fabric.

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