May 30, 1967 C. R. KOLLER 3,322,606
DOUBLE-FACED PILE ARTICLE
Filed June 24, 1963 2 Sheets-Sheet 1

Fig. 1.

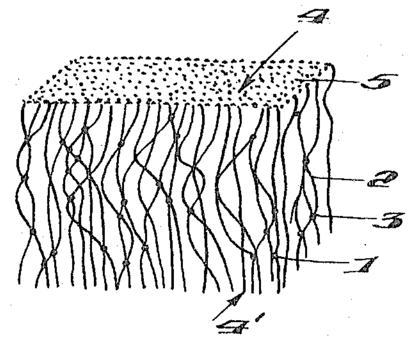

Fig. 2.

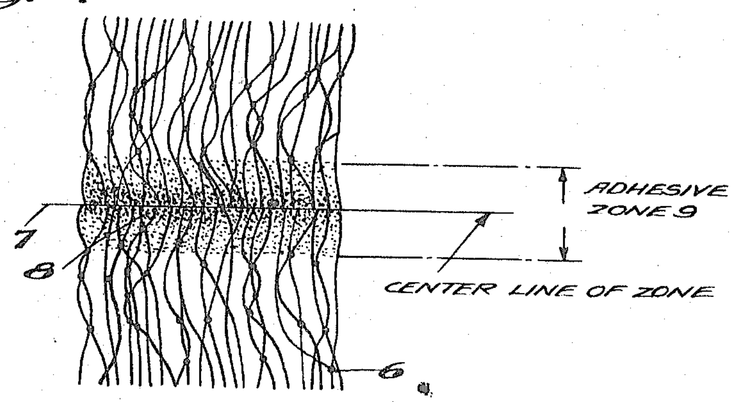

Fig. 3.

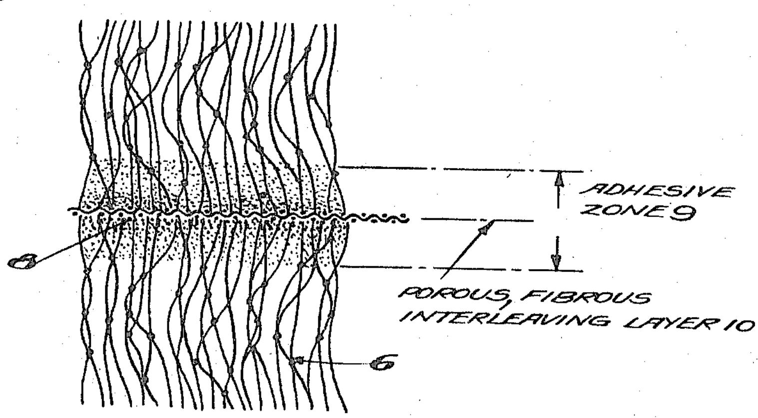

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Fig. 4.

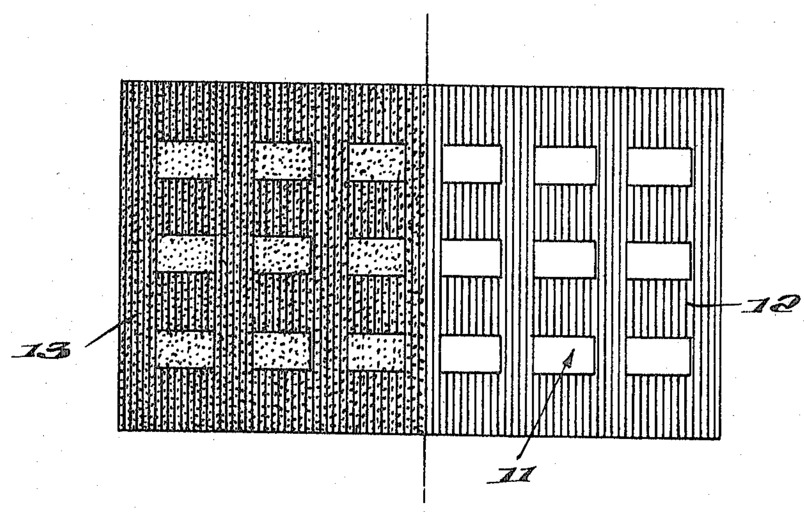
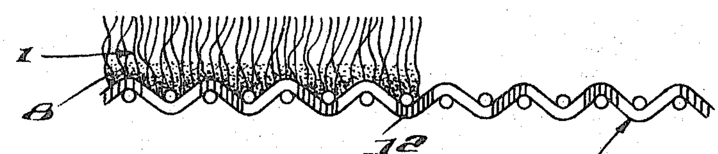


Fig. 5.



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United States Patent Office

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Patented May 30, 1967

3,322,606

DOUBLE-FACED PILE ARTICLE

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Filed June 24, 1963, Ser. No. 290,213
12 Claims. (Cl. 161—67)

This application is a continuation-in-part of copending application Ser. No. 272,545, filed Apr. 12, 1963, now abandoned, which in turn is a continuation-in-part of application Ser. No. 787,662, filed Jan. 19, 1959, now U.S. Patent 3,085,922.

This invention relates to novel double-faced pile fabrics and more particularly to such fabrics having an outstanding combination of functional and aesthetic properties.

A variety of techniques are presently employed for the production of double-faced pile fabrics which possess desirable properties when utilized in blankets and other pile articles. Almost without exception, such techniques as are practiced on a commercial scale involve in one way or another the formation of the pile layers by weaving and/or knitting operations. Although the resultant articles normally provide satisfactory properties of insulation, drape, flexibility and the like, they are frequently susceptible to deterioration both during use and upon washing by conventional home laundry techniques. Often these washing procedures cause a matting and distortion of the pile surface and a lowering of the pile thickness with the consequence that losses are suffered in functional and aesthetic properties.

It is an object of the invention to provide novel, non-woven, double-faced pile fabrics having improved resistance to surface matting and distortion. Another object is to provide double-faced pile fabrics which are breathable, have high insulating value, and which in addition have outstanding properties of drape and flexibility. A further object is to provide a double-faced blanket, fleece, synthetic fur, towel, reversible carpet, pile coating fabric, or other pile fabric which can be freely washed by common washing procedures without severe distortion of the pile surface fibers and without significant loss of pile thickness. Other objects of the invention will appear below.

In accordance with the invention there is provided a breathable and drapable double-faced, pile fabric comprising a laminate of two superposed, non-woven, fibrous pile layers joined at an interface, each said layer being flexible and porous, having a fiber density of 0.3 to 8 pounds/ft.^{3}, and being composed of substantially parallelized, crimped, synthetic organic, polymeric fibers which are attached by a binder composition at a plurality of contact points throughout the three dimensions of the layer, the density of fibers in each said layer exceeding the density of binder composition therein, the two faces of each said layer being composed essentially of opposite ends of said fibers, said interface comprising a fiber end face of one layer contiguous a fiber end face of the other layer and secured thereto by a non-fugitive adhesive composition dispersed within a zone running parallel to and adjacent each of said contiguous faces and acting to bond fibers of one layer to fibers of the other layer at a plurality of contact points. Preferably the zone will have a thickness no greater than 25% of the thickness of fabric and will have a density of adhesive composition therein greater than the fiber density of either layer.

In a preferred embodiment the double-faced pile fabric includes a porous, fibrous, interleaving layer which is disposed at the interface between the two pile layers. Such a layer thus serves as an intermediate or supporting base, since the two pile layers are attached thereto in point-wise fashion by means of the adhesive composition. For purposes of breathability as well as drapability, the interleaving layer must be porous, air permeable and possess a relatively small thickness, e.g. desirably such that the thickness of the adhesive zone formed therewith does not exceed 25% of that of the fabric. Either woven, knitted or non-woven fabrics, felts, batts, or other loosely constructed fibrous material can accordingly be utilized.

The novel products of the invention are particularly advantageous by reason of their outstanding properties of drape, flexibility, and breathability. In comparision with woven or knitted articles, it is especially noteworthy that these properties are achieved notwithstanding the use of a comparatively dense adhesive composition to adhere the non-woven fibrous pile layers together. It will be apparent that the utilization of non-woven fibrous pile layers to obtain such highly desirable properties offers substantial savings in production costs. A further advantage of the products of the invention resides in the high resistance of the fabrics to deterioration during washing and use. The fabrics possess good dimensional strength and resist fiber loss, surface matting and distortion. The fabrics are hence well suited for use in blankets, fleeces, synthetic furs, towels, reversible carpets, pile coating fabrics, garment interliners, and other pile articles.

A full description of methods for producing the non-woven, fibrous pile layers employed in accordance with this invention for the production of double-faced pile fabrics is set forth in C. R. Koller U.S. application Ser. No. 787,662, filed Jan. 19, 1959, now U.S. Patent No. 3,085,922. These layers are of a porous flexible character and are composed of substantially parallelized crimped synthetic organic polymeric fibers which are attached by a binder composition at a plurality of contact points throughout the three dimensions of the material. Although a description of these materials, including definitions of the terms used in connection therewith, is fully set forth in the above Koller application, the disclosure of which is specifically incorporated herein by reference, they will be briefly mentioned herein.

By "crimped," alternatively "contorted," it is meant that the profile (i.e. side elevation) of an individual fiber is irregular (i.e. not straight) when the fiber is viewed from at least one side. By "substantially parallelized," it is meant that although the fibers are crimped, the mean axes of individual fibers are substantially parallelized, i.e. aligned generally in the same direction. This orientation may be further illustrated by considering individual fibers to be surrounded by a circumscribing envelope or cylinder; the mean axes of these envelopes are substantially parallelized. The average angle formed by such axes with the plane of a face of the sheet should be at least 10° and, more commonly, essentially 90°. By virtue of the crimped, substantially parallelized arrangement of the fibers, they "overlap" one another; that is, in at least one view, a fiber crosses over, with or without touching or attachment to an adjacent fiber. As a consequence the fibers are said to "coact" in that the crimp and relative placement of the fibers are such that they assist one another in producing and maintaining the fiber-on-end character both with respect to the general alignment of the fibers and their spacing with respect to each other.

The fibrous pile layers as described in the aforementioned Koller application can be prepared by a method which comprises forming a plurality of bodies containing substantially parallelized fibers, either per se or in the form of other suitable filamentary structures, placing the bodies in a mold and forming a block while keeping the fibers substantially parallelized, impregnating the block with a binder composition, draining off excess binder, curing or otherwise solidifying the binder at spaced contact points throughout the three dimensions of the block, and cutting the resulting block at an angle of at least 10°

to the plane of orientation of the fibers to obtain a porous, self-supporting sheet material.

In accordance with the invention, the production of double-faced pile fabrics of outstanding properties, as described above, requires a judicious selection of the fibrous and non-fibrous components and a critical arrangement thereof. Important considerations leading to the attainment of suitable non-woven fibrous pile layers will not be described in greater detail.

The fiber density of the pile layers, in particular, markedly affects the functional properties of the resultant fabric. It has been found that the fiber density of each pile layer should be in the range of 0.3 to 8 pounds/ft.^{3} to afford a proper combination of properties. For fabrics to be utilized in pile coating fabrics and insulating lining materials for garments, the fiber density is preferably in the range 0.5 to 3 pounds/ft.^{3}, since a greater amount of fiber increases the cost without necessarily improving the properties. The fiber density reported in pounds per cubic foot is a measure of the density of the fibers in the pile layer per se. It is calculated by dividing the effective pile weight of the fibers in the pile layer by the volume these fibers occupy when the specimen is under a barely perceptible load, e.g. of 0.01 p.s.i. The volume in turn is determined by multiplying the average width by the average length of the conditioned specimen by the effective pile height, and then applying suitable conversion factors to obtain the volume in units of cubic feet.

The initial crimped fiber to be used in preparing the fibrous pile layers may be in any of a variety of forms, for example, carded webs of substantially aligned staple fibers or bodies of substantially aligned filamentary structures prepared from a warp of sliver, top, roping, roving, tow, stuffer box crimped tow, steam bulked tow, steam crimped continuous filament yarn, gear crimped continuous filament yarn, twist set-back twisted continuous filament yarn, knife edge crimped continuous filament yarn, two-component bulky continuous filament yarn, spun yarns, and many others. Widely differing types of crimp configurations can be imparted to the fibers. Fibers of either two dimensional or three dimensional crimp or combinations there of can be employed. For example the irregular contortion can be in the form of crimp, e.g., V-shaped, spiral, loopy, zig-zag, sinusoidal, serpentine, multi-cusped, cycloidal, serrated, or any other form of crimp. The irregularity may be in the form of intermittent pronounced protuberances or thickenings along the length of the structure e.g., flocked-yarns, thick-and-thin yarns (e.g., such as those in U.S. 2,975,474) fuzzy yarns, twisted filaments with fins, twisted ribbon filaments, twisted crescent filaments, twisted elliptical filaments, twisted trilobal filaments, twisted tetralobal filaments, twisted pentalobal filaments, and the like.

In preparing a pile layer a wide variety of synthetic organic polymeric compositions may be employed. Typical of the fibers and filaments which may be employed are those made of polyamides, such as poly-hexamethylene adipamide), poly(metaphenylene isophthalamide), poly(hexamethylene sebacamide), polycaproamide, copolyamide and irradiation grafted polyamides, polyesters and copolyesters such as condensation products of ethylene glycol with terephthalic acid, ethylene glycol with a 90/10 mixture of terephthalic/isophthalic acid, ethylene glycol with a 98/2 mixture of terephthalic/5-(sodium sulfo)-isophthalic acids, and trans-p-hexahydroxylylene glycol with terephthalic acid, self elongating ethylene-terephthalate polymers, polyhydroxypivalic acid, polyacrylonitrile, copolymers of acrylonitrile with other monomers such as vinyl acetate, vinyl chloride, methyl acrylate, vinyl pyridine, sodium styrene sulfonate, terpolymers of acrylonitrile/methylacrylate/sodium styrene sulfonate made in accordance with U.S. Patent 2,837,501, vinyl and vinylidene polymers and copolymers, polycarbonates, polyacetals, polyethers, polyurethanes such as segmented polymers described in U.S. Patents 2,957,852

and 2,929,804, polyesteramides, polysulfonamides, polyethylenes, polypropylenes, fluorinated and/or chlorinated ethylene polymers and copolymers (e.g. polytetrafluoroethylene, polytrifluorochloroethylene), cellulose derivatives, such as cellulose acetate, cellulose triacetate, composite filaments such as, for example, a sheath of polyamide around a core of polyester as described in U. S. Patent 3,038,236 and self crimped composite filaments, such as, two acrylonitrile polymers differing in ionizable group content cospun side by side as described in U.S. Patent 3,038,237 and the like. Blends of two or more synthetic organic fibers may be used, as well as blends of a major weight proportion of synthetic fibers with a minor weight proportion of natural fibers e.g. silk, wool, mohair, angora and vicuna.

The pile layers may be prepared from a wide variety of forms of fibers and filaments having any of the above-mentioned compositions, such as, for example, continuous mono-filaments, continuous multifilaments, carded webs, warp, sliver, top, roping, roving, tow, bulked tow, bulked continuous filament yarn, spun yarn, batts, felts, papers and other non-woven webs, and the like. The fibers and filaments used as raw material, in addition to being crimped, can be bulked or unbulked, drawn or undrawn or twisted or untwisted. The denier of the fibers or filaments used in making the pile layers of the double faced fabrics can vary from about 1 to about 25 denier per filament. For blankets the preferred range is 1–6 d.p.f while for interlinings it is 1-12 d.p.f.

In general the amount of binder composition to be employed in a given fibrous pile layer will be an amount sufficient to point bond the fibers in the layer to provide a self-supporting fibrous layer. The maximum quantity of binder in any pile layer should be less than the quantity of fiber in that layer, exclusive of any fibrous interleaving layer, since amounts in excess thereof detract from the desired drapability characteristic of the resultant fabric. Preferably the binder composition density will be 1 to 75% of the fiber density in a given fibrous layer. Typical values may be cited for some of the preferred pile fabrics. The binder density reported in pounds per cubic foot is a measure of the density of the binder in the pile layer per se. It is calculated by dividing the effective weight of the binder in the pile layer by the volume the pile layer occupies when the specimen is under a barely perceptible load, e.g. of 0.01 p.s.i. The volume in turn is determined by multiplying the average width by the average length of the conditioned specimen by the effective pile height, and then applying suitable conversion factors to obtain the volume in units of cubic feet. For a blanket having a fiber density of 0.7 lb./ft.^{3}, the binder density may be 10% of the fiber density e.g. 0.07 lb. of binder/ft.^{3}. Binder density is measured in a manner similar to that used for fiber density, i.e., the binder density reported in pounds per cubic foot is a measure of the density of binder in the pile layer per se. It is calculated by dividing the effective pile weight of the binder in the pile layer by the volume the pile layer occupies when the specimen is under a barely perceptible load, e.g. of 0.01 p.s.i. The volume in turn is determined by multiplying the average width by the average length of the conditioned specimen by the effective pile height, and then applying suitable conversion factors to obtain the volume in units of cubic feet. In a typical example for making an insulating lining for garments, the fiber density may be 2 lbs./ft.^{3} with 30% binder used on the weight of the fiber, e.g. 0.6 lb. of binder/ft.^{3}. Irrespective of the proportionate quantity of binder composition, it should be distributed susbstantially uniformly throughout the pile layer.

The nature of the binder composition employed to interconnect the fibers at a plurality of contact points along their length throughout the three dimensions of the pile layer can vary widely. Depending upon the use desired these may be either soluble or insoluble, and may be either thermoplastic in nature or may be thermosetting, e.g. as having been produced by the application of a curable composition followed by treatment with a curing agent, a catalyst, heat, etc. If it is desired to remove the binder a soluble binder will be employed which may be either organic-soluble or water-soluble. Suitable organic-soluble binders include natural rubber or synthetic elastomers (e.g., chloroprene, butadienestyrene copolymers, butadiene-acrylonitrile copolymers), which may be used in the form of a latex dispersion or emulsion or in the form of a solution, vinyl acetate polymers and copolymers, acrylic polymers and copolymers such as polymers of ethyl acrylate, methyl acrylate, butyl acrylate, methyl methacrylate, acrylic acid/acrylic and methacrylic ester copolymers, cellulose nitrate, cellulose acetate, cellulose triacetate, polyester resins such as ethylene terephthalate/ethylene isophthalate copolymers, polyurethanes such as the polymer from piperazine and ethylene bis-chloroformate, polyamide polymers, and copolymers, methoxymethyl polyamides, vinyl chloride polymers and copolymers such as vinyl chloride/vinylidene chloride copolymer latices. Alcohol soluble polyamide resins are also suitable organic-soluble binders. Suitable water-soluble binders include materials such as polyvinyl alcohol, sodium alginate, acrylic acid polymers and copolymers such as polyacrylic acid, carboxymethyl cellulose, hydroxyethyl cellulose, dextrins, animal glue, soybean glue and sodium silicate. Suitable binders which are insoluble in organic solvents incldue polytetrafluoroethylene and ureaformaldehyde resin latices. If it is desired to leave the binder in the final fabric, a material should, of course, be selected which is not affected by common laundering and/or dry-cleaning techniques.

Additional suitable binder compositions include chlorosulfonated polyethylene; butyl rubbers, such as isobutylene/isoprene copolymers; polyhydrocarbons, such as polyethylene, polypropylene and the like and copolymers thereof; high molecular weight polyethylene glycols sold under the trade name of "Polyox"; epoxide resins, such as the curable epichlorohydrin reaction products with bisphenols and glycols; polystyrene; alkyd resins, such as polyesters of glycerol with phthalic or maleic acid; polyester resins such as from propylene glycol-maleic anhydride-styrene; phenol-formaldehyde resins; resorcinol-formaldehyde resins; polyvinyl acetals, such as polyvinyl butyral and polyvinyl formal; polyvinyl ethers, such as polyvinyl isobutyl ether; starch, zein, casein, gelatine, methyl cellulose, ethyl cellulose, polyvinyl fluoride, natural gums, polyisobutylene, shellac, terpene resins and rosin soaps. Segmented polymers, such as spandex polymers, polyether amides, polyether urethanes (e.g. those in U.S. 2,929,800) and polyester/urethanes are also suitable.

The choice of adhesive composition used to secure the two pile layers together, either directly or to an intermediate interleaving layer as hereinbefore described, and the relative distribution of adhesive within the resultant fabric are critical considerations to the invention. To be effective, the adhesive composition must be such that it is non-fugitive, e.g. to permanently retain its adhesive character upon repeated steps of washing, laundering, and treatment with common dry-cleaning solvents including halogenated hydrocarbons such as carbon tetrachloride and perchloroethylene. It is highly preferred that the insoluble adhesive composition of the final double-faced fabric exist as cross-linked polymer, i.e. one which is in a thermoset or infusible condition. The cross-linking is generally effected by uniting the layers with a solution or dispersion of curable adhesive followed by subjecting the laminate to elevated temperatures in the presence of a curing agent or vulcanizing agent.

In order to produce a double-faced pile fabric which is suitably breathable and permeable to air, the adhesive composition must be distributed in a discontinuous manner within the adhesive zone of the fabric, e.g. so as to

bond either directly or indirectly fibers of one layer to fibers of the other layer at a plurality of contact points without the creation of an impermeable, non-porous intermediate film. Such a distribution is desirably attained by initially applying the adhesive composition to one face of each of the two pile layers to be laminated together. This can be conveniently accomplished by spraying adhesive on the face of the pile layer or by careful doctoring of adhesive on such a face. Alternatively, it is possible to immerse one face of a pile layer into a solution of adhesive composition to a small predetermined depth, followed by removal of the fibrous layer from the solution and drainage of excess adhesive. Since each layer to be joined has two faces which are composed essentially of opposite ends of the pile fibers, subsequent arrangement of two layers in superposed relationship with or without an interleaving layer creates an interface comprising a fiber end face of one layer contiguous a fiber end face of the other layer. The non-fugitive adhesive composition securing the layers together is thus dispersed within a zone running parallel to and adjacent each of the contiguous faces such that the fibers of one layer are bonded to fibers of the other layer at a plurality of contact points. The thickness dimension of the described zone, as it contains a major weight proportion of the adhesive composition in the fabric, should desirably be no greater than 25% of the thickness of the fabric.

Although the distribution of adhesive will depend somewhat upon the manner of its application, it is preferably distributed throughout the adhesive zone in decreasing concentrations from the interface towards the center of the pile layers. In this respect it will be understood that the adhesive density values recited herein are average values considering the adhesive zone as a whole. To ensure proper adhesion, the amount of adhesive used must always be such that the adhesive density is greater than the pile fiber density in the zone occupied by the adhesive.

Typical adhesives for use in cementing the two pile layers together or to an intermediate interleaving layer include those materials which are curable to a thermosetting or infusible condition, e.g., polyurethane resins, polyepoxy resins such as those formed from epichlorohydrin and 2,2-bis(parahydroxyphenyl)propane, and polyvinyl chloride resins plasticized by a curable monomeric or polymeric plasticizer. Other adhesives which are not curable but which are insoluble in common solvents are exemplified by polyamide copolymers of hexamethylene diamine and adipic acid/sebacic acid mixtures. Elastomeric adhesives such as those formed of a polyalkylene-ether glycol polyurethane are especially preferred for their ability to tenaciously bond the pile layers together.

Notwithstanding the above considerations with respect to the densities of fiber, binder and adhesive, the double-faced fabrics of the invention should have an air volume or porosity of at least 80%. Although this degree of overall porosity can be achieved when the individual pile layers have a thickness of as little as 1/16-inch, it is preferred for most applications that the pile thickness be at least 1/8-inch. The maximum thickness attributed to each pile layer will also depend upon the particular use of the fabric. In general pile layer thicknesses up to 1/4-inch or even one inch offer superior combinations of properties.

It will be apparent that the product of the invention can be modified by a variety of additives and treatments to impart special qualities to the products. Thus, if desired an additional binder may be added to one or both pile surfaces of the final double-faced pile fabric, e.g., following removal of the original binder or in order to supplement a permanent binder, for purposes of achieving certain aesthetics or other properties. Dyes, pigments, antioxidants, stabilizers, abrasives, fillers, solid soaps and the like can be incorporated in the fabrics by means well known in the art.

The invention will be more fully illustrated by reference to the drawing.

FIGURE 1 illustrates a perspective view of an individual layer prior to formation of the laminate of the present invention.

FIGURE 2 illustrates a front elevation view of the double-faced pile fabric laminate of the present invention.

FIGURE 3 illustrates a front elevation view of a preferred embodiment of the present invention including an interleaving layer.

FIGURE 4 illustrates a plan view of a preferred embodiment of the present invention with a printed interleaving layer showing a "see-through" effect which will be discussed hereinafter.

FIGURE 5 is a front elevation view of the structure shown in FIGURE 4.

Referring specifically to FIGURE 1, an individual nonwoven fibrous pile layer **1** is illustrated. The layer **1** is composed substantially of parallelized, crimped, synthetic organic polymer fibers **2**, which are attached at a plurality of contact points throughout the three dimensions of the layer by a binder composition **3**. The face **4** is composed essentially of opposite ends **5** of fibers **2**, hereinafter refererd to as fiber end face **4**. A second fiber end face **4'** is on the opposite side of layer **1**.

FIGURE 2 illustrates a double-faced, pile fabric **6** comprising two superposed layers of the layer **1** illustrated in FIGURE 1. The layers are joined at an interface **7** (indicated by an imaginary center line) comprising contiguous fiber end faces **4** of individual layers **1**. The fiber end faces **4** are secured together by a non-fugitive adhesive composition **8** which is distributed in a discontinuous manner within an adhesive zone **9**. The adhesive composition **8** acts to bond fibers **2** of one layer directly or indirectly to fibers **2** of another layer at a plurality of contact points.

FIGURE 3 illustrates a preferred embodiment of the pile fabric **6** illustrated in FIGURE 2. This embodiment includes a porous fibrous interleaving layer **10** included in said interface. Two fiber end faces **4** are contiguous (near, but not necessarily in contact with each other). The fibers **2** of each layer **1** are directly bonded by adhesive composition **8** to the interleaving layer **10** (and the fibers **2** are indirectly bonded to each other).

The following examples will further illustrate the invention. All parts specified therein are by weight unless otherwise indicated.

EXAMPLE I

Crimped staple fibers of ethylene terephthalate polymer which have a filament denier of 4 and a staple length of 2-inches are processed into a thin carded web 27-inches wide, having a high degree of alignment of the fibers in a direction lengthwise of the web. The fibers, prepared in accordance with Kilian U.S. Patent 3,050,821, have a three-dimensional curvilinear crimp, with a filament crimp frequency of 10 crimps per inch and a filament crimp elongation of 100%. The filament crimp elongation is a measure, in percent, of the amount of crimp as determined from the difference between the extended and relaxed length of a fiber divided by the relaxed length, this quantity times 100. The carded web is wound continuously onto a 2-foot diameter circular drum with a minimum of tension until a layer approximately 10-inches thick is obtained. This layer of fibers is cut in a line transverse to the direction of the fibers and removed from the drum to give a batt of carded fibers measuring approximately 27-inches wide x 75 inches long x 10 inches thick having the fibers all aligned in the same general direction along the length of the batt. The batt is cut at 90° transverse to the direction of the

fibers into sections 7 inches long x 10 inches thick and trimmed to 24-inches width. These batt sections are then carefully placed by hand into a perforated metal mold, 24 inches wide x 36 inches long x 7 inches high, having an open top, with the 24 inches by 7 inches sides of the sections face-to-face so that the fibers are all aligned in the same general direction with the fiber ends directed towards the open top and bottom of the mold. As the individual batt sections are placed into the mold, they are gently pushed against each other sideways and released so as to blend and intermingle the fibers in the 24 inch side surfaces of the sections. Considerable overlapping of the fibers is observed at the interfaces between batt sections. A total weight of 984 grams of fiber in batt forms fills the mold at this stage. The top is closed on the mold and cotton threads are inserted by means of a long needle from one side to the other through the perforated mold and fiber assembly at 6 inches intervals in a horizontal plane approximately ½-in. from the top and bottom of the mold to aid in maintaining the fibers in their given positions during impregnation with binder solution.

The filled mold is then turned with its 24 inch side standing vertically and in this position it is slowly lowered and immersed into a tank of binder solution freshly prepared as follows: 2920 grams of the viscous reaction product of a 1.6:1.0 molar ratio of 2,4-toluene diisocyanate and polytetramethylene ether glycol

(M.W.=1000)

are dissolved with 895 g. of castor oil in 32 gal. of perchloroethylene. To this solution is added a solution of 29.8 grams of 4,4'-methylene-bis(2-chloroaniline) dissolved in 425 ml. of methylene chloride. The mold is slowly withdrawn from the binder solution and allowed to drain 20 minutes. The mold is turned over with the opposite side down and heated in an oven with air at 300° F. passing through the assembly for 2 hours to cure the binder. The fiber assembly after removal from the mold consists of overlapped and touching fibers uniformly bonded together throughout the assembly. This bonded fiber assembly is then sliced with a horizontal band knife slitter in a plane at 90° transverse to the direction of the fibers into sheets $\frac{3}{16}$-inch in thickness.

The pile layers so obtained are porous, self-supporting and can be rolled onto a 3-inch diameter tube without splitting or loss of fiber. One sheet cut from the assembly is found to have a fiber density of 0.62 lb./ft.^{3}, a binder content of 6.5% on the weight of fiber and a specific volume at 0.15 p.s.i. of 107 cc./gm.

One face of each of two $\frac{3}{16}$-in. thick sheets is lightly sprayed with an elastomeric adhesive. The adhesive is a freshly prepared solution of the same ingredients as those in the binder solution above, excluding the castor oil, except employing the following amounts of ingredients:

Diisocyanate/glycol reaction product	grams	100
Chloroaniline compound	do	11
Methylene chloride	ml	41
Perchloroethylene	ml	70

The sprayed surfaces are then placed onto opposite sides of a cotton cheesecloth fabric which has also been coated with the same adhesive. The assembly is held together under light pressure and heated for 1.75 hrs. at 300° F. to cure the adhesive to produce a discontinuous vapor permeable adhesive layer at the interfaces between the two pile layers. There is obtained a flexible, soft double-faced pile fabric with sufficient strength to be useful as a blanket. The specific volume as measured at 0.15 p.s.i. upon a four square inch sample of the bonded fiber assembly layer of this product is found to be 107 cc./gm., after shearing off the cotton layer. The softness and drape of this blanket can be further improved by scouring in hot aqueous detergent solution.

EXAMPLE II

The preceding Example is repeated with several variations. The two pile layers are porous ⅛-inch thick self-supporting slices of a fibrous block formed of a partially hydrolyzed polyvinyl acetate binder and a carded batt of 1½ inch long, alinged, zig-zag crimped staple fibers, 3 d.p.f., of polyhexamethylene adipamide. The fiber density and binder density of the block, respectively, are 7.05 $lbs./ft.^3$ and 2.66 $lbs./ft.^3$. One face of each of the pile layers is adhered to an open marquisette nylon fabric by means of chloroprene rubber adhesive. Upon washing the fabric in water to remove the binder composition, a double-faced blanket-like structure is obtained. The fiber adhesion is quite good as there is virtually no tendency of fibers to shift or shed.

EXAMPLE III

Crimped staple fibers of polyethylene terephthalate polymer consisting of a blend of 60 parts of 4 denier per filament, 2 inch long staple fibers having a three-dimensional curvilinear crimp and 40 parts of 1.5 denier per filament, 1.5 inch long staple fibers having a stuffer box type of crimp are carded to form a 160 grain/yd. sliver. Lengths of this sliver are assembled in side-by-side relationship to form a batt 40 inches wide x 96 inches long x 12 inches thick with the fibers generally aligned along the length of the batt. The batt is cut at 90° transverse to the direction of the fibers into sections 40 inches wide x 10 inches long x 12 inches thick. A number of these sections are assembled with their 40 inch x 10 inch faces adjacent to one another and the assembly compressed to a density of about 0.9 $lbs./ft.^3$ within a perforated metal mold 40 inches wide x 48 inches long x 10 inches deep so that the fibers are generally directed towards the 40 inch x 48 inch faces of the mold. The mold is immersed into a 4% by weight binder solution in trichloroethylene solvent of a heat curable polyurethane formed of 2,4-toluene diisocyanate and polyester of ethylene glycol and adipic acid, then removed and excess binder solution allowed to drain. The assembly is heated at 240° F. for 1 hour to volatilize the solvent and cure the polyurethane resin. The bonded fiber assembly is removed from the mold and found to have a fiber density of 0.90 $lbs./ft.^3$ and a binder content of 7.6% based on the weight of the fiber. The bonded fiber assembly is sliced with a horizontal band knife as in Example I to provide flexible, self-supporting bonded sheets 5⁄32-inch thick.

One face of each of two of these sheets is sprayed with an adhesive solution consisting of the following ingredients:

	Grams
Reaction product of a 1.6:1.0 molar ratio of 2,4-toluene diisocyanate and polytetramethylene ether glycol (M.W.=1000)	100
Acetone	100
Particulate silica (anhydrous colloidal)	10

The adhesive is applied at a level of 1.2 $oz./yd.^2$ and to a depth of about 20% of the sheet thickness to give a discontinuous adhesive layer. The sprayed surfaces of the bonded fiber sheets are then placed against opposite faces of a 2.7 $oz./yd.^2$ cotton muslin fabric and held together under 0.15 p.s.i. pressure while being heated at 240° F. for .7 hour in ethylene diamine vapor to cure the adhesive to produce a discontinuous vapor permeable adhesive layer that adheres the bonded fiber wafers to the fabric. The double-faced pile fabric is then washed in a 4% caustic solution at 170° F. for 15 minutes, rinsed and tumble dried. There is obtained a soft, flexible double-faced fabric suitable for use as a blanket, the resultant double-faced fabric has good drape with a flexural rigidity value of 712 mg./cm.; a high air permeability, 268 $ft.^3/min./ft.^2$; and a high thickness to weight ratio, .034 $in./oz./yd.^2$. The pile layers have a high initial bulk, 69 $cm.^3/gram$. After 10 washes the pile fabric exhibits low surface distortion, low fuzzing, and has a thickness retention of 95%.

A particularly unique advantage of the bonded pile fabrics of this invention, having a combination of low pile fiber density, i.e., 0.3–3 pounds per cubic foot, and low pile height, i.e., 1⁄16-inch to ⅜-inch, is the fact that highly attractive styling effects can be achieved by providing a coloring agent in the adhesive zone which runs parallel to and adjacent each of the contiguous faces of the layers. Thus the coloring agent can be applied in such a manner as to be visible to the naked eye when viewed from the top of the pile, although no coloring or pigmentation is directly applied to the fibers in the pile layer. Products which have been styled in this way have a particularly pleasing appearance and yet offer substantial savings in fabrication costs while realizing a high degree of product uniformity.

One method of making such products having a so-called "see-through" effect is to employ a support fabric or interleaving layer which has been predyed a solid shade or else has been printed with a design or pattern prior to adherence to the bonded pile layers. Another suitable method involves incorporating inorganic or organic dyestuffs with the adhesive composition before the latter is used for purposes of laminating the bonded pile layers to each other or to the support fabric. Still another technique which can be used to achieve the "see-through" effect involves an after treatment of the laminated fabric as initially formed. For example, color may be applied to the laminated product by selectively dyeing the support fabric, the laminating adhesive, or the binder composition, either singly or in combination. More specifically, pastel shades may be obtained by dyeing the support fabric only, medium depth shades by dyeing the laminating adhesive and/or the binder composition, and darker shades by dyeing all three components. By dyeing the support fabric one color and the laminating adhesive and binder composition a contrasting color, novel color effects are obtained.

Referring to FIGURES 4 and 5 a plan view and front elevation view, respectively, of a preferred embodiment illustrating the "see-through" effect is seen. The non-woven fibrous pile layer 1 is bonded by adhesive composition 8 to a printed interleaving layer **11**. The printing is indicated by the dark solid lines **12**. In this embodiment the only coloring in the adhesive zone is in or on the interleaving layer **11** in the form of a printed pattern. In the front elevation view of FIGURE 5, no "see-through" effect is seen. However, in the plan view of FIGURE 4, the pattern printed on the interleaving layer **11** shows through the pile, as is indicated by the lighter solid lines **13**. In this illustration the coloring is added only to the interleaving layer and the "see-through" effect is obtained. In other embodiments, coloring may be added to the binder, the adhesive, the fiber and/or the interleaving layer.

Conventional dyeing and printing equipment may be employed, either batch-wise or continuously. Dyes for the support fabric are those conventionally used; namely direct, pad, or fiber-reactive dyes for cellulosic fibers; acid, disperse, or fiber-reactive dyes for polyamide fibers; disperse or cationic dyes for polyester or acrylic fibers. Acid and disperse dyes have an affinity for a wide range of adhesive compositions and binder compositions, but it will be obvious to those skilled in this art that the selection of a dye will depend on the chemical nature of the adhesive, binder, and type of fiber being dyed.

A typical procedure for making a pile fabric having a "see-through" effect by coloring the adhesive composition prior to laminating is described in Example IV.

EXAMPLE IV

A porous bonded fiber block is prepared following the general procedure given in Example III, from a blend of 60 parts of 4 denier per filament, 2 inch long staple polyethylene terephthalate fibers having the three-dimensional helical crimp described in Example I and 40 parts by weight of 1.5 denier per filament, 1.5 inch long staple polyethylene terephthalate fibers having a stuffer-box type (i.e., zig-zag) crimp. The fiber density of the block is 0.9 pound per cubic foot. The binder composition employed in making the bonded block is the same curable polyurethane resin as that described in Example III. The binder concentration in the final cured block is 8% on the weight of the fiber in the block, and the fiber density is 0.9 pound per cubic foot. Self-supporting wafers are sliced 5/32-inch thick from the block at an angle perpendicular to the two faces of the block containing the fiber ends. The laminating adhesive is prepared from the polyurethane composition described in Example III. To obtain a good dispersion of pigment in the adhesive, a colored premix is made by combining 70 parts of the polyether glycol urethane resin, 17.5 parts of acetone and 12.5 parts of "Monastral" Red B (gamma quinacridone) pigment. This combination is sand milled for 15 minutes to give a colored paste. Two parts of this paste are then mixed with 210 parts of the adhesive formulation of Example III, giving a final adhesive composition containing approximately 1% of coloring material. The colored adhesive is sprayed on one face of each of two of the sliced bonded fiber wafers so that there is approximately one ounce per square yard of adhesive picked up by each wafer. The two coated wafers are then laminated under slight pressure to either side of a woven cotton scrim fabric while being heated at 240° F. for 0.7 hour in ethylene diamine vapor to cure the adhesive.

The resulting double-faced blanket has a pleasing pink color when viewed from either pile surface, even though no coloring material has been added to the pile fibers. The blanket is also soft and luxurious to the feel. The shade of coloring can be varied depending upon the concentration of coloring material used in the adhesive; for example, the above adhesive composition may be made up containing coloring material varying from about 0.2 to 2% based on the total weight of adhesive composition. Also, it should be realized that the shade, at a given concentration of coloring material, will also be a function of the pile fiber density and the pile height. By using primary colors, any combination of shade may be obtained.

Aside from uses of the foregoing products as blanket structures, they are also well suited for use in power puffs, reversible polishing and buffing pads, washing, cleaning and dusting cloths, thermal insulation, filters, weather stripping and the like.

What is claimed is:

1. A breathable and drapable double-faced, pile fabric comprising a laminate of two superposed, non-woven, fibrous pile layers joined to a porous, fibrous, interleaving layer disposed between said pile layers at an interface, each of said pile layers being flexible and porous, having a fiber density of 0.3 to 8 pounds/ft.^{3}, and being composed of substantially parallelized, crimped, synthetic organic, polymeric fibers which are attached by a binder composition at a plurality of contact points throughout the three dimensions of each of the said pile layers, the density of fibers in each said pile layer exceeding the density of binder composition therein, the two faces of each of said pile layers being composed essentially of opposite ends of said fibers, said interface comprising a fiber end face of each of said pile layers in direct contact with the said interleaving layer and being secured thereto by a non-fugitive adhesive composition dispersed in a discontinuous manner within a zone running parallel to and adjacent to each of said fiber end faces and acting to bond fibers of said pile layers to said interleaving layer at a plurality of contact points.

2. The fabric of claim **1** wherein said zone has a thickness no greater than 25% of the thickness of said fabric and has a density of adhesive composition therein greater than the fiber density of either layer.

3. The fabric of claim **1** wherein said fiber density is 0.5 to 3.0 pounds/ft.^{3} and wherein said binder composition density is 1 to 75% of said fiber density.

4. The fabric of claim **3** wherein said binder composition density is 1 to 30% of said fiber density.

5. The fabric of claim **1** wherein the said fibers have a denier of 1 to 25.

6. The fabric of claim **1** wherein the said adhesive composition is a thermoset polymer.

7. The fabric of claim **1** wherein the said adhesive composition is an elastomeric polyalkyleneether polyurethane.

8. The fabric of claim **1** wherein a coloring agent is provided in said zone.

9. The fabric of claim **8** wherein said fiber density is 0.3–3 pounds per cubic foot, and the height of each of said pile layers is less than 3/8-inch.

10. The fabric of claim **8** wherein said coloring agent is provided in said adhesive composition.

11. The fabric of claim **8** wherein said coloring agent is provided in said interleaving layer.

12. The fabric of claim **1** wherein a coloring agent is provided in said binder composition.

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