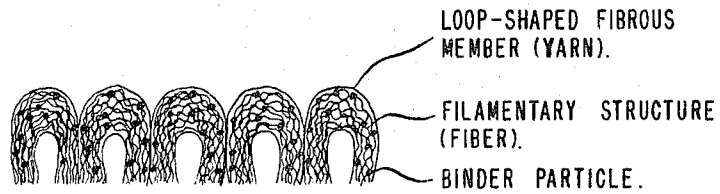
Sept. 6, 1966 C. R. KOLLER 3,271,216

PRODUCTION OF LOOP PILE TEXTILES

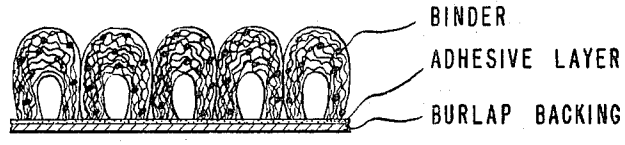
Filed Jan. 22, 1963

FIG. 1



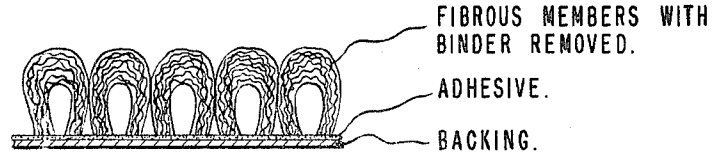
BONDED SELF-SUPPORTING SHEET

FIG. 2



BACKED ARTICLE WITH BINDER

FIG. 3



BACKED ARTICLE WITH BINDER REMOVED

INVENTOR
CHARLES RICHARD KOLLER

BY Donald A. Hoes

ATTORNEY

United States Patent Office

3,271,216

Patented Sept. 6, 1966

3,271,216

PRODUCTION OF LOOP PILE TEXTILES

Charles Richard Koller, Wilmington, Del., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

Filed Jan. 22, 1963, Ser. No. 253,186
3 Claims. (Cl. 156—72)

This invention relates to loop pile textiles and to processes for the manufacture thereof.

An object of this invention is to provide both self-supporting sheets as well as backed articles having a loop pile configuration in at least one face, whereby the sheets and backed articles exhibit a combination of improved properties over existing pile structures and, in addition, provide a range of different aesthetics not possible in pile structures wherein the surface is defined solely by cut filament ends. A further object includes novel processes for the manufacture of said loop pile self-supporting sheets and backed articles. More specifically it is an object of this invention to provide novel pile fabrics having better tuft adhesion, as well as less "grinning." Other objects will be apparent from the description of the invention given below.

This application is a continuation-in-part of U.S. application, Serial No. 787,662 filed January 19, 1959, now U.S. Patent No. 3,085,922.

This invention provides a porous self-supporting sheet material having two opposing faces and comprising a multitude of loop-shaped fibrous members. Each of the fibrous members is in turn composed of a plurality of filamentary structures or fibers which are aligned generally in the same direction throughout the member and which overlap and are interconnected at a plurality of spaced points throughout the three dimensions of the sheet material. One of the opposing faces is defined by a series of pairs of cut ends of the loop-shaped fibrous members, that is, for each fibrous member both of the cut ends will serve to define that face. The other opposing face is defined by a plurality of the closed curved portions of the loop-shaped fibrous members. The sheet material is further characterized as having a fiber density below about 25 lbs./ft.^{3}. In a preferred embodiment, the porous self-supporting sheet material will have at least 65% by weight of the filamentary structures extending from one cut end of the loop-shaped fibrous member to the other cut end. The invention also provides a textile article such as a pile fabric comprising a backing layer and a pile layer, the pile layer constituting a porous self-supporting sheet material as described above. In this case the loops will be exposed and upstanding such that the cut ends of the fibrous members will be attached to the backing. The invention also provides such backed pile layers from which the interconnections have been removed.

According to the process of the invention, the foregoing materials are prepared by first providing one or more fibrous bundles each composed of a plurality of contorted filamentary structures which are overlapping and intercontacting throughout the three dimensions of the bundle. The filamentary structures also are aligned generally in the same direction throughout the bundle. Thereafter the bundles are pleated in sinusoidal configuration to provide a body having a fiber density below 25 lbs./ft.^{3}, wherein filamentary structures of adjacent pleats of the bundles overlap one another, and wherein the body has two opposing faces defined by closed curved portions of the bundles. At least a major proportion of the filamentary structures are then interconnected at a plurality of spaced points along their lengths throughout the three dimensions of said body while maintained in sinusoidal configuration, and finally the body is sectioned in a plane

intermediate the two opposing faces. Preferably the body will be so sectioned or sliced as to provide two substantially equal halves, e.g. by a median planar slice parallel to both opposing faces of the body. Both resulting sheet materials will thus be of nearly equal dimension and will have one face defined by the closed loops of fibrous members, i.e. portions of the sectioned bundles, and the other face defined by cut filament ends.

As indicated the fibrous bundles to be pleated, interconnected and sectioned in accordance with this invention are composed of filamentary structures or fibers which are aligned generally in the same direction throughout the bundle. Similarly the resulting sheet material will be composed of fibrous members or severed sections of the bundles which also are aligned generally in the same direction throughout the member. In either case "aligned" refers to the characteristic that although the filamentary structures have a contorted configuration between their ends and are curved in a loop, many nevertheless extend from one cut end of the fibrous bundle or member to the other cut end. In the case of a sheet material, at least 65% by number of the filaments should extend from one cut end to the other.

If the fibrous members or bundles are so severed to remove the loop configuration, at least 65% by number of the filamentary structures therein are aligned generally in a direction between about 20° and about 90° transverse to at least one of the two resulting faces but preferably in the same direction. To ascertain if the filamentary structures of any fibrous bundle or member are aligned generally in the same direction therein, it is helpful to visualize that the bundle or member has been so severed to remove the loop and that all portions of individual filamentary structures are circumscribed by an imaginary cylinder, the filamentary structure ends terminating in the bases of the cylinder. The individual filaments may be said to have a direction corresponding to the direction of the axis of the cylinder. The filamentary structures then can be said to be aligned generally in the same direction when the axes of the circumscribing cylinders are aligned generally in the same direction.

The textile articles of this invention are useful per se in the form of self-supporting sheet material or they may be further processed by attaching the face of the sheet material containing the cut filament ends to a backing layer. After applying a backing any binder composition employed in the pile layer to interconnect the filamentary members may be left in the final textile article or may be removed, depending upon the use intended and the properties desired in the final article.

The invention will be further described in the accompanying drawings. FIGURE 1 illustrates the self-supporting sheet material of this invention. FIGURE 2 illustrates the backed article of this invention with the binder still present in the pile layer. FIGURE 3 illustrates the backed article of this invention after removal of binder from the pile layer.

A preferred method for preparing the novel sheet material illustrated in FIGURE 1 involves first assembling at least one, preferably several, groups of highly crimped continuous filaments wherein the individual filaments are aligned in the same direction and wherein they overlap one another in the fibrous bundle. The bundles are assembled in a mold having two open faces and which is further provided with a series of bars for pleating. Each of the fibrous bundles is pleated by passing over and under the bars to form a series of sinusoidal configurations. Thus each bundle will form a repeating S shaped pattern or meandering path, the closed curved loops of which define opposite surfaces. The portions of such bundles between the loops are adjacent one an-

other in substantially parallel arrangement with fibers of one portion overlapping and contacting fibers of another portion. The bundles are thus arranged so that the closed loops point to the open faces of the mold, each bundle being pleated behind the next succeeding bundle in the mold. The bars are arranged so that the pleats may be held mechanically during application of a binder. After closing the mold, the assembly of pleated fibrous bundles is impregnated by filling the mold with liquid binder composition through an entry pipe. The mold is then drained of excess binder from the fibrous assembly through an exit pipe while maintaining the pleated configuration. The mold is then heated to drive off excess liquid and solidify the binder at a plurality of spaced points along the lengths of the filaments. After bonding the filaments together to provide interconnections of binder composition the sides of the mold and the pleating bars are removed to leave an assembly of bonded pleated filaments. A knife or other cutting means is then used to slice approximately half way between the two faces of the bonded filamentary assembly, essentially in a plane parallel to the two faces and transversely to the filaments. As a result two self-supporting sheets are produced, each sheet being characterized by having one face defined by each of the cut ends of fibrous members, sectioned portions of the bundle, and the other face being defined by closed loops of the fibrous members. These sheets are self-supporting by virtue of the fact that the pleated filaments constituting the fibrous members are interconnected at a series of spaced points with sufficient binder to prevent the filaments from falling out of the sheet when the sheet is handled, processed or bent around a mandrel. Then, if desired, the sheet material may be attached to a backing such as a layer of burlap fabric by placing a layer of suitable adhesive on one face of the backing and pressing the face of the sheet containing the cut filament ends into the adhesive, forming a backed textile article, the pile surface of which is composed of closed filament loops.

In a preferred embodiment the fibrous members whose ends define one face of the self-supporting sheet material of this invention are upstanding in relation to that face such that the portion of the members adjacent the cut ends intersects the face at an angle of at least 30° and usually of at least 50°.

An alternative process may be employed in which the fibrous bundles are partially bonded and/or stiffened with binder prior to pleating. After pleating the pleating bars, or slots, can be removed and the assembly retains its pleated arrangement because of its stiffness. This pleated assembly may then be further impregnated with binder to obtain a more completely bonded pleated assembly. The dimensions of the fibrous bundles are not critical so long as the length is adequate to permit the formation of a series of pleats. In cross section the bundle may be circular, oval, rectangular, etc. For certain purposes a single wide bundle may be employed to produce a sheet material of suitable surface area although the use of a plurality of bundles is preferred. For most applications a sheet material having a pile height below 2 inches will be adequate.

A full description of the filamentary materials employed in accordance with this invention for the production of styled pile fabrics is set forth in the above mentioned Koller U.S. application, Serial No. 787,662. These materials are of a porous character and have a plurality of contorted, e.g. crimped, filamentary structures which overlap, are aligned generally in the same direction, are intercontacting or interconnected throughout the three dimensions of the material and the material has a fiber density below 25 lbs./ft.^{3}, preferably below 8 lbs./ft.^{3}. 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 "contorted" it is meant that the profile (i.e. side elevation) of an individual filament is irregular (i.e. not straight) when the filament is viewed from at least one side. In addition to being contorted, it is necessary that such filamentary structures overlap adjacent structures throughout the three dimensions of the article. By the term "overlap" is meant that in at least one view a filamentary structure crosses over, with or without touching or attachments, an adjacent filamentary structure. Furthermore, it is critical to such structures that the contortion and overlapping of the filamentary structures do coact or are allowed to coact with one another. By "coact" is meant that the contortion and relative placement of the filamentary structures are such that they assist one another in producing and maintaining the claimed structures both with respect to the general alignment of the filamentary structures and their spacing with respect to each other to achieve the desirable densities contemplated.

The initial fibrous bundles 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. The above procedure may then be followed to prepare the pleated arrangement of such bundles for use in this invention.

In preparing a fibrous bundle of contorted fibers a wide variety of 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(meta-phenylene isophthalamide), poly(hexamethylene sebacamide), polycaproamide, copolyamides 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 acids, ethylene glycol with a 98/2 mixture of terephthalic/5-(sodium sulfo)-isophthalic acids, and trans-p-hexahydroxylylene glycol with terephthalic acid, self-elongating ethyleneterephthalate polymers, 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, polytrifluorochloroethylenes), 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 the 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, regenerated cellulose, cotton, wool, glass, metal, ceramic and the like. Blends of two or more synthetic or natural fibers may be used as well as blends of synthetic and natural. Other fibers such as silk, animal fibers such as mohair, angora, vicuna are also suitable.

The self-supporting material 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 monofilaments, 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 may be either crimped or uncrimped, bulked or unbulked, drawn or undrawn or twisted or untwisted. The denier of the filaments is not critical and may vary from about 0.5 to about 50 denier or even higher.

The use of a binder is preferred to interconnect the filamentary structures at a plurality of points along their length. Depending upon the use desired, these may be either soluble or insoluble, and may be either thermoplastic in nature or may be thermosetting for subsequent reaction with a curing agent to form a cured polymer. By "binder" is meant the additional material used to attach the filaments to each other. Normally these materials will be used in an amount of at least about 0.5% by weight based on the filamentary structures. If it is desired to remove the binder after attaching to a backing to the traversely sliced sheet material 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 dispersions or emulsion or in the form of a solution, vinyl acetate polymers and copolymers, acrylic polymers and copolymers such as 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 include polytetrafluoroethylene and ureaformaldehyde resin latices.

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 diepoxide of 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 poymers, such as spandex polymers, polyether amides, polyether urethanes (e.g. those in U.S. 2,929,800) and polyester/urethanes are also suitable.

The adhesives which may be used when applying the backing are varied. By "adhesive" or "glue" is meant the material used to cause the filamentary structures and sheet materials to adhere to the backing or is meant the material used to constitute the backing. Illustrative adhesives are: chloroprene rubber, elastomeric foams and sponges, butadiene-styrene rubber, polyvinyl chloride resin (e.g. those in combination with either a polymeric plasticizer or a monomeric plasticizer curable after application of the adhesive), polyurethane resins, polyamide copolymer of hexamethylene diamine and adipic and sebacic acids, casein resin, and epoxy resins such as the diepoxide of 2,2-bis(parahydroxyphenyl)propane. Illustrative backings are: woven fabrics such as burlap, canvas, and nylon scrim fabrics, knit fabrics such as nylon tricot, nonwoven fabrics such as polyethylene or polypropylene fiber webs, resin bonded polyethylene terephthalate fiber webs, papers of cellulosic and/or synthetic fibers, paper felts such as asphalt impregnated cellulose, elastomeric foams and sponges, plastic films such as from polyethylene terephthalate, polypropylene and polyvinyl chloride polymers, metal foils and rigid sheets such as fiber glass reinforced polyester resins, metals, ceramics and wood, elastic, stretchable or shrinkable fabrics and films, and the like.

The pile fiber density or simply "fiber density" reported in pounds per cubic foot is a measure of the density of the fibers in the pile layer of the specimen from which the binder has been removed, or in other words the density of the shearable fiber above the adhesive line. The pile fiber density is calculated by dividing the pile weight of the fibers in the pile layer by the volume these fibers occupy. This volume is determined by multiplying the average width by the average length of the conditioned specimen by the pile height of the sheared fibers, and then applying suitable conversion factors to obtain the volume in units of cubic feet.

One advantage of this invention is that it provides textile articles such as pile fabrics having for some purposes superior aesthetics in comparison with previously known pile fabrics having a cut pile surface. Thus the pile fabrics described herein provide more luxuriousness and flexibility of styling when prepared in the form of carpets. The textile articles of this invention also have superior compressional properties than those made by weaving and tufting. In addition, pile fabrics described herein possess better tuft adhesion than conventional loop pile fabrics in that no chain reaction occurs on pulling out one loop as in a conventional woven or tufted loop pile carpet. Still further, the pile fabrics described herein exhibit less "grinning" and better cover than conventional loop pile carpets when bent over a curved surface such as a stair.

The self-supporting sheets and textile articles of this invention are useful in the form of floor coverings, such as carpets and tiles, upholstery fabrics, furs and fleeces, garment interliners, cushions and mattresses, pile fabrics, fibrous laminated structures, sponges, dust mops, air and dust filters, cleaning cloths, railroad car journal box lubricator pads and the like.

The following examples illustrate specific embodiments of this invention but are not intended to limit the scope of the invention.

Example I

The filaments used are in the form of continuous filament polyhexamethylene adipamide yarns (3700 denier, 204 filaments, 0.5 Z twist and trilobal cross section). These yarns are first bulked with steam under the condition disclosed in Example 2, Table III of Belgian Patent 573,230. Approximately 42 ends of this bulked yarn are aligned together in the same direction to form a warp or bundle about 5 inches wide which is sprayed with a 10% by weight solution of a polyamide binder in a 80/20 alcohol/water mixture by volume. This polyamide binder is an alcohol soluble terpolymer formed by condensing together caprolactam, hexamethylene diamine, adipic acid and sebacic acid such that there are substantially equal proportions of polycaproamide, polyhexamethylene adipamide and polyhexamethylene sebacamide in the terpolymer. The sprayed yarn warp is allowed to air dry to harden the binder and bond the yarns together. This warp of yarns is then pleated back and forth over 2-inch wide metal slats to form a pleated assembly of yarns 5" wide x 14" long x 2" thick with the loops of yarns in the top and bottom faces (5" x 14" face). The metal slats are removed from between the pleats by pulling them out from the side of the pleated assembly which is sufficiently stiff to maintain its pleated arrangement.

This assembly is placed in a perforated metal mold and immersed in a 5% solution of the above described polyamide terpolymer binder in alcohol/water (80/20 by vol.). The mold is removed, excess binder solution allowed to drain and the assembly heated at 120° C. to harden the binder. The mold is removed and there is obtained a bonded pleated fiber assembly having a fiber density of about 4.5 lbs./ft.^{3} and binder content of 7% on the weight of the fiber.

This assembly is sliced transversely to the fiber direction with a horizontal band knife slicer in a plane parallel with the top and bottom pleated surfaces (5" x 14" faces). There are obtained two porous self-supporting sheets of bonded fibers with one face consisting of cut ends of yarns and the opposite face consisting of yarn loops. This sheet can be wrapped with its cut face around a small diameter mandrel without splitting or loss of fiber. The porous self-supporting sheet is useful as a scrubbing pad.

Example II

A porous self-supporting bonded fiber sheet approximately 4" wide x 14" long x ¾" thick prepared as described in Example I is attached to a backing fabric by embedding the face of the sliced sheet consisting of cut ends of yarn in a layer of rubber adhesive coated onto one face of a burlap fabric. This assembly is held together under light pressure while being heated at 82.2° C. to harden the adhesive and bond the cut ends of the yarns to the burlap backing. This backed structure is then washed in a solvent of 80 parts alcohol and 20 parts by volume of water to dissolve and remove the terpolymer binder. After drying there is obtained a soft loop pile carpet sample having an attractive loop pile surface, excellent coverage of the backing and good compressional properties. The cut ends of the yarn loops are strongly bonded to the backing fabric.

What is claimed is:

1. Method for the production of a porous self-supporting sheet material comprising

(a) providing one or more fibrous bundles each composed of a plurality of contorted filamentary structures which are overlapping and intercontacting throughout the three dimensions of the bundle, said filamentary structures being aligned generally in the same direction throughout the bundle,

(b) pleating said bundles in siusoidal configuration to provide a body having a fiber density below 25 lbs./ft.^{3}, wherein filamentary structures of adjacent pleats of the bundles overlap one another, and wherein said body has two opposing faces defined by closed curved portions of said bundles,

(c) interconnecting at least a major proportion of said filamentary structures at a plurality of spaced points along their lengths throughout the three dimensions of said body while maintained in sinusoidal configuration, and

(d) sectioning the body in a plane intermediate said two opposing faces.

2. Method according to claim **1** wherein the interconnecting of said filamentary structures is effected by means of a binder composition.

3. Method according to claim **2** wherein said binder composition is provided in an amount of at least about 0.5% based on the weight of said filamentary structures.

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EARL M. BERGERT, *Primary Examiner.*

HAROLD ANSHER, *Examiner.*