Aug. 1, 1967 C. R. KOLLER 3,334,006

BONDED PILE ARTICLE AND PROCESS FOR THE PRODUCTION THEREOF

Filed Jan. 22, 1963

FIG. 1a

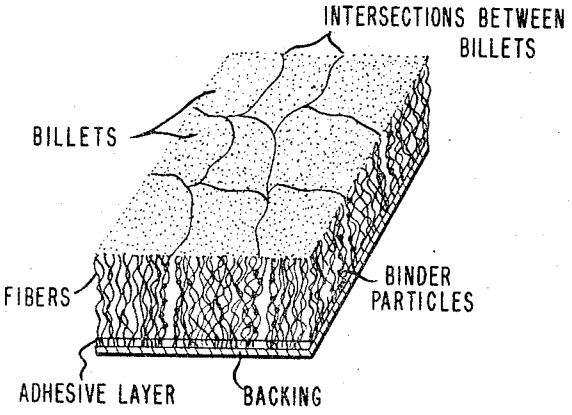


FIG. 1b

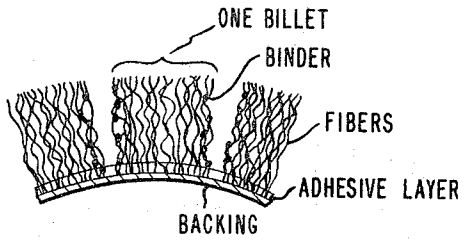


FIG. 2a

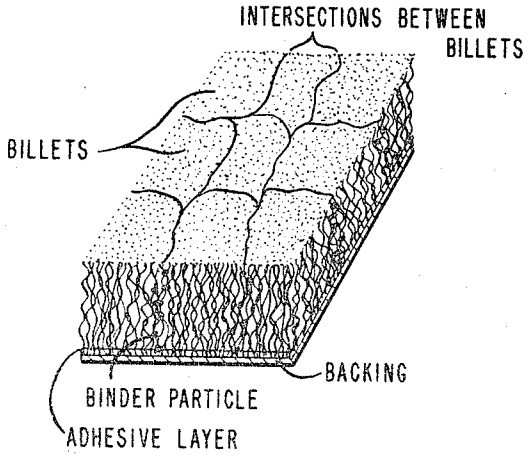
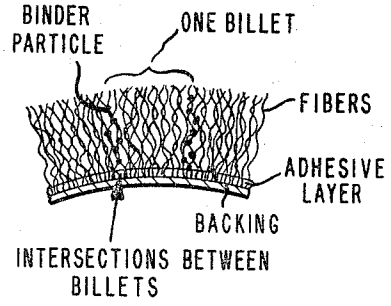


FIG. 2b



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BONDED PILE ARTICLE AND PROCESS FOR THE PRODUCTION THEREOF

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8 Claims. (Cl. 161—62)

This invention relates to textile articles and to processes for the manufacture of same.

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

This invention relates generally to the type of textile articles disclosed in the foregoing applications but is a further improvement for certain purposes in that the resultant textiles have less diaphragm action under compressional loads, more drape, better wiping and scrubbing action, as well as other property advantages.

It is an object of this invention to provide a group of textile articles having a combination of improved drape and superior scrubbing action in comparison with products heretofore available. Another object is to provide processes for making these textile articles. Further objects include the manufacture of pile fabrics such as floor coverings, blankets, furs and fleeces having superior aesthetics. Other objects will be apparent from the description of the invention given below.

According to the invention there is provided a pile article comprising a backing having attached to at least one surface thereof a face of a porous pile layer having two opposite faces, each being defined by the ends of a plurality of contorted filamentary structures. These filamentary structures are so arranged as to overlap while being aligned generally in the same direction to form a pile having a fiber density below 25 lbs./ft.^{3}, preferably below 8 lbs./ft.^{3}. The pile further constitutes a network wherein at least a major proportion of the filamentary structures contact each other throughout the three dimensions of the pile. The unique pile structure of the invention is characterized by having isolated volumes of the pile extending throughout the pile thickness which are substantially free of interconnections between the filamentary structures thereof, i.e. in those areas the fibers simply contact one another without being bonded along their lengths. These volumes are however each bounded in the thickness dimension of the pile by surrounding volumes wherein the filamentary structures are interconnecting by means of discontinuous point bonds.

It will be apparent that the textile articles of this invention will have a non-homogeneous pile layer in that there will be isolated areas having no interconnections between the filamentary structures with these each being bounded by areas provided with interconnections. In a preferred embodiment, the interconnections between the filamentary structures are created by small amounts of binder composition applied to bond two or more fibers together at points. Also the attachment of ends of the filamentary structures to the backing layer is desirably achieved by applying an adhesive composition to the fiber ends, to the backing, or both in order to firmly secure the filamentary structures to the backing to provide a unitary textile article which will not lose fibers in use.

According to the invention the foregoing pile fabrics are produced by a series of steps wherein first a group of filamentary structures are aligned generally in the same direction such that they are overlapping and intercontacting throughout the three dimensions of the group. The outer filamentary structures of the group are then interconnected to one another at a plurality of spaced

points to form a unitary bonded bundle having an interior volume of non-interconnected filamentary structures. These bundles, or billets as they will also be called, are unitary in that the bonds are sufficient to keep the entire structure from falling apart. A block is then formed by assembling a plurality of the bundles in parallel contacting arrangement such that the filamentary structures of each are aligned generally in the same direction. Desirably the block will have a fiber density below about 25 lbs./ft.^{3}. Subsequently the block is sliced in a plane transversely to the direction of filament alignment to provide a face of cut filament ends and this is then adhered to a backing. Thereafter the backed block can be sliced in a plane parallel to the first slice to provide a pile of desired thickness.

The textile articles of this invention can differ somewhat depending upon whether the billets attached to a backing are interconnected to one another along their lengths. The differences will be further illustrated in the drawings. It is to be understood that conections between the filamentary structures of each billet and, where provided, between the filamentary structures of adjacent billets, are preferably in the form of small globules of binder composition, but can also be in the form of point bonds between adjacent filaments resulting from softening or partial fusion of the filaments without the application of any foreign binder composition.

One form of textile article illustrated in FIGURES 1*a* and 1*b* is an assembly of groups of filaments adhered to a backing in which there are no interconnections or bonds between adjacent fibers in whole isolated areas throughout the article, but in which there are interconnections or bonds between a few adjacent filaments or a very narrow channel of adjacent bonded filaments surrounding each localized area of unbonded filaments. This type of bonding is in the form of what might be termed narrow channels or shells of filaments which have been bonded together discontinuously at a plurality of points along their lengths, each shell surrounding whole isolated groups of contorted and overlapping filamentary members aligned in the same direction. The shell filaments run the full length from exposed face to backing.

The second form of textile article which is illustrated in FIGURES 2*a* and 2*b* resembles closely the structure shown in FIGURES 1*a* and 1*b*. It differs simply in that the interfaces of adjacent shells have been further bonded to one another by interconnections between filaments of adjacent shells. In other words, the differences between the structure shown in FIGURES 1*a* and 1*b* and the structure shown in FIGURES 2*a* and 2*b* are differences occurring where the interface of two adjacent bonded shells meet. FIGURES 1*a* and 1*b* shows the structure to have shells which touch each other, but are not bonded to each other; whereas FIGURES 2*a* and 2*b* shows structures in which shells not only touch each other but are also bonded to each other by point bonds.

One suitable process for preparing the textile article illustrated in FIGURES 1*a* and 1*b* comprises first assembling a group or "billet" of contorted filaments aligned in the same general direction and such that the filaments are overlapping. A suitable binder is applied to the assembly of filaments while held together, e.g., in a mold, such that the outer surface of the billet is coated or impregnated, without allowing the binder to penetrate the thickness of the billet. This can be achieved by spraying the billet with a liquid binder or solution or dispersion of a solid binder. The binder is then set to attach adjacent fibers together which are on the outside of the billet. The binder can be applied uniformly to the whole outer surface of the billet, or non-uniformly to selected areas of the outer surface of the billet, but in either case the binder

is applied discontinuously along the length of the fibers in such proportions that the bonded billet can be handled and assembled with similar billets in the next step of the operation without any loss of fibers from the billet. Several billets are then laid up with the filament direction and parallel to each other by placing the billets side-by-side in a mold. A slight compression may be given to the assembly of billets in the mold, but there is no attachment by binder between the interfaces of the billets. A leveling slice is then made with a knife or other suitable cutting means across one face of the mold assembly of billets. This molded assembly of billets will hereafter be referred to as a "block." This leveling slice provides a uniform surface of fiber ends defining one face of the block. The leveling slice is discarded. Then a suitable adhesive is applied to the fiber ends or to one face of a backing, or both, and the backing is applied with slight pressure to the face of cut fiber ends. Then another slice is made through the block equal to the desired pile height in the final article, such slice being made transversely to the direction of alignment of the filaments in the block. This results in the textile article illustrated in FIGURE 1*a*.

The article illustrated in FIGURE 2*a* can be prepared readily by carrying out an additional step in the process described above. This additional step involves bonding together the interfaces between the billets, preferably at the stage when they are assembled in the mold. This bonding together of the billet interfaces may be accomplished by raising the temperature of the whole block just sufficiently to soften the binder in the outer surface of each billet, if the binder has been selected which has a suitably low softening point for accomplishing this. Alternatively, two or more binders of different softening points may be selected for different billets being assembled in the same mold, so that only a certain portion of the billets will be bonded together at their interfaces.

A full description of the filamentary materials employed in accordance with this invention for the production of pile fabrics is set forth in the above-mentioned Koller U.S. application, Ser. 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}. 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 filament groups 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.

In preparing a filament group 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-hexahydroxylene 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 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 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 fibrous groups 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 bond the billet of fibers together at the exterior of the bundle. 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 filament 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 a series of billets 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, butadieneacrylonitrile copolymers), which may be used in the form of latex dispersions or emulsions or in the form of 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 ethyl-

ene 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 polytetrafluroethylene 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 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 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, butadienestyrene 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 shinkable 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.

The primary advantage afforded by this invention resides in the provision of textile articles such as pile fabrics having less diaphragm action under compressive loads than similar textile articles heretofore known. By less diaphragming action is meant that upon application of an isolated compressional force to the pile surface of the textile article, the force is taken up in a localized area of the pile surface rather than distributed throughout the whole area of the pile surface of the article. As a result greater comfort and a softer more cushion-like feel are afforded when an individual steps on a carpet or sleeps on a mattress or cushion made of the textile material of this invention. In addition, these new articles have greater fabric drape due to the discontinuous bonding in the directions parallel to the backing compared with similar fabrics made from filaments which are bonded uniformly throughout the three dimensions of the pile. This is exhibited as a definite improvement in the aesthetics of apparel fabrics. The textile articles of this invention also have better wiping and scrubbing action due to the discontinuous nature of the bonding, which is exhibited when they are used as sponges, wiping cloths, door mats or dusters. Also, these articles pick up more soil than the articles bonded uniformly throughout the three dimensions of the pile, which is an advantage in certain types of fabrics designed to remove soil from other surfaces.

The textile articles of this invention are useful in the form of floor coverings such as carpets, tiles, upholstery fabrics, furs and fleeces, cushions and mattresses, cleaning fabrics such as dusters and wiping cloths, sponges, air and dust filters, single and double faced blankets, suedes, leather replacements for shoe uppers, paint roller covers, powder puffs, and the like. The products of the invention are also susceptible to other uses, for example those disclosed in Banigan et al., U.S. Patent No. 2,295,823.

The following examples illustrate specific embodiments of this invention but are not intended to limit the scope of the invention. All parts are by weight unless otherwise specified.

Example I

Steam crimped continuous filament nylon yarn (3700 denier, 204 filaments) made in accordance with Belgium Patent 573,230, is formed into bundles of 90 ends of yarn, 1 meter long with all the yarns aligned in the same direction. The yarns on the outer surface of the bundles are sprayed with a binder composition consisting of 10 parts of an isocyanate terminated polyurethane formed from meta-toluene diisocyanate and polytetramethylene ether glycol, 10 parts acetone and 1 part finely divided silica. The yarn bundles are hung from one end in an oven at 250° F. for 30 minutes in the presence of ethylene diamine vapor to cure the binder. The yarns in only the outer surface of the bundle are bonded together to give a self-supporting billet having a total binder content of 11% based on the fiber weight. These billets are cut transversely to the direction of the yarns into 5-inch long sections. A number of these billets are assembled side-by-side in an open face mold 8.75" long x 5" wide x 5" deep so that the yarns are all aligned in the same direction with the yarn ends directed toward the open top and bottom faces of the mold (8.75" x 5" faces). The yarn billets have been compressed together laterally so as to provide a fiber density of 2.9 lbs./ft.^{3}. This fiber assembly is forced out of the top of the mold a distance of about ¼" by applying a force on a plate against the ends of the yarns in the bottom face. The extruded fiber assembly is sliced with a horizontal band knife slicer transversely to the yarns in a plane parallel with the top of the mold to provide a uniform face of cut fiber ends.

A piece of burlap fabric with a .020 inch thick layer of polyurethane adhesive coated on one face is placed against the cut fiber ends so as to embed the fiber ends in the adhesive. The burlap is held against the fiber ends with light pressure and the assembly heated at 250° F. for 1 hour to cure the adhesive. The fiber assembly is then extruded about ½" out the top of the mold as above and sliced transversely to the direction of the fibers in a plane parallel with the top of the mold and ⅜" from the burlap fabric. The layer sliced off is a pile fabric con-

sisting of ⅜ inch high pile yarns upstanding from and attached to a burlap backing. This soft, resilient pile fabric is suitable for use as a carpet and exhibits excellent compressional properties.

Example II

A bicomponent polyacrylonitrile filament is employed having the structure and crimp characteristics described by Taylor U.S. Patent 3,038,237, issued June 12, 1962. A continuous filament yarn is prepared from these bicomponent filaments such that the yarn has a denier of 1800 and is composed of 120 filaments. The multifilament yarn is opened by passing the yarn through a forwarding jet together with steam at 257.3° C. and 50 p.s.i. steam pressure. The yarn is passed through the jet at 60% overfeed, and the opened yarn is collected on a moving surface followed by cooling in a relaxed state to develop the major portion of the crimp. The resulting crimp yarn has a denier of about 2900. Approximately 100 of these yarns are aligned together in the same direction in the form of a bundle about 30″ long. The outer surface of each bundle of yarn is sprayed with a 25% by weight aqueous solution of polyacrylic acid binder, and then allowed to air dry to harden the binder. The yarns in only the outer layers of each bundle are thereby bonded together giving a self-supporting billet having a total binder content of 85%, based on the total weight of yarn in the billet. The distribution of binder in each billet is such that there is no binder between filaments in the center portion of the billet, i.e., the yarns in the outer periphery of each billet contain 2–3 times the concentration of binder above that for the average concentration of binder in the whole billet. Each billet is cut transversely to the direction of the filaments into billet sections 5″ long. A number of these billet sections are placed side-by-side in an open-faced mold measuring 5½″ wide x 9″ long x 5″ deep, so that the yarns are all aligned in the same direction with the yarn ends directed toward the open top and bottom faces of the mold (5½″ x 9″ faces). This assembly, having a fiber density of 2.8 lbs./ft.^{3}, is pushed out of the top of the mold a distance of about ½″ by applying a force on a plate against the ends of the yarns in the bottom of the mold.

The extruded portion of the fiber assembly is then sliced transversely to the fiber direction in a plane parallel with the top of the mold to provide a uniform face of fiber ends. These fiber ends are embedded in a layer of rubber adhesive coated onto one side of burlap fabric and the adhesive is then allowed to harden. The fiber assembly is extruded another ½″ out of the top of the mold as above and is sliced transversely to the direction of the fibers in a plane parallel with the top of the mold and ½″ from the burlap backing fabric.

The layer sliced off consists of an assembly of pile yarns about ½″ long with the ends in one face attached to the burlap backing. This carpet is schematically illustrated in FIGURES 1*a* and 1*b*. The polyacrylic acid binder was removed from the pile layer by washing with water to produce a polyacrylonitrile pile carpet. This carpet had a soft textured surface and exhibited good compressional properties.

Example III

Billets having a polyacrylic acid binder on their outer surfaces are made from polyacrylonitrile yarns and assembled in a mold, as in Example II. Steam is passed through the mold from bottom to top to soften the binder. Then hot air (93.3° C.) is passed through the filament assembly to harden the binder and cause the billets to become firmly attached together along their touching sides. The filament assembly is extruded out of the top of the mold, sliced, the filament ends attached with a rubber adhesive to a burlap backing, and a backed pile structure sliced off, all as in Example II. After removal of the polyacrylic acid binder, there is obtained a soft pile carpet, which is schematically illustrated in FIGURES 2*a* and 2*b*. When this carpet is bent over a stair tread, there is no tendency for the pile to "grin" or open up.

What is claimed is:

1. A pile article comprising a backing having attached to at least one surface thereof a face of a porous pile layer having two opposite faces, each being defined by the ends of a plurality of crimped filamentary structures, said filamentary structures overlapping, being aligned generally in the same direction, and forming a pile having a fiber density below 25 lbs./ft.^{3}, said pile constituting a network wherein at least a major proportion of the filamentary structures contact each other throughout the three dimensions of the pile, isolated volumes of the pile extending throughout the pile thickness being substantially free of interconnections between the filamentary structures thereof and said isolated volumes being bounded in the thickness dimension of the pile by surrounding volumes wherein the filamentary structures are interconnecting.

2. The article of claim **1** wherein adjacent surrounding volumes are interconnected to one another.

3. The article of claim **1** wherein adjacent surrounding volumes are substantially free of interconnections to one another.

4. The article of claim **1** wherein the filamentary structures are interconnected by a binder composition.

5. Method for the production of a pile article comprising

(a) aligning in generally the same direction a group of crimped filamentary structures such that they are overlapping and intercontacting throughout the three dimensions of the group,

(b) interconnecting the outer filamentary structures of the group to one another at a plurality of spaced points to form a unitary bonded bundle having an interior volume of non-interconnected filamentary structures,

(c) forming a block by assembling a plurality of said bundles in parallel contacting arrangement such that the filamentary structures of each are aligned generally in the same direction, the block having a fiber density below about 25 lbs./ft.^{3},

(d) slicing said block in a plane transversely to the direction of filament alignment to provide a face of cut filament ends, and

(e) adhering said face to a backing.

6. The method of claim **5** wherein following adherence to the backing the block is sliced in a plane parallel to the first slice to provide a pile of desired thickness.

7. The method of claim **5** wherein said interconnections are provided by application of a binder composition to the filamentary structures of the group.

8. The method of claim **5** wherein following assembly of the bundles, the resultant block is treated to interconnect the bundles.

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