Nov. 3, 1959 H. G. LAUTERBACH 2,910,763

FELT-LIKE PRODUCTS

Filed Aug. 17, 1955

Fig. 1

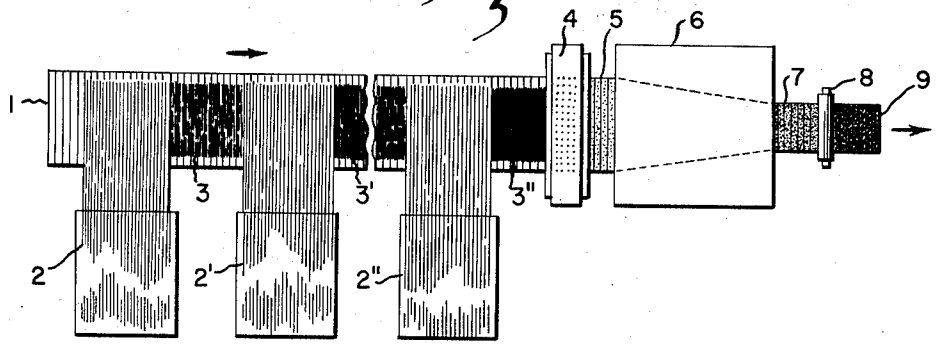


Fig. 2

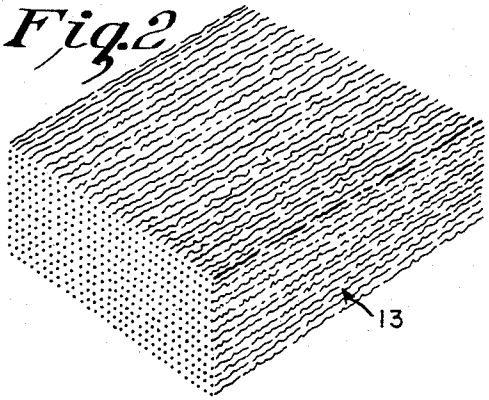


Fig. 3

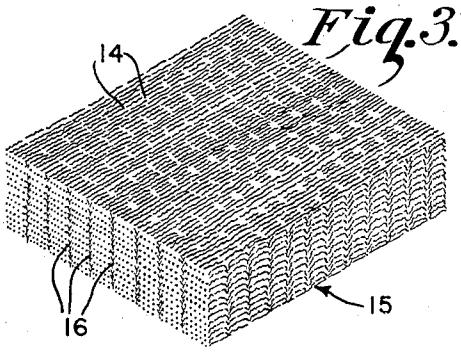


Fig. 4

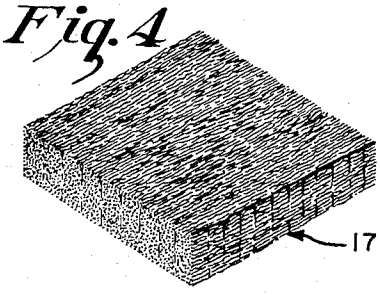
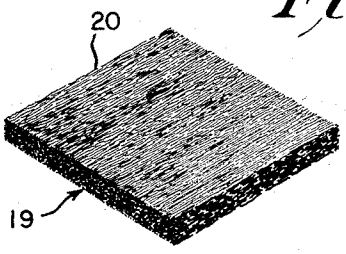


Fig. 5



INVENTOR

HERBERT G. LAUTERBACH

BY Charles A. McQuarrie

ATTORNEY

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FELT-LIKE PRODUCTS

Herbert G. Lauterbach, Wilmington, Del., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

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12 Claims. (Cl. 28—72.2)

This invention relates to formation of synethic filamentary material into non-woven felt-like products.

Felts (i.e., non-woven unbonded fibrous structures deriving coherence and strength from interfiber entanglement and accompanying frictional forces) represent the oldest form of textile fabric. Animal fibers such as wool and, to a degree, fur are accepted as the only true feltable fibers. Forming them into felts requires preliminary compaction or "hardening" followed by additional mechanical working with addition of heat and usually moisture. Felting of other filamentary materials has not been possible, and felt-like products composed of them not been made heretofore. Although felts containing synthetic fibers blended with conventional felt-forming fibers are known, the synthetic component has occupied a secondary role in the felt formation, although perhaps endowing the product with desirable qualities, such as improved abrasion resistance or dimensional stability.

One of the objects of this invention is production of non-woven felt-like products composed wholly of synthetic filamentary material. Another object is formation of felt-like products from synthetic filamentary material that is retractable, i.e., characterized by a property of shortening, as by crimping or shrinking, when treated with heat or other suitable agent. An additional object is provision of felt-like materials from synthetic filamentary material while avoiding the steps of mechanical working necessary to felt wool fibers. Still another object is accomplishment of the above objects in a substantially continuous manner. Other objects of this invention, together with means and methods for attaining the various objects, will become apparent from the following description and the accompanying diagrams.

Figure 1 is a schematic representation of apparatus useful according to this invention, illustrating continuous processing. Figure 2 is a perspective representation of a layered batt of filamentary material. Figure 3 represents the batt of Figure 2 after needle-punching. Figure 4 represents the same batt after retraction into a felt-like product. Figure 5 represents, also in perspective, the article of Figure 4 after a subsequent pressing step.

In general, the objects of this invention are accomplished by forming filamentary material, at least a preponderant part of the material being retractable and of synthetic composition, into a loose batt as a plurality of superimposed substantially parallel layers, the filamentary material lying essentially coplanar in each layer, forcibly orienting some of the filamentary material from each layer into at least one adjacent layer, and then compacting the batt by exposure to treatment effective to retract the retractable component. The retraction of the retractable component compacts the batt to a coherent felt-like product suitable for the general uses for which conventional felts are employed, as well as for other uses. Thus, this invention contemplates, as a principal product, a felt-like article containing a preponderance of synthetic filamentary material retracted to diminished length in situ; it comprehends a retracted felt-like article consisting

essentially of needle-punched filamentary material, a preponderant part of the component material being of synthetic composition and having been characterized before formation of the retracted felt-like article by a degree of retractability such that the numerical product of the degree of retractability by the content of the retractable filamentary material, each expressed percentagewise, is at least two thousand.

In the apparatus shown in Figure 1 movable belt 1 supports filamentary material being processed according to this invention. Multiple cards 2, 2′, and 2″ arranged alongside the belt deposit successive carded layers 3, 3′, and 3″ of filamentary material on top of one another on the belt for transport through needle loom 4, which reciprocates needles into and out of the batt, forcibly orienting some of the filamentary material substantially perpendicularly from one layer into another. The needle-punched batt at 5 is carried through vessel 6, such as an oven, in which retraction of component filamentary material occurs, as by heating to suitable temperature, with corresponding compaction—suggested by reduced width at 7. Rolls 8 grip the resultant felt-like strip and forward it to a collection point at 9, the roll pressure smoothing the surface somewhat and compressing the strip to reduced thickness if desired.

After being deposited on the belt and before entering the needle loom, filamentary material treated as just described has the appearance of batt 13 shown in some detail in Figure 2; that oblique view reveals the orientation of successive layers parallel to the top and bottom faces of the batt, as well as a substantially parallel alignment of the individual filamentary components of the batt produced in each carded layer in the absence of appreciable crosser-lapping. Figure 3 shows similarly the appearance of the material being processed after completion of the needling step; needled batt 15, which is somewhat thinner than the batt of Figure 2, is characterized by slight indentation 14 of the top surface where the needles entered and by visible vertical deviation at intervals 16 from the predominantly horizontal filamentary orientation throughout the batt. Figure 4 shows the product 17 after retraction of the filaments has compacted the batt of Figure 3 to diminished thickness and has rendered the needled regions scarcely discernible from the rest of the material; in outward appearance, this felt-like product closely resembles conventional felts made with wool. A more highly compacted and smoother-surfaced modification produced by application of pressure during passage of the article of Figure 4 between relatively cool rolls appears in product 19 of Figure 5, no trace of the needling remaining on the surface 20.

The process described lends itself admirably to continuous operation. The carded layers may be deposited on the belt in proper synchronism with the belt movement to build up the batt evenly. Successive cards may be arranged to deposit layers on the belt at different azimuthal angles to decrease the difference between longitudinal and transverse orientation of the individual filamentary components in the batt. All or some of the cards may be provided with crosser-lappers to shift the orientation of successive layers.

Alternatively, the filamentary material may be built into batt form directly on the belt by jet devices used to forward the filamentary material. The speed of the belt may be regulated to control the thickness of batt laid down, and jet turbulence or other randomizing influence in positioning of the material may be supplemented by mechanism for oscillating the jets or the belt to deposit the material evenly. On the other hand, fibers may be collected, as on perforated screens, from dispersions in water, air, or other fluid medium. Deposition of the filaments with fluid means permits elimination of blend-

ing and carding procedures and generally simplifies handling of starting materials.

Regardless of the method of batt formation, the batt ordinarily will consist of superimposed layers of the filamentary material, the individual components of each layer being substantially coplanar. The material will remain oriented in layers more or less parallel to the faces of the initial batt (and the final product) unless some way is found to cause interlocking between layers; hence, retraction of unmodified layers would give a product weak in the vertical direction and very likely inferior in split resistance to conventional felts. A surprising feature of the present invention is the discovery that retraction will accomplish the desired result if even a relatively small amount of the component filamentary material of each layer has been inter-layered, i.e., reoriented out of the predominating planar configuration into at least one adjacent layer as well.

Needling with a machine usually called "needle loom" has been identified as the preferred method of achieving the required reorientation of filaments in the batt. Such a machine has a large number of closely spaced reciprocatable needles designed to catch or drag filamentary material upon passing into the batt during relative horizontal movement of the batt, which may be either intermittent (while the needles are drawn clear of the batt) or continuous. As this type of machine is well known for use in various textile operations, further description is unnecessary. Obviously any other suitable means may be used for forcibly orienting filaments into the desired position, an operation frequently designated here by terms such as "needling" or "punching." The same effect, though without great regularity, can be obtained by hand-punching of the batt with any instrument effective to disorient one or more fibers from the surface toward the interior, but such a procedure is quite tedious, of course.

A preponderant amount of the filamentary material used in the practice of this invention should have the ability to retract when properly treated, as with heat or swelling agent. The retraction may result from a simple reduction in length (i.e., shrinking) or from a distortion of the filament into an irregular shape (i.e., crimping or curling) or both. The retractability or degree of retraction refers to a free filament at the treating conditions and is expressed conveniently as the percent decrease (based upon the original value) in shortest distance between two points on an individual filament; thus, when both shrinking and crimping occur, it is a summation of the effect produced by diminution in length and assumption of a more irregular path between the points of measurement. Materials not retractable under the conditions of treatment and, therefore, unsuitable as sole constituent can be blended in minor amounts with retractable synthetic filamentary material or lapped with it in order to achieve special effects; at textile-treating temperatures, glass fibers exhibit zero retractability and the retractability of wool fibers is essentially nil.

A working minimum on batt compaction requires, for good results according to this invention, that the amount of total retractable component present in the material being processed times its retractability, both expressed percentagewise, be not less than about two thousand; thus, if all the material (100%) is similarly retractable a retractability of at least about 20% is called for, and if a sole retractable component constitutes about 50% of the total its retractability should be at least about 40%. Because of the assumed predominantly copanar filamentary orientation in the needled batt, retraction of the retractable filamentary component diminishes the surface area of the batt; usually the actual area loss is at least ½, often from ⅔ to ¾, and sometimes virtually all that would be expected from the retractability, depending in part upon frictional characteristics of the material used. Of course, increasing the amount of retractable component or substituting filamentary material of greater retractability, to exceed the two thousand product figure, usually will produce a more compact batt, with further surface loss during retraction.

Practically all synthetic polymeric fiber-forming compositions can be manufactured so as to have the necessary retractability and, thus, can be treated according to this invention to produce useful products. In addition to those exemplified hereinafter, they include (inter alia) polyamides (e.g., polyhexamethylene sebacamide, poly-epsilon-caproamide, and copolymers of these or other polyamides), polyesters (e.g., polyethylene sebacate), polyesteramides, polyureas, polyurethanes, acrylonitrile polymers (including copolymers of acrylonitrile, especially with other ethylenically unsaturated monomers, such as vinyl chloride, vinyl acetate, methyl acrylate, and vinyl pyridine), vinyl polymers generally (e.g., polyvinyl acetate, polyvinyl chloride, and polystyrene), polymerized hydrocarbons (e.g., polyethylene) and halogenated derivatives thereof, synthetic proteinaceous polymers, and cellulosics (including esters, ethers, and similar derivatives of cellulose).

Blends or mixtures of various polymers may be employed; furthermore, the individual filaments may be formed hollow or with a sheath-core or other multicomponent configuration. If desired, layers of these or other filamentary materials may be combined in the same article; selection of batt components from the wide variety of synthetic filamentary materials that can be manufactured to have the ability to retract will be guided not only by the known properties of each material itself but also by its observed behavior in the present process and of course, the desired end use of the product so obtained.

Especially desirable results in the production of felt-like products intended for the same uses as wool felts have been obtained with filamentary polyethylene terephthalate prepared as disclosed by Hebeler in Patent No. 2,604,689 and by Kolb in a patent application filed June 25th, 1952 as Serial No. 295,565 and now U.S. Patent No. 2,758,908. Having a property of crimping spontaneously when heated in water at or near the boil or in hot air at temperature from about 95° up to about 180–200° C., such filamentary material not only has a superficial wool-like appearance but also compares favorably with wool in resilience and other properties. Good results have also been obtained according to this invention with filamentary material that retracts but does not crimp when heated; preparation of such filaments of polyethylene terephthalate is disclosed by Whinfield and Dickson in Patent No. 2,465,319 and by Kolb in his patent application mentioned above.

Another type of spontaneously crimpable filamentary material that gives desirable felt-like products according to this invention is regenerated cellulose of the kind produced as described by Nicoll in Patent No. 2,515,834; it crimps spontaneously at room temperature in a swelling agent, such as an aqueous alkali or anhydrous liquid ammonia (among those disclosed in the patent). Liquid ammonia will also cause retraction (by shrinkage rather than crimp formation) of ordinary viscose rayon, which also can be used to prepare felt-like products by the method of the present invention.

As suggested, the retraction treatment may consist of heating by various means, as by application of water, oil, steam, air, or other fluid that is relatively inert with respect to the particular filamentary material or it may involve exposure of the material to a swelling agent in addition to or in place of the heat treatment. A combination of chemical and physical treatments may be used, mild acid and alkali baths being examples of what often may be acceptable chemical treatments. Any method of shortening the end-to-end length of the filamentary material without too adversely affecting the fiber structure itself is acceptable. If the filaments are to be retracted in a liquid bath, instead of by heating, a conveyor belt may be arranged to carry the batt through a tank where

the filaments are submerged in or padded or sprayed with the retraction-inducing liquid. This may be followed by suitable means for removing the liquid, such as wringer rolls and a drier, as will be understood in the art. The time of treatment may vary from a few seconds to hours, although for simplicity, times of the order of a minute or so are preferred.

The felt-like products of this invention resemble wool felts in many ways, but their structure may be distinguished upon close inspection by the recurring filamentary orientation in the thickness direction at intervals corresponding to the penetration of the needles; they also are readily distinguishable from non-wool "felts" containing thermoplastic filamentary materials bonded to one another (as by heating and application of external pressure) because of their superior pliability, the bonded structures being usually stiff and unyielding and almost invariably deficient in resistance to splitting. The process of this invention should not be confused with ordinary felt-making operations; the usual procedure of matting fibers together by mechanical working, rubbing, hardening, or fulling is not employed here. In the absence of some unique combination of elastomeric properties, the synthetic filaments with which this invention is concerned cannot be converted into felt-like materials in the conventional manner of mechanical working used for wool, and animal fibers alone cannot be formed into a highly compacted product by the process of this invention because of their insufficient retraction without mechanical working. Substitution of retractable synthetic fibers for a minor amount of wool, say one-fourth or so, in batts to be felted in manner known heretofore gives products inferior to those of this invention, notably in tensile strength and density.

The following examples illustrate the invention but are not to be construed as limitative or as indicating that the products obtained are fully equivalent. Tests of physical characteristics (thickness, weight, tensile strength, and elongation) for which values appear in the examples were conducted (unless otherwise indicated) according to recognized felt-testing methods of the American Society for Testing Materials, specifically ASTM–D–461–53.

EXAMPLE I

A quantity of 3 denier, 3″ staple fiber formed from polyethylene terephthalate drawn to 4 times its original length after extrusion, as disclosed by Whinfield and Dickson in Examples 16 and 17 of their patent mentioned above, and not relaxed (retractable about 20%) is carded as in conventional textile operations. A batt is formed from carded layers to a depth of about 1½″ with a density of about 0.01 gram per cubic centimeter (g./cc.). This batt is passed through a needle loom with regular barbed needles to punch a number of the fibers into and through the batt in the direction of its thickness, i.e., substantialy perpendicular to the top and bottom surfaces. The needling action occurs about 50 times per square inch of batt surface. After needle-punching from the top, the batt is turned over and run through the needle loom again to punch it from the other side. Needling increases the specific gravity of the batt to about 0.11. The needled batt is immersed in boiling water for two minutes, at which time the batt loses about one-quarter of its surface area and shrinks to about ⅛″ in thickness. Upon removal from the water and subsequent drying, the batt appears quite compact, having a specific gravity of about 0.20; traces of the needled pattern are hardly noticeable. A long 2″ strip cut longitudinally from the resulting sheet and placed in 2″ jaws 3″ apart moving apart at 12″ per minute gives an elongation to break of slightly above 100%, requiring a force of about 200 pounds to break this width. A 2″ transverse strip gives a break elongation of 85% at a force of about 85 pounds. Pressing at 110° C. and 500 pounds per square inch (p.s.i.) smoothes the slightly fuzzy surface and increases the specific gravity to 0.30. The product is a coherent felt-like article, which illustrates the suitability of a wholly synthetic filamentary material in a construction not previously known. With care individual fibers can be separated from the final product without any indication of fusion or adhesive bonding of the respective fibers to one another, frictional forces alone apparently providing the observed coherence.

EXAMPLE II

Using a card and crosser-lapper, a batt weighing 8.1 ounces per square yard (oz./sq. yd.) is prepared from 2½″ staple fibers of polyethylene terephthalate, 60% of the total being of 12 denier and having an inherent shrinkage (i.e., retractability) of 50% in boiling water and 40% being of 3 denier and having negligible shrinkage in boiling water. Four plies of this batt are needle-punched together on a plate-type needle loom (made by James Hunter Machine Co., North Adams, Mass.) using regular barbed felting needles (15 x 18 x 25 x 3½) for a total of eight passes, alternately on each side, causing the batt to receive a total of 960 penetrations per square inch. The resulting batt is immersed in boiling water, whereupon it shrinks instantaneously 52.5% in area to form a felt 0.16″ thick weighing 32.7 oz./sq. yd. and having a tensile strength of 850 p.s.i. with elongation of 159%. Thus, the all-synthetic felt-like product need not consist wholly of retractable material to give satisfactory results according to the present invention, a mere preponderance being sufficient. A wool felt of comparable density (SAE–F–5) may be expected to have a tensile strength of about 400 p.s.i.

EXAMPLE III

A quantity of 10 denier, 3 inch spontaneously crimpable regenerated cellulose staple fiber manufactured according to the process described by Nicoll in his patent mentioned above is carded and lapped into a loose batt. After needle-punching from both sides, this batt is immersed in water at 100° C. until no further perceptible shrinkage occurs. The batt shows a 25% decrease in area and a density increase of 14%. It is now a moderately coherent felt-like mass that can be duplicated by dipping a similar batt twice for 3 minutes (each time) into anhydrous liquid ammonia; five additional similar dippings of a batt treated with ammonia bring about a total area decrease of 75%, resulting in a medium-weight felt, such as is useful for a carpet underliner. This illustrates the preparation of a wholly synthetic felt-like article from one of the older available man-made fibers, affording a great saving over the expense of wool felts of comparable physical characteristics.

EXAMPLE IV

A 50/50 stock blend of 3″ staple fibers, consisting of a mixture of 12 denier polyethylene terephthalate drawn to twice the as-spun length (retractability 50%) and 6 denier rayon manufactured as described by Nicoll above (retractability 25–50%) is formed into a batt and needle-punched in the manner described in Example I. The needled batt is immersed for 2 minutes at room temperature in 5% aqueous sodium hydroxide. A 12% decrease in area is observed as the rayon component retracts; the product resembles a light-weight felt at this point. Additional shrinkage of 32%, based upon the original area, is brought about by immersion for one minute in boiling water. After this two-step retraction the thickness is about ¼″, and the density is 0.15 g./cc., as compared with a density of 0.11 g./cc. after needling. Pressing at 90° C. and 100 p.s.i. for 2 minutes doubles the density, giving a final product with breaking strengths of 117 and 42 pounds for longitudinal and transverse 2″ pieces. Thus, a combination of retractable filamentary components and corresponding retracting treatments may be employed according to this invention, with separate retraction steps, if desired.

EXAMPLE V

Polytetrafluoroethylene filaments of 3 to 5 denier, drawn to 3 times the original length at room temperature (retractability of about 40% at 300° C.) are skeined and cut into 3" staple. The retractable staple is run through a garnett to open it up. The staple is passed through the garnett a second time and collected as a loose batt about 1½" thick. The batt is passed through a needle loom; this needling treatment punches a number of the fibers into and through the batt in the thickness direction. The needling action occurs about 100 times per square inch of batt surface. After needle-punching from the top, the batt is turned over and run through the needle loom again to punch it from the other side. The needled batt is suspended in a Lindberg furnace at 300° C. for 1 hour. The treatment decreases the thickness of the batt and shrinks the batt about 40% in area to a loose soft felt useful for a wide range of uses as a gasketing material, polytetrafluoroethylene being one of the most chemically stable of the fiber-forming polymers.

A needled batt was prepared as in Example V using the same means and was heated in the furnace at 325° C. for 1 hour. It decreased in thickness and contracted about 50% in area to form a much stronger though still fairly soft felt useful as a wick for corrosive liquids, for example. Another batt prepared as in Example V was passed through the needle loom again once on each side (making a total of four passes through the loom), and then heated for a period of 5½ hours in the furnace at 325° C. There was a further decrease in thickness below that of the felt product of Example V. An over-all area shrinkage of 75% was obtained, resulting in a very hard felt useful for dust filtration, especially in the presence of corrosive fluids or at high temperatures.

EXAMPLE VI

Sixty grams of 3 to 5 denier polytetrafluoroethylene filaments drawn to 7 times the as-spun length (retractability of 50% at 325° C.) are cut into approximately 3" staple lengths and mixed with 10% by weight of 2 denier, 2" cellulose acetate staple (non-retractable here). The mixture is carded and collected on a drum; presence of the acetate fiber aids batt formation by counteracting the extreme slipperiness of the preponderant component fiber. The resultant batt is folded 4 times to give a thickness of about 1½" and needle-punched once on each side by passing it through a needle loom. The needle-punched batt is immersed in acetone to remove the acetate fibers, rinsed well, and dried. The dried batt is inserted in a Lindberg furnace at 450° C. for a few seconds, whereupon shrinkage takes place immediately, and the resultant article is taken from the furnace so quickly that it does not reach a temperature as high as 327° C. There is a small decrease in thickness as compared with the thickness of the needled batt. A strong moderately soft felt is obtained, useful as a filter cloth for corrosive liquids. The minor amount of included non-retractable filamentary component alternatively may be removed later, as by burning off to leave a like felt-like product.

EXAMPLE VII

Wool fibers and shrinkable (retractability of 50%) polyethylene terephthalate staple of like lengths are hand-blended at 25% wool content and passed twice through a garnett equipped with crosser-lapper. The batt so formed is needle-punched using regular barbed needles in a Hunter needle loom, the area increasing to 227% of the original value. The needled batt weighs 6.2 oz./sq. yd. and is 0.098" thick. A 10" x 10" piece of this needled batt is boiled in water at 212° F. for 10 minutes. At the end of that period, it measures 6.38" x 6.38", having shrunk in area by 59%, and is 0.176" thick, an increase of 180%. The article so produced is coherent and felt-like, with a tensile strength of about 30 p.s.i., elongation of slightly over 60%, and density of 0.16 g./cc.

A 6" diameter circle cut from the product of Example VII and fulled for 1½ hours in an Abbott Laboratory felting machine with steam, soap and water remains unchanged in diameter while its thickness diminishes to 0.13", a 26% reduction, corresponding to 15 oz./sq. yd. The tensile strength and elongation after this fulling treatment became 33 p.s.i. and 60%, respectively, showing the inutility of adding a fulling step at the end of the present process.

When the initial needle-punching step of Example VII was replaced by 3½ minutes fulling at 50–60° C. the tensile strength of the final product dropped way off to about 4½ p.s.i., with 43% elongation, the density dropping slightly to 0.13 g./cc. This shows that, especially at the higher contents of retractable filamentary component, usual felting procedure cannot replace the step of providing interlayered filamentary orientation prescribed according to this invention.

The process of Example VII was repeated with the relative amounts of the two constituent fibers reversed. The same increase in area took place during the needling step, but the batt percentage decrease in thickness was half again as great. After the immersion in boiling water for 10 minutes, the needled batt measured 9" x 9", representing an area shrinkage of 19%, and the thickness was 0.158", an increase of only 13% over the needled thickness. A 6" diameter circle of this material fulled as in the example underwent no change in diameter, and its thickness dropped about 55%. The resulting tensile strength was less than 20 p.s.i., or only about 30% of the value obtained in Example VII (with elongation half again as great), and the density bore a like inferior relationship to that of the exemplified product, whose superiority in these important criteria of felt characteristics is evident.

The procedure of the last paragraph was repeated with a stock blend of wool (80%) and 20% of a copolymer of vinyl chloride and vinyl acetate ("Vinyon") of 50% retractability (at 100° C.) for purposes of comparison. Needle-punching with regular barbed needles was performed once on each side for a total of two passes. After needle-punching, the batt weighed 8.3 oz./sq. yd. and was 0.178" thick, having undergone a 50% decrease in thickness. The needle-punched batt was immersed in boiling water at atmospheric pressure for 10 minutes, during which it lost 25% in area. After immersion, it was 0.115" thick, a further decrease in thickness of 35.4%. A 6" circle cut from this material and fulled in the Abbott Laboratory felting machine for 1½ hours with steam, soap and water attained a density of 0.14 g./cc., measuring 5⅞" in diameter, with slight further area shrinkage of 4%, and was 0.080" thick, a further decrease of 30% in thickness. The resulting product had a tensile strength of 28 p.s.i. with elongation of 65%, but it was rather stiff, as though some of the vinyl fibers had been bonded together by the heating. A like sample prepared in the same manner, except that 3½ minutes of hardening treatment was performed (in lieu of the needle-punching) before shrinkage, has a less uniform appearance and a density only ⅔ as much at the same thickness; the tensile strength also was reduced ⅓.

As a general observation from the above runs, it can be stated that a needle-punched batt submitted to heat shrinkage, shrinks quite uniformly and coherently while a hardened batt (containing a minor amount of feltable and a preponderance of heat-retractable material) submitted to heat shrinkage does not shrink very uniformly and often fails to remain coherent. Furthermore, even with mixtures of material in which a preponderant part is non-retractable, giving a product inherently inferior to those of this invention, needle-punching would be preferred to an initial hardening step for production

of a strong, pliable, unbonded felt-like article by anyone who actually tried both.

EXAMPLE VIII

A batt weighing 6.4 oz./sq. yd. is prepared as in Example II except that 40% of 80's wool is substituted for the 40% of 3 denier, 2½" fibers of Example II, the rest remaining shrinkable (retractability of 50%) polyethylene terephthalate and is treated in like manner. Upon immersion in boiling water, shrinkage takes place to the extent of 51.5% in area, and the resultant felt is 0.16" thick and weighs 27.8 oz./sq. yd. It exhibits a tensile strength of 362 p.s.i. and elongation of 138%.

EXAMPLE IX

A portion of a batt composed of a 50/50 stock blend of wool and polyethylene terephthalate staple (retractability of 50%) is needle-punched on a Hunter needle loom using regular barbed needles. The carded batt weighs 14.1 oz./sq. yd. and is 0.31" thick. After punching, the weight is 6.2 oz./sq. yd., and the thickness is 0.116 inch. This punched batt is boiled at atmospheric pressure in water for 10 minutes, whereupon a shrinkage of 40% takes place. The thickness becomes 0.135". The tensile strength is about 15 p.s.i. with elongation of about 100%; the density is lower than in the blends of higher retractable synthetic content. This article represents a border-line product of the present invention, useful for many uses but not for so many as those in the preceding examples of blends containing more synthetic component, and less wool.

A 6" diameter circle of the product of Example IX is inserted in the Abbott machine and fulled for 1½ hours with steam, soap and water. No change in diameter occurs. The product, which has a density of about 0.16 g./cc., has a tensile strength of about 20 p.s.i. and elongation of 90%, illustrating the slight effect of such an additional step performed upon the corresponding product of the example.

A 4-gram piece of the unneedled batt of Example IX, 0.124" thick and 6" in diameter, was placed in the Abbott Laboratory felting machine for 3½ minutes and hardened at 50–60° C. There was no change in diameter. A 10-minute boil in 212° F. water resulted in a 5" diameter. After 1½ hours fulling, the area was 22.2 sq. in. The resultant article exhibited properties greatly inferior to those of the product of Example IX, a tensile strength of only 3½ p.s.i., with elongation of 70%, at lower density (about 0.11 g./cc.). Thus, hardening is not a satisfactory substitute for the needle-punching step of the example.

Interesting and novel products may be formed from laps of dissimilar materials that are differentially retractable. For example, a simple sandwich of one material between two batts or laps of another may be so constructed and treated that only the outer laps retract, providing an inner cushion of filamentary material securely held by contortion of the needled portions of the outside laps onto it and each other. The outer lap may be made very dense without an equal increase in density of the center lap. The unretracted center lap may be made of any filamentary material insensitive to the particular retracting treatment effective upon the outer laps. For example, natural mineral fibers or non-retractable ceramic or glass fibers may be used. Such a product is suitable for heat and noise insulation, among other uses, the coherent outer surfaces greatly alleviating the tendency of the confined material to break loose and eliminating the necessity for woven or paper backings. Of course, multiple laps of each material may be employed. Alternatively, a lap of retractable filamentary material may be sandwiched by two non-retractable laps as in the following example. In this type of article, which intentionally is not uniform throughout, the requirements upon retractability and retractable content apply only to the retractable laps or batts, of course.

EXAMPLE X

A batt is prepared from dissimilar 3" staple fibers as follows: Seventy-five grams of 3 denier polyacrylonitrile staple drawn to 4 times the extruded length is fed into a carding machine and the resulting web collected in open width on a rotating drum. Fifty grams of spontaneously crimpable polyethylene terephthalate staple of the Kolb type formed from filaments drawn to 2.5 times the original length (retractability of 25%) is carded similarly and deposited on the same drum on top of the polyacrylonitrile fiber lap. Another 75 grams of polyacrylonitrile staple follows to complete the sandwich. The mass is stripped from the drum and passed through a needle loom. Subsequently heated to 165° C. for about 5 minutes, the multiple-layered mass loses 50% of its area, mostly as a result of retraction of the polyethylene terephthalate fibers. The surface layers, which are not retractable by such heat treatment, buckle but do not separate from the shrunken middle portion. The bulky product somewhat resembles a needled felt supported by a woven central core, but the retracted center layer grips the outside fiber layers much more tenaciously than can an unshrunk fabric. This type of product, which may be formed with appropriate materials to adapt it to a particular use, is suitable as a fur replacement, carpet, pile fabric, or even papermakers' felts.

Polyacrylonitrile filamentary materials are retractable under the conditions specified for items C and D below after exposure to a suitable swelling agent (e.g., cyclic tetramethylene sulfone, N,N-dimethyl formamide); alternatively they may be retracted by exposure to super-atmospheric steam or by treatment with aqueous solutions of zinc chloride, ethylene glycol, acetonitrile, nitromethane, formic acid, or nitric acid. Thus, one or both of the surface layers of the article formed in Example X might be retracted also, if a more compact surface is desired.

The following table summarizes similar examples of this invention performed with additional kinds of filamentary materials.

Table

Item	Fiber	Retraction, Medium	Temp. ° C.	Time, Mins.	Specific Gravity		Percent Area Loss
					Needled	Retracted	
A	Cellulose acetate, 2 denier staple.	49% aq. acetone	20	0.5	0.09	0.14	69
B	Nylon, 6 denier staple	dil. nitric acid	20	1.0	0.09	0.10	55
C	40/60 Acrylonitrile/Vinyl chloride copolymer, 5 denier staple.	air	150	5	0.11	0.12	41
D	10/90 Vinyl chloride/Vinylidene chloride copolymer, 25 denier staple.	air	170	5	0.19	0.28	77
E	Polyethylene, 6 denier staple	water	100	0.5	0.17	0.26	80
F	Polystyrene, 4 denier staple	air	110	5	0.10	0.18	60

The compactness and strength of the products of this invention is a concomitant of the shrinkage or crimping of the retractable starting materials, despite individual length discontinuities, which also may be present in sliver or top used in formation of the batts, for example. For light-weight materials where a high initial degree of interlocking is desired, the starting material itself may be crimped, a distortion usually not lost and occasionally even enhanced by the retraction. The effect of increased frequency or depth of needling becomes apparent after retraction, when it will be seen to have imparted an increased laminar strength (i.e., resistance to splitting in the thickness or vertical dimension) to the product. Depending upon the frequency and depth of punching, the mass may gain or lose in thickness; infrequent needling may be insufficient to overcome the opposing tendency to increase in thickness as the surfaces of the batt corresponding to faces of the product diminish in area. Increased severity in needling, with consequent greater entangling and interlocking of individual filamentary components with their neighbors in adjacent or nearby layers, may overcome the usual tendency of the batt to increase in thickness upon retraction of the predominantly coplanar fibers.

The rather fuzzy surface of the product can be smoothed by pressing, as indicated above. A heated pressing surface may induce additional retraction of surface fibers, but the temperature should be maintained below the softening temperature of the fiber to prevent fusion. No reliance is placed upon occurrence of interfiber adhesion resulting from softening or partial fusion. In fact, such fusion is undesirable because of its frequently adverse effect upon physical characteristics of the product, including the more subjective properties of drape and handle. This added compacting treatment is not essential in the majority of uses, nor need the product be subjected to any equivalent of felting, fulling, or hardening. The initial conditions of batt density and the intensity of treatment can be chosen to produce practically any desired density and coherence in the product without necessity for any rubbing pretreatment or fulling after-treatment. The retractability of many synthetic filamentary materials, which usually is related to the original degree of molecular orientation (perhaps largely the result of some drawing) may be adjusted with due regard to the desired resulting fiber elongation and tenacity.

Felt-like materials of substantially any desired characteristics may be formed according to this invention. Thus, rather than the type of product determining utility, as so often happens, here the products of the invention may be made so as to fill a wide variety of uses for nonwoven materials. These felt-like materials may be manufactured in suitable form for many industrial, as well as household and apparel uses. For certain types of apparel felts, it is advantageous to blend the synthetic, retractable fiber with minor amounts of non-retractable fiber, as for example, 75% of retractable fiber from an acrylonitrile polymer blended with 25% of wool; the presence of the non-retractable fiber distributed throughout helps endow the resulting felt-like article with more pleasing aesthetic surface qualities, as judged by drape, handle, and general appearance. They are adapted to common textile-finishing treatments, including brushing, napping, shearing, singeing, and embossing, and they can be resin-impregnated and starched to lend stiffness when desired. The transverse and longitudinal properties may be made practically identical by blending or lapping, or wide differences between them may be secured by sufficient orientation of the starting filaments or fibers. The shape of the product may be determined by placing the batt against or around a fixed form so that the batt assumes the configuration of the form during retraction, and pressing also may be useful to improve shape correspondence in this process modification.

Among the industrial uses are paper-makers' felts, filtration felts (both gas and liquid), carpets and their underliners, heat, sound and electrical insulation, polishing felts (sheet and wheel), frictional felts (dynamic and static), coverings for billiard tables, and felts for lubricating, wicking, sealing, cushioning, spacing, shock absorbing, vibration absorption, padding, packaging, tennis balls, dental and medical applications, artificial limbs, roll coverings and jackets, clutch coverings, penumatic tube sealers, mallet head coatings for drums, Mason's felt for smoothing concrete, press coverings for finishing leather goods, laundry presses, endless bands for polishing and grinding, covers for bells in plating process (sheradizing), rub aprons in spinning wool, as well as piano and organ felts, saddle felts, and the like. Among the apparel uses are included hats, overcoatings, suitings, shoe uppers, soles, and arch supports, blouses, caps, dresses, gloves, jackets, linings, mittens, paddings, pajamas, robes, scarves, skirts, slippers, snow suits, sport shirts, ties, as well as such household uses as bath mats, bedspreads, blankets, chamois, drapes, linings, napkins, stuffings (pillows and sleeping bags), table cloths, toweling, upholstery, and the like. Many other uses for the products of this invention will be apparent.

This application is a continuation-in-part of application Serial No. 312,067 filed September 29, 1952, now abandoned, and of application Serial No. 436,014 filed June 11, 1954, and now U.S. Patent No. 2,893,105.

I claim:

1. A felt-like article consisting essentially of filamentary material characterized by predominantly horizontal coplanar superimposed layers of the filamentary components interrupted by occasional interlayered orientation, at least 50% of the filamentary component material in each layer being synthetic staple fibers characterized by a capacity for retracting subsequently to diminished length without fusing.

2. The felt-like article of claim 1 in which a minor part of the component material is a natural fiber.

3. The felt-like article of claim 1 in which the synthetic fibers are polyethylene terephthalate.

4. The felt-like article of claim 1 in which the synthetic fibers are a polymer of acrylonitrile.

5. The felt-like article of claim 1 in which the synthetic fibers are a polyamide.

6. The felt-like article of claim 1 in which the synthetic fibers are polytetrafluoroethylene.

7. The felt-like article of claim 1 in which the synthetic fibers are regenerated cellulose.

8. A retracted felt-like article consisting essentially of predominantly horizontal coplanar superimposed layers of filamentary material interrupted by occasional interlayered orientation, at least 50% of the component material in each layer being synthetic staple fibers which were characterized before formation of the retracted felt-like article by a degree of retractability without fusing such that the numerical product of (1) the degree of retractability and (2) the content of retractable filamentary material, each expressed percentagewise, is at least 2000.

9. Process comprising forming filamentary material into a loose batt as a plurality of super-imposed substantially horizontal parallel layers, at least 50% of the filamentary material in each layer being retractable synthetic staple fibers, forcibly orienting some of the filamentary material into substantial parallelism with one another and into at least one adjacent layer at occasional intervals distributed throughout the batt, and then compacting the batt by exposure to treatment effective to retract the retractable component without fusing the fibers.

10. The process of claim 9 in which the fibers in the loose batt are forcibly oriented by needle-punching.

11. The process of claim 10 in which the synthetic staple fibers are characterized before formation of the

batt by a degree of retractability such that the numerical product of (1) the degree of retractability and (2) the content of retractable filamentary material, each expressed percentagewise, is at least 2000.

12. Process for making a felt-like laminar non-woven product comprising forming a batt of staple fibers including heat-retractable polytetrafluoroethylene, staple fibers, forcibly orienting some of the polytetrafluoroethylene fibers into parallelism with one another substantially percendicular to the faces of the batt, and diminishing the batt by heat-retraction of the fibers into a coherent mass.

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