May 31, 1966 J. J. SUCH 3,253,317

METHODS OF PRODUCING TEXTURED NON-WOVEN FABRIC

Filed Oct. 22, 1962 2 Sheets-Sheet 1

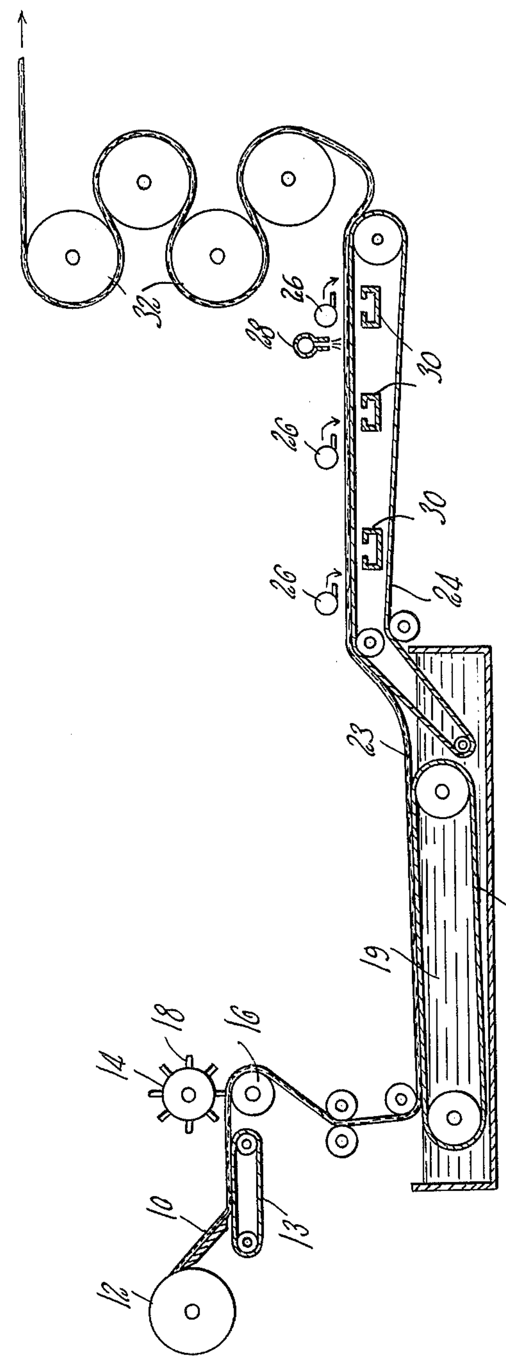

Fig. 1.

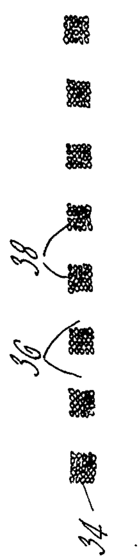

Fig. 3.

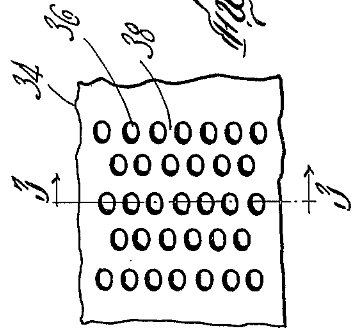

Fig. 2.

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METHODS OF PRODUCING TEXTURED NON-WOVEN FABRIC

Filed Oct. 22, 1962 2 Sheets-Sheet 2

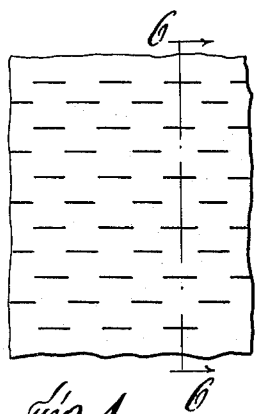

Fig. 4.

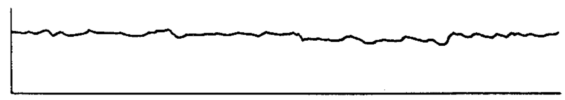

Fig. 5.

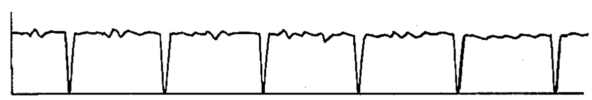

Fig. 6.

Fig. 7.

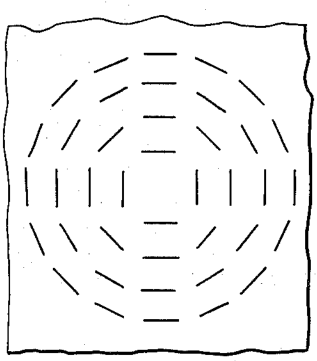

Fig. 8.

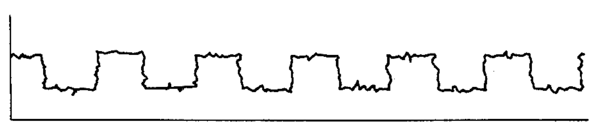

Fig. 11.

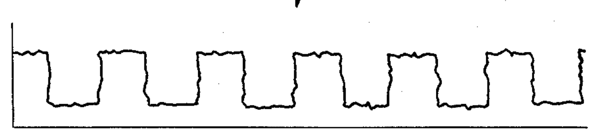

Fig. 12.

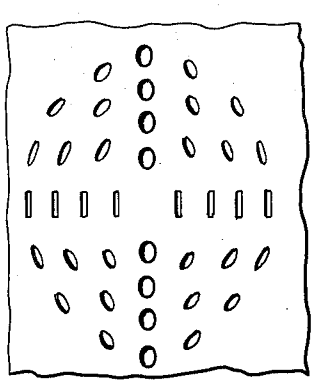

Fig. 9.

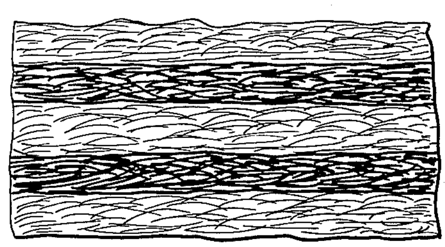

Fig. 10.

United States Patent Office

3,253,317
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3,253,317
METHODS OF PRODUCING TEXTURED NON-WOVEN FABRIC

John J. Such, Wrentham, Mass., assignor to The Kendall Company, Boston, Mass., a corporation of Massachusetts

Filed Oct. 22, 1962, Ser. No. 231,988
5 Claims. (Cl. 28—76)

This invention relates to a novel patterned textile sheet material and to methods for manufacturing the same. More particularly, it relates to the preparation of a patterned non-woven felt-like assembly of fibers which is soft, porous, highly conformable, and which has adequate strength for many textile purposes without the addition of any saturant or binder.

Felt-like non-woven fabrics are well known in the art, and are described in patents such as U.S. 2,528,793 and 2,774,129 to H. A. Secrist. In the preparation of such products, a uniform sheet-like array of interlaced retractable fibers is subjected to the action of a retracting agent while the fibers are free to move or shrink, with the result that a smooth, uniform sheet of even density is produced. By retractable fibers I mean those which are under such internal stress that when they are exposed to a releasing environment, which may be chemically or thermally induced, the fibers tend to writhe, gyrate, curl, loop and twist together, condensing and interlocking the fibrous body into an integral and integrated structure.

The present invention relates to improvements in this art, whereby the fibers in the product are not disposed in a continuous, uninterrupted sheet of uniform fiber concentration, but are organized into preferably interconnected bands or zones of high fiber concentration, these zones being adjacent to zones of low or even zero fibers concentration. There is thus created a patterned or textured effect which is novel in the art. The textured effect may range from a pattern of apertures enclosed in a matrix of interconnected fibrous bands of interlaced fibers to series of parallel fibrous bands of alternating high and low fiber concentration, presenting a definite ribbed appearance like a sculptured felt or fabric. Coarse-knitted and meshed effects are also readily produced, of pleasing and novel esthetic appearance as well as utility in the non-woven art.

By variation in fiber concentration or density, I do not mean that the fibers are necessarily closer together in some areas than in others, nor that there are more fibers per unit of volume in some areas in the sculptured product. Rather, I mean that the product is characterized by thick and thin places, where a cross-section will show many more fibers piled up in certain areas than in others, without regard to fiber approximation or density per unit volume in the strict sense.

It is therefore a primary object of this invention to provide a patterned felt-like non-woven fabric of non-uniform texture.

It is a further object of this invention to provide a novel process for the creation of textured and patterned effects in felt-like non-woven fabrics.

Still a further object of this invention is to provide a novel textured non-woven fabric in which zonal differences in fiber concentration provide zonal differences in absorbency and rate of capillary flow.

In the production of prior art felt-like assemblies of textile fibers by processes which retract the fibers to make them twist, curl, and interlock, it has been considered desirable that the fiber deposition be as uniform and sheet-like as possible, and that no restraint be offered to the retracting procedure. Such conditions are set fotrh as desirable in the Secrist 2,528,893 patent mentioned above.

Such considerations of uniformity are dictated by the nature of the forces involved in retracting or shrinking the fibers in a fibrous web. Such webs are generally the product of a card, garnett, air-lay machine, or the like, employed to produce a more or less uniform web or fleece of fibers. When a web of fibers of this nature is subjected to forces which cause the fibers to retract, and no restraint is placed on the retraction process, the web of fibers shrinks in area, increasing in weight per unit area, to form a substantially uniform felt-like non-woven fabric.

Retractable fibers which form felt-like non-woven fabrics may be fibers which due to their chemical nature show a substantial percentage decrease in length when heated, as in the case of Dacron 61, a Du Pont polyethylene terephthalate fiber. They may also be fibers which do not shrink excessively in absolute length, but which tend to kink, curl, bend, and twist when subjected to certain forces: such behavior is characteristic of fibers such as cotton or jute in sodium hydroxide solution of proper concentration.

Although fibers of this latter type may not shrink more than 10% in absolute length in a caustic shrinking process, the gyrations of the individual fibers cause a web composed thereof to shrink 50% or more in area in such a process. Similar behavior is shown by certain polyvinyl alcohol fibers in water. The fibers used in this invention may actually shrink in length, or they may retract by developing convolutions: the common element of behavior is that a web or fleece of such fibers, with the fibers interengaged, will show a substantial area shrink when exposed to conditions which release the internal retractive forces in the fibers.

I have found that it is possible to introduce a disproportionating tendency into a fleece or web of retractable fibers, which, when coupled with edge restraint in the retracting process, leads to novel sculptured or textured felt-like non-woven fabrics. By a disproportionating tendency I mean in general terms that I superimpose on the web a selected type or pattern of gross irregularity of fiber distribution in a controlled manner, so that in the subsequent retracting process the tendency of the fibers to retract is either facilitated or hindered in selected areas, or facilitated in some areas and hindered in others. As will appear more fully hereinbelow, this results in non-uniform retraction and the formation of textured products.

Although a wide variety of patterned effects are possible, the invention will be illustrated chiefly as it relates to the preparation of a non-woven felt-like product of an apertured nature, resembling a net, wherein interconnected relatively flat fibrous bands are integrated into a network defining an array of holes. Such a product can be made, as will be set forth more fully hereinbelow, by subjecting the fibrous web to a localized weakening operation, such as cutting, slitting, crushing, or the like, whereby a series of actual or potential discontinuities is imposed on the web, preferably in a transverse direction, and then subjecting the web to a retracting operation.

The invention will be more readily understood in connection with the drawings, wherein:

FIGURE 1 is a diagrammatic side-elevation of the preferred apparatus of the invention.

FIGURE 2 is a plan view of a fabric made in accordance with this invention.

FIGURE 3 is a cross-section along the line 3—3 of FIGURE 2.

FIGURE 4 is a plan view of a carded web of fibers after the cutting operation but before the retraction process.

FIGURE 5 is a fiber-density profile of a typical card web.

FIGURE 6 is a fiber-density profile of the cut web of FIGURE 4 along the line 6—6.

FIGURE 7 is a fiber density profile of the fabric of FIGURE 2 along the line 3—3.

FIGURE 8 is a plan view of a cut web in which the cutting operation has been performed at various angles to the axis of fiber orientation.

FIGURE 9 is a plan view of the cut web of FIGURE 8 after carrying out the retraction thereof.

FIGURE 10 is a plan view of another example of fabric made according to this invention.

FIGURE 11 is a fiber density profile of the untreated fibrous web used to produce FIGURE 10.

FIGURE 12 is a fiber density profile of the product of FIGURE 10.

The superimposed irregularity of fiber distribution is accomplished in one preferred example by a cutting operation which interrupts the fiber continuity, and provides what may be considered as a multiplicity of "inside edges." I have observed that in retraction processes involving fibrous webs, shrinkage is most rapid and pronounced at the web edges, presumably because the shrinkage forces in the fiber population at the web's edge are unopposed. Therefore, by opening up the interior body of the web with a pattern of cuts, I provide inside edges from which the fibers will retract with the formation of apertures. Of considerable additional importance is the fact that the deliberate provision of a multiplicity of such edges provides a multiplicity of areas where the shrinkage forces developed in the retraction process can be dissipated in a uniform and orderly fashion. Although the force exerted by a single fiber in shrinking may be small, the aggregate of forces developed by all the fibers in a web is of considerable magnitude. In an unrestrained shrinkage operation on a non-slit web, these forces act from the outside edges inwardly. Restraint or impediment to shrinkage, either at the edges or in the body of the web, results in irregularities in the finished product. By providing inside edges, as in the practice of this invention, and by exercising outside edge restraint, I provide a number of release points—that is, I subdivide the overall shrinkage process, which is most forcible at the edges, into a number of internal local processes scattered throughout the length and breadth of the web, each local process possessing its own edges, of any desired geometry.

The retractive forces set free in the fibers of a web are transmitted mainly by frictional engagement between fibers, and the cumulative effect is propagated mainly along the direction of fiber alignment if the fibers in the web are oriented. The effect of outside edge restraint—that is, restraint on overall area shrink—is to impart a level of resistance to the tendency of the fibers to act in concert, which would result in substantial area shrink without the development of a pronounced textured pattern. By providing outside restraint, however, I effect a transmittal of the retractive forces liberated within the fibers to the weakest points in the system. At these weak points, which I have imposed on the web in a controlled and patterned manner, there is a reduction in fiber concentration, with the formation of a textured effect.

Since most carded webs are rather highly oriented in the machine direction, the forces tending to draw the web in sideways are moderate, and the maximum restraint needed to restrain lengthwise retraction may be provided by the lengthwise tension exerted by the continuous processing tensions conventional in textile operations.

The applied outside restraint need not be absolute. That is, it is not necessary that overall area shrinkage be absolutely prevented. It is only necessary that the fibers be prevented from exerting most of their fullest retractive force on the outside edges of the web. I have found, or example, that if a web of cotton fibers is provided with a pattern of cut slits, as in Example I below, completely unrestrained shrink results in an overall area shrink of 75% or 80%, with only rudimentary formation of a pattern of apertures. If sufficient edge restraint is provided to allow a widthwise and a lengthwise retraction of about 20% each, the overall area shrink is about 36% and the product has an apertured, textured appearance. Various methods of exercising restraint, such as web-engaging belts or screens which exert varying frictional restraint on the fibers due to a variable screen pattern of surface roughness, will readily suggest themselves to those skilled in the art.

Referring to the drawings, in FIGURE 1 a web **10** of textile-length fibers, preferably cotton, is formed in a conventional web-forming apparatus **12**, which may be a garnett, a card, or an airlay device of known type for associating textile fibers into a fleece or web. The web **10** is passed by a conveyor belt **13** between a pair of opposed rolls, **14** and **16**, one of which is equipped with a set of radially-extending knife edges **18**. These knives **18** acting against the web as it passes over roll **16** cut a pattern of nicks, grooves, or slots in the base web, severing the fibers and thereby providing a multiplicity of points of disengagement, where the fiber-to-fiber continuity is deliberately interrupted to provide shrinkage points.

The web, thus provided with a multiplicity of slits in any desired pattern, is next subjected to a shrinking force while under restraint. A convenient shrinking medium is presented by a fluid bath of shrinking agent, **19**, through which the web is conveyed on a flexible, preferably porous screen, **22**, which may be of woven stainless steel wire.

In the case of cotton fibers, an aqueous solution of sodium hydroxide having a concentration of 8% to 30%, or any of the equivalent swelling agents as described and taught in Secrist Patent Number 5,528,793, may be used. Secrist Patent Number 2,774,129 describes techniques and swelling agents which may be employed for other fibrous materials, and such techniques and swelling agents are now well known to those skilled in the art and are employed in accordance with the present invention as described in said patents. The web is affected by the swelling reagent acting upon the fibers thereof to cause them to twist, bend, writhe and loop in all and random directions. The fibers also decrease in span and entangle with themselves, drawing bodily together and away from the area of the perforations.

In general, the fibers of the product of this invention, in both the high concentration and in the lower concentration areas, are integrated together by the curling, interlocking, and entanglement of one fiber with another as a result of the release of reactive forces during the shrinkage process. The fibers are not, however, in a particular state of tension: that is, in the broadly-disposed fiber bands, the individual fibers follow a generally irregular path, and are not appreciably parallelized.

As set forth above, it is important, for the development of well-defined apertures, that the web be restrained from complete area shrink during the exposure to a shrinking agent. In a normally-oriented card web, the more important restraint will be along the machine direction, and can readily be effected by suitable control of machine draft and carrying speed. Control of lateral shrink, a secondary and generally less pronounced matter, may readily be accomplished by providing the edges of the flexible conveyor belt with an endless chain of pins, as in a pin tenter, or clamps, as in a clamp tenter, devised to hold a fabric out to width during wet processing. Such devices are known in the art and are not shown. Whatever method is used, it is important that the shrinkage forces set up within the fabric shall be enabled to expend a substantial part of their strength in the areas of least resistance, i.e., at the slits or discontinuities heretofore provided. Normally, in a continuous, unslit web, rather rapid shrinkage can take place both laterally and transversely, as taught by U.S. Patent 2,528,793. This two-way shrinkage toward the center of the web, with consequent thickening and weight increase per unit area, should be at least partially inhibited in the present invention.

In this way, the nicks or slits in the web are observed to enlarge and expand during the local shrinkage process, said shrinkage appearing to take effect outwardly away from the cut edges of the fibers. Presumably, as set forth above, this is because shrinkage takes place most readily at a boundary—that is, at the edge of a web. It is obvious that at an edge the shrink-induced pull of the fibers is in one direction, away from the edge. However, by providing a spaced series of inner discontinuities, or artificial internal edges, and shrinking the web under conditions of edge restraint, as set forth above, the shrinkage forces open up the slits to approximately circular shape, with no appreciable over-all area shrink. In this manner, the unshrunk material of FIGURE 4 is transformed into a reticulated, lace-like network as shown in FIGURE 2.

I have found that the edges or rims of the apertures formed by this embodiment of the invention are markedly different from the edges of apertures formed by punching or otherwise cutting holes into an ordinary felt or into a non-woven felt-like material such as is described in the Secrist 2,528,793 patent. In a punched felt, the edges of the apertures are marked by a multitude of protruding fiber ends, since the aperture, being formed after the felting operation has taken place, necessarily cuts across the fibers and leaves the rim of the aperture lined with cut fiber ends.

By first severing the fibers before shrinking, however, the retracting forces are apparently enabled to act freely on the rims of the slits, the cut fiber edges are curled back and twisted together during shrinkage, so that the edges or rims of the apertures are characterized by a smooth, tucked-in appearance, substantially free of cut fiber ends. In effect, the peripheries of the apertures possess the smooth, finished appearance typical of the outside selvage edges found on products of this type.

In the preferred method of this invention, the slits are so arranged in size and in placement that a localized internal shrinkage of about 35% takes place. This means that in carrying out the process of this invention, the apertures after processing constitute 35% or more of the total area of the product. With perforations of this order of magnitude, it is found that the fibers are grouped into bundles of substantially higher concentration of fibers than were present in the original web, the bundles of fibers being intermittently united to form a substantially foraminous sheet 23. The sheet 23 is conveyed away from the swelling agent 19 by a conveyor belt 24, and the sheet is washed free of swelling agent by flooders 26. A neutralizing agent if needed, may be sprayed on the apertured sheet through sprayers 28 which are positioned before the last flooder. The excess liquid is removed from the sheet by suction boxes 30, and the apertured sheet is dried in a suitable manner as by running the same through a network of steam cans 32.

The fabric, as is shown in FIGURE 2 and FIGURE 3, comprises a substantially smooth surfaced non-woven fabric 34 which is made up of bundles 36 of fibers of high concentration intersecting and integrating with each other through the kinks, twists, and bends of the fibers making up these bundles. These fiber bundles are spaced apart by areas 38 of substantially no fiber to form a stable, foraminous sheet.

The above-described process, resulting in the non-woven fabric of FIGURES 2 and 3, is the result of superimposing on an oriented card web a patterned set of cuts normal to the axis of fiber orientation. In general, the degree to which a round aperture will be formed from a slit is to some extent a function of the fiber orientation in the immediate vicinity of the slit. I have found that when the fibers are highly oriented, as in a drafted card web, maximum roundness develops when the cuts are normal to the fiber axis. Cuts parallel to the fiber axis of an oriented web result in apertures which are generally lenticular in shape, with cuts at other angles assuming an oval or intermediate shape, as described in Example II and shown in FIGURES 8 and 9. When the fibrous web is prepared on an air-lay machine the fibers are laid down in a random non-oriented direction. Such a product is called an isotropic web, and when it is used in the process of this invention, the shrinkage force components are nearly equal in all directions. It will be obvious to one skilled in the art that patterns other than simple cuts can be used—e.g., V-shaped. By proper choice of the shape of the cut or slit, the organization of the cuts into an over-all pattern, and the degree of fiber orientation in which the fibers are organized, a widely diversified range of apertured non-woven fabrics can be made.

In one respect, an area of low fiber density may be regarded as an area of low inertia, so far as the shrinkage forces are concerned. In an actual slit, or fiber discontinuity, the inertia is zero. As explained above, the tendency is for fibers to retract from low-inertia into high-inertia areas. Novel and useful products may be made by a process that is the converse of the process leading to the material of FIGURES 2 and 3. That is, instead of providing a pattern of areas of low inertia, a pattern of areas of high inertia is created by superimposing on a normal card web a set pattern of bars, strips, stripes, or tufts of additional fiber. This increases the fiber population in selected areas. In accordance with principles set forth above, the resulting more populous areas shrink more than the less populated area of the normal web, so that the added fibrous pattern is augmented and increased in the number of fibers held herein, while the thinner areas of the normal web become even more attenuated, being depleted of fibers by the patterned areas where the shrinkage forces are greater. Such products show contrasting bands, stripes, or ribbed or tufted patterns: a typical example of augmenting shrinkage inertia by adding fiber in selected areas is set forth in Example III.

A preferred fiber for use in the practise of this invention is cotton, which seems to be particularly susceptible to a retracting, curling, and twisting operation when the potential energy of the fiber is released by swelling agents. The potential energy of the cotton fiber is very high, due presumably to its natural growth habit, wherein helical spirals of cellulose wind around the fiber structure with many reversals of direction. However, other naturally-occurring cellulosic fibers such as jute and ramie also exhibit this phenomenon and are useful in the practise of my invention. Additionally, other means, besides chemical swelling, may be used to release these internal retractive forces: for example, heating will cause numerous synthetic fibers to retract and entangle together. Certain polyester fibers are capable of substantial retraction when heated. Vinyl fibers of the type known as Vinyon (a trademark of Union Carbide) also show marked retraction when heated. Such fibers are well-known in the art, and their retraction by heating is suitable for the practise of my invention where patterned or textured felted webs of heat-sensitive fibers are desired

The following examples will illustrate typical methods of carrying out the process of my invention.

Example I

A carded web of bleached cotton fibers weighing about 30 grams per square yard is prepared by the conventional carding operation yielding a mat of loosely assembled fibers with an orientation ratio of about 4 to 1: that is, the fiber distribution is such that the web is about four times as strong in the machine direction as it is in the cross direction. The fibers used are, in this case, 100% cotton and in the bleached state have a length ranging from ¼ inch to ¾ inch and a diameter of about 10 to 15 microns. With a sharp cutting blade, a series of transverse slits is made in the web according to a pattern illustrated in FIGURE 4. The slits are so made as to cut through the full thickness of the web, completely severing all fibers along the line of the cut to provide narrow zones of fibers discontinuity throughout the length and breadth of the web. The cut pattern is so chosen as to offset or stagger successive cut lines so that there is a minimum of overlap of progressive line cuts. A pattern consisting of ¼ inch cuts spaced ¼ inch apart in the line, and the successive lines ¼ inch apart and offset ¼ inch has been found to give good results.

The slit web is then laid on a foraminous supporting surface and heavy bars placed along the four edges of the sample piece of web. The sample is then immersed in a tray containing sodium hydroxide at 13% concentration at a temperature of about 3° C., under which conditions the specific gravity of the solution is 1.148. Under the swelling action of the caustic, the slits are seen to open up into a pattern of clearly defined apertures.

When the reaction is completed, the treated web is lifted out of the caustic bath, neutralized by dipping into a tray of dilute acetic acid, and thoroughly washed by flooding with water and suction extracting. This yields the product shown in FIGURE 2.

Example II

Using a carded web of bleached cotton fibers as in Example I, a pattern of slits or cuts is made as before. In this case, however, instead of the slit orientation being predominantly tranverse to the direction of principle fiber orientation, the pattern is one in which the slit angle is varied over all possible inclinations, with ¼-inch cuts distributed uniformly along the peripheries of circular arcs of increasing radius, as is shown in FIGURE 8. When the web is restrained along its edges and treated with caustic as in the previous example, the slit places open up in a manner to illustrate the principle which I have found to govern the movement of fibers under these particular conditions. The extent of the opening up of the variously oriented slits is seen to be related to the direction of orientation of fibers of the base web, the maximum amount of opening coming where the slits are normal to the fiber direction, and a lesser effect occurring where the slit length is parallel to the fiber orientation.

Slits running in the direction of fiber orientation are seen to be decidedly lenticular in shape compared to the full-circular openings made by those cuts whose direction is transverse to the main fiber orientation. The extent of the opening up of the slits is seen to depend on the sine of the angle of inclination, which is also a measure of the number of free fiber ends in a line section inclined at an angle to an oriented array of fibers. FIGURE 9 is a representation of the effect produced in this manner.

Example III

An oriented carded web of bleached cotton fibers, weighing about 22 grams per square yard, is cut into tapes or strips about ½ inch wide. These strips are then overlaid at a spacing about one-half inch apart, onto another base web of cotton of similar weight, in a pattern parallel to the major fiber axis, or machine direction. A moderate pressing between conventional squeeze rolls facilitates integration of the fibers into a banded structure.

When this composite web is treated with cold caustic, as in the previous examples, and under edge restraint, the double-weight thick stripes are observed to become much thicker, while the inter-stripe areas of the base web become thinner. The fiber density profile of FIGURE 11 will illustrate the fiber distribution of the composite card web before shrinking, and should be contrasted with FIGURE 12 showing the fiber density profile of the heavily ribbed or sculptured fabric constituting the final product.

Instead of parallel ribs, crosswise or diagonal fibrous bands may be used, or a criss-cross or lattice pattern may readily be employed to create a variety of textured nonwoven fabrics.

Example IV

A bat of Dacron 61 fibers was made up of a plurality of carded webs, Dacron 61 being a Du Pont trademark for a type of polyethylene-terephthalate fiber susceptible to high shrinkage when heated. The fibers were 2 inches long, 1½ denier, and the batt weighed about 100 grams per square yard. For convenience in handling, the web was strengthened by a needling operation of about 350 needle perforations per square inch. This had also the effect of spreading the batt so that its final net weight was about 50 grams per square yard.

A staggered pattern of slits ½ inch long, spaced ¼ inch in line and with lines ½ inch apart was cut into the web, after which the slit web was heated to 250° F. in a hot air oven for 3 minutes while restraining the edges. The result is an apertured Dacron felt similar to FIGURE 2.

Having thus described my invention, what I claim is:

1. A process for producing an apertured felt-like nonwoven fabric which comprises the steps of forming a substantially uniformly distributed web of retractable textile-length fibers, perforating the web at selected, spaced-apart locations across its surface by rupturing substantially all of the fibers across the areas of the perforations to provide a multiplicity of fiber ends adjacent said perforations, and subjecting the perforated web of fibers to a retracting operation while limiting the overall area shrinkage of said web, whereby the retractive energy of the fibers is released to cause said fibers to shrink away from the areas of the perforations and to entangle and interengage with each other into an interconnected series of substantially flat fibrous bands, said fibrous bands being separated by areas substantially devoid of fibers.

2. A process for producing an apertured felt-like nonwoven fabric which comprises the steps of forming a substantially uniform web of textile-length fibers capable of retracting and entangling together under the influence of heat, perforating the web at selected spaced-apart locations across its surface by rupturing substantially all of the fibers across the areas of the perforations to provide a multiplicity of fiber ends adjacent said perforations, and subjecting the perforated web of fibers to a heating operation while limiting the over-all area shrinkage of said web, whereby the retractive energy of the fibers is released to cause said fibers to shrink away from the areas of the perforations and to entangle and interengage with each other into an interconnected series of substantially flat fibrous bands, said fibrous bands being separated by areas substantially devoid of fibers.

3. The process according to claim **2** wherein the fibers consist substantially of heat-retractable polyester fibers.

4. A process for producing an apertured felt-like nonwoven fabric which comprises the steps of forming a substantially uniform web of textile-length fibers capable of retracting and entangling together under the influence of a chemical swelling agent, perforating the web at selected spaced-apart locations across its surface by rupturing substantially all of the fibers across the areas of the perforations to provide a multiplicity of fiber ends adjacent said perforations, and subjecting the perforated web of fibers to a chemical swelling operation while limiting the overall area shrinkage of said web, whereby the retractive energy of the fibers is released to cause said fibers to shrink away from the areas of the perforations and to entangle and interengage with each other into an interconnected series of substantially flat fibrous bands, said fibrous bands being separated by areas substantially devoid of fibers.

5. The process according to claim **4** wherein the fibers consist substantially of naturally-occurring cellulosic fibers.

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