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Kalwaites

[11] **3,837,046**

[45] **Sept. 24, 1974**

[54] **METHOD (CLOSED SANDWICH WITH LARGE APERTURE FORMING MEANS AND PERFORATED BACKING MEANS)**

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[21] Appl. No.: **225,332**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 22,321, March 24, 1970, abandoned.

[52] **U.S. Cl.** ..... **19/161 P**

[51] **Int. Cl.** **D04h 11/00**

[58] **Field of Search** ..... 19/161 P; 161/109, 169; 28/72 NW

[56] **References Cited**

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Primary Examiner—Dorsey Newton

[57] **ABSTRACT**

A method and apparatus utilizing fluid rearranging forces to produce, from a layer of fibrous material such as a fibrous web, nonwoven fabrics that contain apertures or holes, or other areas of low fiber density, and have a plurality of patterns of groups of fiber segments that alternate and extend throughout the fabric. One form of the method includes the steps of positioning the starting web between an apertured forming means and a backing means that has continuous imperforate portions that lie between and interconnect discontinuous permeable portions, then directing fluid rearranging forces through the apertures of the forming means against the fibers of the starting web, causing some of the fluid streams to strike the continuous imperforate portions of the backing means and all of the fluid streams ultimately to pass through the permeable portions of the backing means. Each of the discontinuous permeable portions of the backing means has an area less than about one-half, preferably less than one-quarter the area of one of the apertures of the forming means. The resulting fabric consists of fibers that have been rearranged to provide a first pattern of nubs of tightly packed, randomly oriented fiber segments corresponding to the discontinuous permeable portions of the backing means, a second pattern of yarn-like bundles of fiber segments arranged in a pattern complementary to the apertures of the apertured forming means, and a third pattern of flat, ribbon-like groups of substantially aligned fiber segments interconnecting the portions of the fabric in the first pattern with each other, as well as interconnecting some of them with the yarn-like bundles in the second pattern.

2 Claims, 7 Drawing Figures

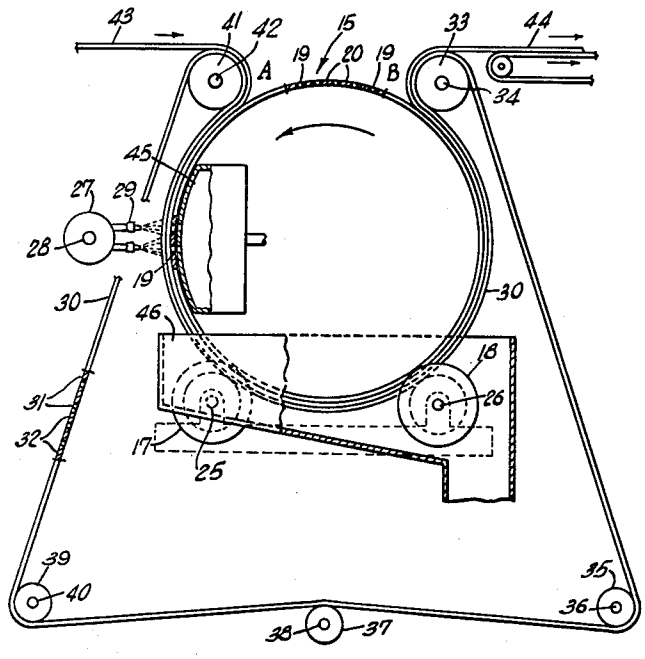

Fig. 1.

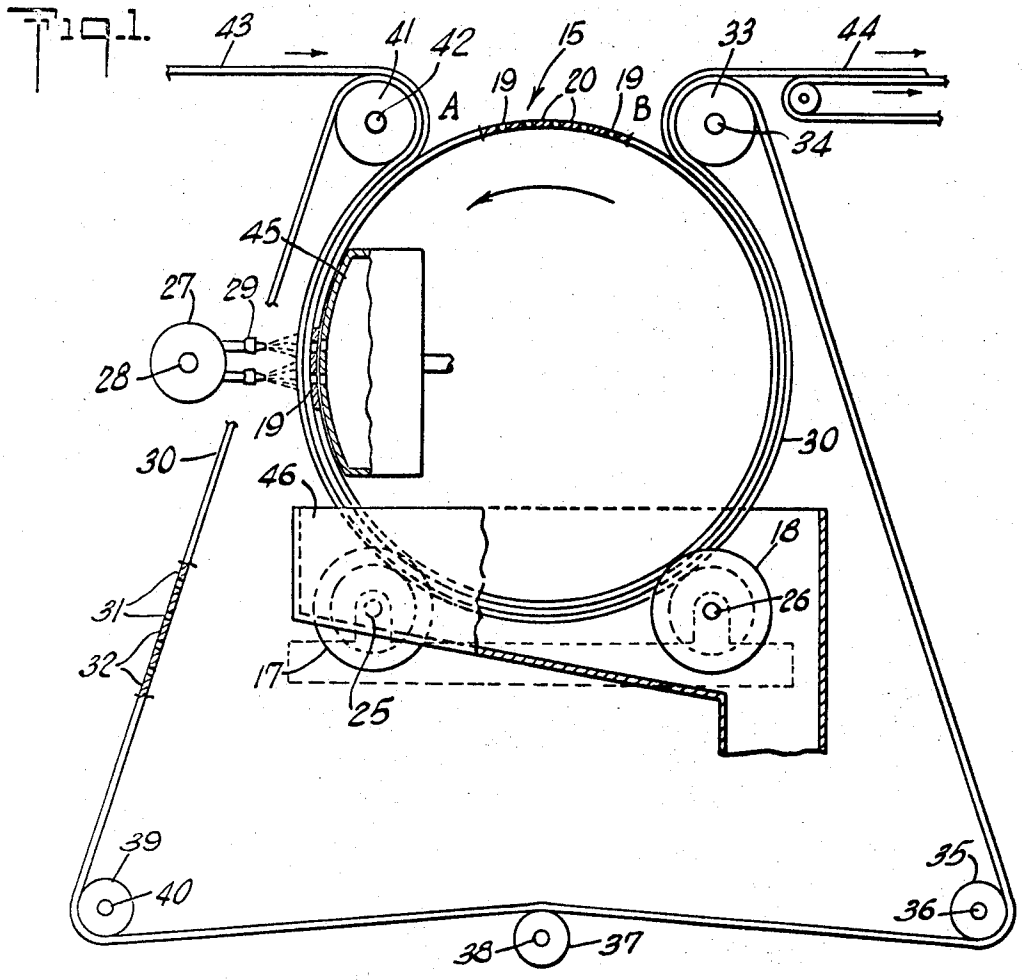

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Fig. 2.

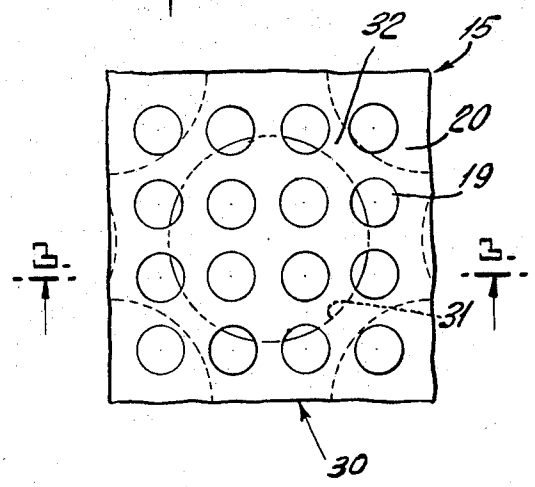

Fig. 3.

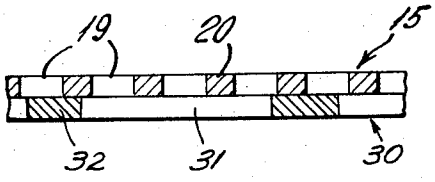

Fig. 4.

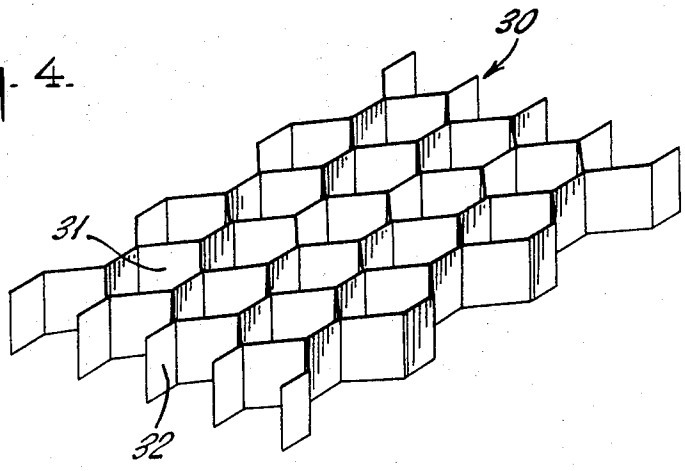

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Fig. 5.

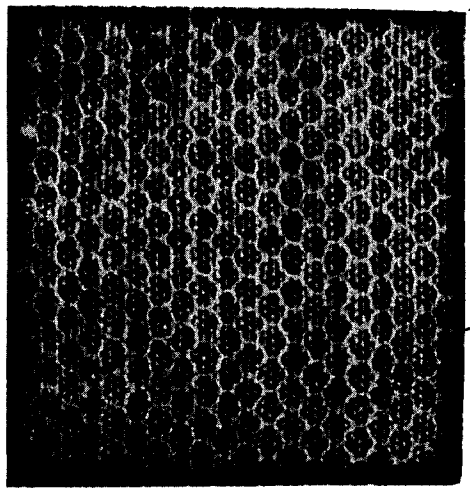


Fig. 6.

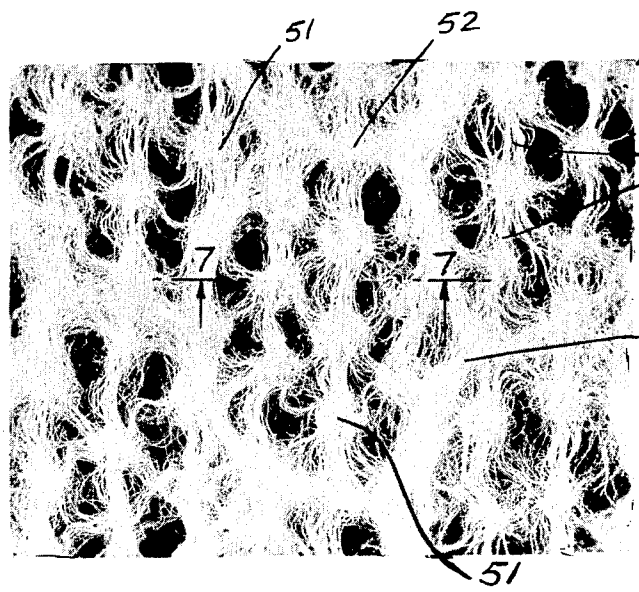
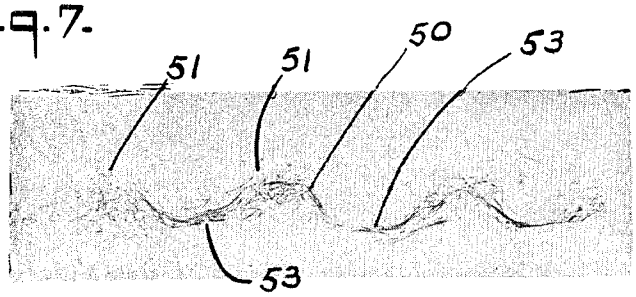


Fig. 7.



METHOD (CLOSED SANDWICH WITH LARGE APERTURE FORMING MEANS AND PERFORATED BACKING MEANS)

This is a continuation-in-part application of my copending application Ser. No. 22,321, filed Mar. 24, 1970 now abandoned.

This invention relates to a method and apparatus for the production of nonwoven fabrics, and more particularly to a method and apparatus for the production of nonwoven fabrics from a layer of fibrous material such as a fibrous web in which the individual fiber elements are capable of movement under the influence of applied fluid forces, to form a fabric that contains apertures or holes, or other areas of low fiber density, and has a plurality of patterns of groups of fiber segments that alternate and extend throughout the fabric.

BACKGROUND OF THE INVENTION

Various methods and apparatus for manufacturing apertured nonwoven fabrics involving the rearrangement of fibers in a starting layer of fibrous material have been known for a number of years. Some of the methods and apparatus for the manufacture of such fabrics are shown and described in U.S. Pat. No. 2,862,251, which discloses the basic method and apparatus of which the present invention is a specific form, and in U.S. Pat. Nos. 3,081,500, 3,025,585 and 3,033,721.

The rearranged nonwoven fabrics made by the methods and apparatus disclosed in those patents contain apertures on holes, or other areas of low fiber density, often outlined by interconnected yarn-like bundles of closely associated and substantially parallel fiber segments. (The term "areas of low fiber density" is used herein to include both (1) areas in which relatively few fibers are found in comparision to the rest of the fabric, and (2) apertures (holes) that are substantially or entirely free of fibers.)

One of the specific methods for producing rearranged nonwoven fabrics that is disclosed in U.S. Pat. No. 2,862,251 is to support a loose fibrous web or layer between an apertured forming member and a permeable backing member, and then direct streams of rearranging fluid through the apertures of the forming member in order to apply spaced sets of opposing fluid forces to the layer. The spaced streams of fluid pass through the fibrous layer and over and through the backing member, to pack groups of fiber segments into closer proximity and substantial parallelism in interconnected yarn-like bundles of fiber segments that decline holes or other areas of low fiber density corresponding to the pattern of the apertures in the apertured forming means.

Another known method for producing rearranged non-woven fabrics is to support a loose fibrous web or layer upon solid backing means with spaced apertures distributed throughout the area thereof, and direct streams of rearranging fluid against the fibrous starting layer so that the fluid passes through that layer and then out through the spaced apertures in the backing means. The result of this method is to form a nub of interentangled, tightly packed, helter-skelter fiber segments in each aperture of the backing means, and to position other fiber segments in flat, ribbon-like groups of substantially aligned fiber segments between pairs of immediately adjacent nubs to interconnect the same.

In the first method just described, the streams of rearranging fluid *enter the fiber rearranging zone at spaced locations* determined by the position of the apertures in the apertured forming means against which the fluid streams are first directed. Then, when the rearranging fluid leaves the rearranging zone, it does so through foramina uniformly dispersed throughout the permeable backing member.

Exactly the contrary is true with the second method just described. In that method, the streams of rearranging fluid are dispersed uniformly across the layer of fibrous starting material as they are directed against that layer upon entering the rearranging zone, and *leave the rearranging zone at spaced locations* determined by the position of the apertures in the apertured backing means.

Another significant feature of the second method is that streams of rearranging fluid initially dispersed uniformly across the fibrous starting layer are consolidated into spaced streams confined by the walls of the apertures in the apertured backing means as they pass out of and away from the fiber rearranging zone. It is this consolidation of the streams of fluid that creates the turbulence that in turn packs the nubs in the nonwoven fabric of this prior art method into tightly compacted, interentangled fiber accumulations, with the individual fibers thereof having entirely random orientation.

SUMMARY OF INVENTION

I have now discovered that, unexpectedly, one can combine these two different prior art methods of producing rearranged nonwoven fabrics, and achieve very satifactory rearrangement of the fibers of the fibrous starting material into a fabric having a plurality of patterns of groups of fiber segments that alternate and extend throughout the fabric.

In the method of this invention, the starting material is a layer of fibrous material whose individual fibers are in mechanical engagement with one another but are capable of movement under applied fluid forces. The layer of fibrous starting material is supported in a fiber rearranging zone in which fiber movement in directions parallel to the plane of said fibrous material is permitted in response to applied fluid forces. Streams of rearranging fluid, preferably water, are projected into the fibrous layer at entry zones spaced from each other adjacent one surface of the layer. These streams of rearranging fluid are passed through the layer of fibrous starting material as it lies in the rearranging zone, to effect movement of at least some segments of the fibers transverse to the direction of travel of the projected streams.

In the next step of the method, the passage of first portions of the rearranging fluid out of the fibrous layer is blocked at a barrier zone located adjacent the opposite surface of the fibrous layer, and, at the same time, those portions of fluid are deflected sidewise towards the other portions of the rearranging fluid and are actively mingled with the latter in discontinuous, permeable exit regions spaced from each other throughout the barrier zone. Each of the fluid exit regions has an area less than about one-half, and preferably only about one-quarter or less, of the area of one of the entry zones.

The passage of the rearranging fluid through the layer of fibrous starting material as just described moves some of the fiber segments that are in registry

with the continuous barrier zone into the fluid exit regions, and subjects them there to the action of the intermingled fluids. At the same time, the rearranging fluid moves some of the fiber segments that are in registry with the fluid entry zones into yarn-like bundles of closely associated and substantially parallel fiber segments in locations complementary to those entry zones. In addition, the rearranging fluid moves other fiber segments that are in registry with the barrier zone into substantial alignment in bridging positions extending between the discontinuous fluid exit regions, and between some of those regions and the yarn-like bundles of fiber segments just mentioned.

The result of this fiber rearrangement is a non-woven fabric having a first pattern of nubs of tightly packed, randomly oriented fiber segments in discontinuous portions of the fabric corresponding to the pattern of the fluid exit regions, a second pattern of yarn-like bundles of closely associated and substantially parallel fiber segments arranged in a pattern complementary to the entry zones, and a third pattern of flat, ribbon-like groups of substantially aligned fibers interconnecting portions of the fabric in the first pattern with each other, as well as interconnecting some of them with the yarn-like bundles in the second pattern.

In one form of the method and apparatus of this invention, the fibrous starting layer is supported on a backing means that is imperforate except for spaced permeable portions arranged in a discontinuous pattern, and an apertured forming means is positioned above the fibrous layer to provide a zone in which fiber movement in directions parallel to the backing means can occur in response to applied fluid forces. The area of each of the permeable portions of the backing means is less than about one-half, and preferably only about one-quarter or less, of the area of one of the apertures of the apertured forming means.

With a layer of fibrous starting material positioned between the elements just described, streams of rearranging fluid, preferably water, are projected through the apertures of the apertured forming means, against the layer of fibrous starting material, against the continuous imperforate portions of the backing means, and out through the discontinuous permeable portions of the backing means. At the discontinuous permeable portions of the backing means, the portion of the rearranging fluid that have struck the imperforate portions of the backing means, and have been deflected thereby, are actively mingled with other portions of rearranging fluid.

Under the influence of the forces applied by these streams of fluid, some of the fiber segments that are in registry with the continuous imperforate portions of the backing means are moved into areas of the fibrous layer overlying the permeable portions of the backing means and are subjected there to the action of the intermingled rearranging fluid. At the same time, some of the fiber segments that are in registry with the apertures of the apertured forming means are moved by the rearranging fluid into surrounding areas of the fibrous layer complementary to the apertures of the apertured forming means, where they are positioned in yarn-like bundles of closely associated and substantially parallel fiber segments. In addition, the rearranging fluid moves other fiber segments that are in registry with the continuous imperforate portions of the backing means into substantial alignment in bridging positions extending between the permeable portions of the backing means, and between some of the permeable portions and the yarn-like bundles of fiber segments just mentioned.

In the practice of this invention as just described, the rearranging fluid that passes through the fibrous material, and thereafter through the permeable portions of the backing means, forms a nonwoven fabric having three fiber patterns, all of which alternate and extend throughout the fabric. The first pattern is a pattern of nubs of tightly packed, randomly oriented fiber segments arranged in accordance with the pattern of arrangement of the discontinuous permeable portions of the backing means. The second is a pattern of yarn-like bundles of closely associated and substantially parallel fiber segments, arranged in accordance with the land areas of the apertured forming means. The third pattern is a pattern of flat, ribbon-like groups of substantially aligned fiber segments interconnecting portions of the fabric in the first pattern, and interconnecting some of those portions with the yarn-like bundles in a second pattern; this third pattern corresponds to the configuration of the continuous imperforate portions of the backing means.

When the apertures of the apertured forming means produce bundled rearrangement of fibers as in the first prior art method described above, every effort is made to avoid "flooding" of the fibrous starting layer caused by accumulation of excess fluid in the zone where rearrangement is taking place, and one of the means of avoiding such flooding is to provide a direct, rapid, and effective escape route for the streams of rearranging fluid after they have passed through the fibrous layer. But since the area of an individual permeable portion of the backing means in the present invention is less than half that of an individual aperture of the apertured forming means, this necessarily means that imperforate portions of the backing means of considerable extent underlie each forming aperture, where they would be expected to impede seriously the movement of the rearranging fluid away from the rearranging zone.

Still another factor that would be expected to interfere with the orderly and controlled fiber rearrangement necessary to produce a nonwoven fabric having a plurality of patterns that alternate and extend throughout the fabric is the marked imbalance in the magnitude of the fluid rearranging forces employed when, as in the present invention, one of the areas (i.e., a forming aperture) through which the fluid rearranging streams pass is at least about two times, and preferably about four or more times, as large as the other area through which the fluid passes (i.e., one of the permeable portions of the backing means). Such a great imbalance of rearranging forces would be expected to set up a grossly unequal "competition" between the two different types of fiber rearranging forces, and this would be expected to have a disruptive effect and make it impossible to achieve good fiber rearrangement.

Surprisingly, it has been found that neither the obstruction of the rearranging fluid provided by the imperforate portions of the backing means nor the great imbalance between competing fluid rearranging forces produces the undesirable results just described. On the contrary, the method and apparatus of this invention successfully combine the two types of fluid rearranging forces to bring about satisfactory fiber rearrangement of very dissimilar types, and thus produce an attractive

nowoven fabric having a plurality of patterns which alternate and extend throughout the fabric.

FURTHER DESCRIPTION OF INVENTION

The basic method and apparatus of this invention are shown and described fully in my U.S. Pat. No. 2,862,251, issued Dec. 2, 1958. Full particulars of the basic invention as disclosed in that patent are incorporated in this application by reference, although some of those particulars are repeated here. In addition, the specific features peculiar to the method and apparatus of the present invention — which for the method is the use of specified types of rearranging forces in a particular environment, and for the apparatus is the use of a backing means having permeable portions that are a specified number of times wider than the average diameter of the fibers of the fibrous starting material and at the same time have an area less than a specified fraction of each aperture of the apertured forming means with which the backing means is used — are described in detail in this application.

Starting material

The starting material used with the method or apparatus of this invention may be any of the standard fibrous webs such as oriented card webs, isowebs, airlaid webs, or webs formed by liquid deposition. The webs may be formed in a single layer, or by laminating a plurality of the webs together. The fibers in the web may be arranged in a random manner or may be more or less oriented as in a card web. The individual fibers may be relatively straight or slightly bent. The fibers intersect at various angles to one another such that, generally speaking, the adjacent fibers come into contact only at the points where they cross. The fibers are capable of movement under forces applied by fluids such as water, air, etc.

To produce a fabric having the characteristic hand and drape of a textile fabric, the layer of starting material used with the method or apparatus of this invention may comprise natural fibers such as cotton, flax, etc.; mineral fibers such as glass; artificial fibers such as viscose rayon, cellulose acetate, etc.; or synthetic fibers such as the polyamides, the polyesters, the acrylics, the polyolefins, etc., alone or in combination with one another. The fibers used are those commonly considered textile fibers; that is generally having a length from about ¼ inch to about 2 to 2½ inches. Satisfactory products may be produced in accordance with this invention from starting webs weighing between 80 grains per square yard to 2,000 grains per square yard or higher.

Apertured forming means

In one form of the method of this invention, and in the apparatus of this invention, the fluid entry zones into the fiber rearranging zone are defined by an apertured forming means.

The apertured forming means used with the method and apparatus of this invention has forming apertures disposed longitudinally and transversely across its area, with land areas lying between the apertures. The forming apertures may have any desired shape, i.e., round, square, diamond, oblong, free form, etc., and may be arranged in any desired pattern over the surface of the forming means.

The land areas of the apertured forming means that lie between and interconnect the forming apertures may be either narrow or broad in comparison to the forming apertures, as desired. Generally speaking, the narrower the land areas are, the more tightly compacted will be the yarn-like bundles of closely associated and substantially parallel fiber segments that are formed beneath those land areas. To produce yarn-like bundles of substantial weight, the width of each land area of the apertured forming means is equal to at least about 10 times the average diameter of the fibers of the fibrous starting material or 0.015 inch.

To provide room for the positioning of the nubs of tightly packed, randomly oriented fiber segments of the first pattern within the second pattern of yarn-like bundles of fiber segments, the area of each permeable portion of the backing means is less than about one-half, and preferably only about one-quarter or less, of the area of each aperture of the apertured forming means. To put it another way, the area of each forming aperture is at least about two times, and preferably about four or more times, the area of one of the permeable portions of the backing means.

The maximum size of each aperture of the apertured forming means is limited only by esthetic requirements.

Backing means having discontinuous permeable portions

As already indicated, in one form of this invention the fibrous starting layer is supported on backing means having permeable portions arranged in a discontinuous pattern and continuous imperforate portions that lie between and interconnect the discontinuous permeable portions to provide a barrier zone against the passage of rearranging fluid out of the layer of fibrous starting material.

The bridging of the imperforate portions of the backing means by aligned fiber segments referred to above that is produced by the practice of this invention is brought about by three factors — (1) good drainage of the rearranging fluid from the fiber rearranging zone with no uncontrolled washing away of fibers, (2) the accumulation and retention of groups of fiber segments to form nubs at spaced points across the backing means, and (3) the pulling taut of other fiber segments that extend between such nubs and are anchored by the nubs at a plurality of points along each fiber segment.

Good drainage is achieved by avoiding the use of too much rearranging fluid and by employing in the backing means discontinuous permeable portions of sufficient size and not too widely spaced. These permeable portions are large enough and closely enough spaced to each other that they occupy together at least 2 percent, and preferably five per cent or more, of the total area of the backing means.

Accumulation and retention of fiber segments to form nubs at spaced points across the backing means takes place when each permeable portion of the backing means is large enough that a group of fiber segments can be positioned there in tightly compacted, helter-skelter fashion. Thus, the width of each permeable portion of the backing means at its narrowest part; if the shape of the permeable portion is other than circular, or the diameter of the permeable portion if its shape is circular, is equal to at least about 25 times, and preferably 50 or more times, the average diameter of the fibers in the fibrous starting material; i.e., 0.04 inch and preferably 0.07 inch.

The pulling taut of fiber segments between adjacent groups in which they are anchored is achieved by limiting both the minimum and the maximum spacing of the permeable portions of the backing means. Thus, the spacing between a given pair of adjacent permeable portions of the backing means is large enough that a stream of rearranging fluid passing through a third permeable portion of the backing means that lies to one side of the axis between the given pair can get sufficient "purchase" on the intervening portion of a fiber extending between the two given permeable portions to bend that intervening fiber segment, and move it so that it extends between the two permeable portions by way of the third permeable portion. In addition, the spacing described is large enough that when a fiber is bent by fluid rearranging forces into a zigzag configuration that passes over a series of permeable portions of the backing means, the straight fiber segments oriented in successively different directions in that zigzag pattern are long enough for the eye of the viewer to be able to visually resolve the pattern of the fabric. To achieve these two purposes, immediately adjacent permeable portions of the backing means are spaced from each other by a distance equal to at least about 25 times, and preferably about 50 times, the average diameter of the fibers of the fibrous starting material; i.e., about 0.04 inch and preferably 0.075 inch.

At the same time, the spacing of adjacent permeable portions cannot be so wide as to prevent reliable anchoring of each fiber segment at two or more points along its length. To establish two reliable anchor points for each individual fiber segment, the permeable portions of the backing means should be spaced from other such portions immediately adjacent thereto by no more than about one-third the average length of the fibers being rearranged, and preferably no more than about one-fifth or one-sixth the length of the fibers. In general, this means that with 1½ inches staple length fibers, each pair of foraminous portions of the backing means should be spaced, at their closest points, no more than about one-half inch apart, and preferably no more than about one-fourth inch apart.

The maximum limit on the area of each permeable portion of the backing means is limited automatically by the requirement mentioned above that the area of each permeable portion of the backing means is less than about one-half and preferably less than about one-quarter, of the area of each aperture of the apertured forming means.

In plan view, the discontinuous permeable portions of the backing means may have any shape desired, i.e., circular, oval, diamond, square, etc. In addition they may be arranged in any desired pattern over the surface of the backing means.

Each permeable portion of the backing means may be a single opening separate from every other such opening, or each permeable portion may be a formaminous area comprised of a plurality of foramina. If the discontinuous permeable portion is foraminous, it may be flush with the imperforate portions of the backing means, or at a different elevation. If a three-dimensional effect is desired for the fiber grouping accumulated at each such foraminous portion of the backing means, the continuous imperforate portions of the backing means may lie above the foraminous portions by about one thrity-second inch or one-sixteenth inch, or in other words the foraminous portions may be depressed below the imperforate portions by that distance.

Generally speaking, with a foraminous portion at a lower elevation or with the permeable portion a single hole, the larger the area of that portion, the more pronounced will be the three-dimensional effect in the resulting fabric. The three-dimensional effect also increases with increased flexibility in the fibers being rearranged, since the more flexible a fiber is, the more easily it can conform to the lower elevation of the foraminous portions of the backing means or to the full opening of the single holes in the backing means.

During use of the method or apparatus of this invention, the apertured forming means and the backing means are spaced from each other to provide a fiber rearranging zone in which fiber movement in directions parallel to the backing means is permitted in response to applied fluid forces.

Rearranging fluid

The rearranging fluid for use with this invention is preferably water or a similar liquid, but it may be other fluids such as a gas, as described in my U.S. Pat. No. 2,862,251.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully described in connection with the accompanying drawings, in which:

FIG. **1** is a diagrammatic showing in elevation of one type of apparatus that can be employed in the present invention.

FIG. **2** is an enlarged diagrammatic plan view of a portion of a backing means that can be used in the apparatus of FIG. **1**, with the apertures of an apertured forming means that may be used with the backing means indicated in dashed lines.

FIG. **3** is a cross sectional view of the backing means of FIG. **2**, taken along the line **3—3** of that figure.

FIG. **4** is a perspective view of a portion of an apertured forming means that can be used in the practice of the present invention.

FIG. **5** is a photograph of a nonwoven fabric made in accordance with the present invention, shown in the original drawing at one-half actual size.

FIG. **6** is a photomicrograph of the nonwoven fabric of FIG. **5**, shown at an original enlargement of five times.

FIG. **7** is a photomicrograph of a cross sectional view of the nonwoven fabric of FIG. **5** taken along a line similar to that shown as line **7—7** in FIG. **6**, shown at an original enlargement of 10 times.

DETAILED DESCRIPTION OF SPECIFIC FORMS OF THE INVENTION

FIG. **1** shows one form of apparatus that may be used in accordance with the present invention. Full particulars of the basic apparatus of which this apparatus is a specific form, including methods of mounting, rotation, etc., are described in U.S. Pat. No. 2,862,251 issued Dec. 2, 1958, and are incorporated in the present application by reference and thus need not be described in complete detail here. in view of this reference, the apparatus of FIG. **1** will be described in general terms insofar as its essential elements are the same as in the patent just mentioned, and the novel features used to manufacture non-woven fabrics in accordance with the present invention will be described in more detail.

The apparatus of FIG. 1 includes a rotatable backing drum 15 suitably mounted on flanged guide wheels 17 and 18, which are mounted for rotation on shafts 25 and 26. The drum has open or permeable portions 19 uniformly spaced over its entire surface, with the remaining portions of the drum that lie between and interconnect the open portions constituting imperforate land areas 20.

Backing drum 15, as shown in FIG. 2, has a discontinuous pattern of foraminous portions 19 and a continuous pattern of imperforate portions 20 lying between and interconnecting them. In FIG. 2, the foraminous portions are round and arranged in a square pattern over the surface of drum 15. As already indicated above, the permeable portions of the backing member may have any shape desired. They may also be arranged in any discontinuous pattern over the support member; i.e., they may be aligned longitudinally and/or transversely, staggered, etc. FIG. 3 shows a cross section of the backing means of FIG. 2.

Outside the drum, a stationary manifold 27 to which a fluid is supplied through conduit 28 extends along the full width of the drum. On one side of the manifold is a series of nozzles 29 for directing the fluid toward the drum.

About the greater portion of the periphery of the drum there is positioned an apertured forming belt 30. Forming belt 30 has forming apertures 31 disposed across its surface, with land areas 32 between the forming apertures. These forming apertures may have any shape desired, and they may be arranged in any discontinuous pattern over the support member; i.e., they may be aligned longitudinally and/or transversely staggered, etc. In the apparatus of FIG. 1, forming apertures 31 are circular in shape and are arranged in a diamond pattern over the surface of forming belt 30.

FIG. 2 shows the entire perimeter of a single forming aperture 31 and portions of several other forming apertures 31 in dashed lines in place above backing means 15. Apertures 31 are arranged such that four of them form a diamond pattern on apertured forming means 30. The diameter of each circular aperture 31 in the embodiment shown in FIG. 2 is about nine times the diameter of each permeable portion of backing means 15, and thus the area of the former is about 80 times that of the latter. As shown, land areas 32 lie between each adjacent pair of forming apertures 31.

Forming belt 30 passes about drum 15 and separates from the drum at guide roll 33, which rotates on shaft 34. The belt passes downwardly around guide roll 35, rotating on shaft 36, and then rearwardly over vertically adjustable tensioning and tracking guide roll 37 rotating on shaft 38, and then around guide roll 39 on shaft 40. The member passes upwardly and around guide roll 41 rotating on shaft 42, to be returned about the periphery of the drum.

Backing drum 15 and apertured forming belt 30 provide a rearranging zone between them through which a fibrous starting material may move to be arranged, under the influence of applied fluid forces, into a nonwoven fabric having a plurality of patterns that alternate and extend throughout its area.

Tension on forming belt 30 is controlled and adjusted by the tensioning and tracking guide roll. The guide rolls are positioned in slideable brackets which are adjustable to assist in the maintenance of the proper tension of the belt. The tension required will depend upon the weight of the fibrous web being treated and the amount of rearrangement and patterning desired in the final product.

Backing drum 15 rotates in the direction of the arrow shown in FIG. 1, and apertured forming belt 30 moves in the same direction at the same peripheral linear speed and within the indicated guide channels, so that both longitudinal and lateral translatory motion of the backing means, the apertured forming means, and the fibrous layer with respect to each other are avoided. The fibrous material 43 to be treated is fed between the backing drum and apertured forming member 30 at point A, passes through a fiber rearranging zone where fluid rearranging forces are applied to it, and is removed in its new, rearranged form as nonwoven fabric 44 between the backing drum and apertured forming belt at point B.

As fibrous material 43 passes through the fiber rearranging zone, a liquid such as water is directed against the outer surface of apertured forming belt 30 by nozzles 29 mounted outside the drum, the water passes through apertures 31 of forming means 30 into the layer of fibrous starting material 43 to produce rearrangement of the fibers of the web and the water thence passes through permeable portions 19 of backing drum 15.

Vacuum assist box 45 is located inside rotating drum 15 opposite manifold 27 and nozzles 29. Vacuum box 45 has a slotted surface located closely adjacent the inner cylindrical surface of drum 15, and through which suction is caused to act upon the web. Suction thus applied assists in the rearrangement of the fibers as the web material passes through the rearranging zone. In addition, it serves to help dewater the web and prevent flooding during fiber rearrangement. A drain pan 46 is provided in order that water deflected by the outside of apertured forming belt 30 will be carried away from the machine.

In the apparatus of FIG. 1, the relative positioning of rotatable backing drum 15 and apertured forming means 30 with respect to the fibrous layer 43 being rearranged is maintained through the rearranging zone by guarding against either longitudinal or lateral translatory movement in the manner explained above. This maintains the integrity of the rearranged fabric as it is subjected to fluid forces from the rearranging liquid.

The directions the streams of rearranging fluid projected through apertures 31 of apertured forming means 30 take as they move into and through the fibrous web determine the type of forces applied to the fibers and, in turn, the extent of rearrangement of the fibers. Since the directions the streams of rearranging fluid take after they pass through apertures 31 are determined by foraminous portions 19 and imperforate portions 20 of support member or backing means 15, it follows that it is the pattern of these areas that determines the pattern of fiber arrangement, as well as the patterns of holes or other areas of low fiber density in the resultant fabric.

When backing means 15 and apertured forming means 30 are employed in the method or apparatus of this invention as shown in FIG. 2, streams of rearranging fluid passing through forming apertures 31 cause some of the fiber segments that are in registry with continuous imperforate portions 20 of backing means 15 to move into areas of fibrous layer 43 overlying permeable portions 19 of the backing means. The streams of

rearranging fluid also move some of the fibers in registry with forming apertures **31** into areas underlying land areas **32** between apertures **31**, and position them there in yarn-like bundles of closely associated and substantially parallel fiber segments. At the same time, the rearranging fluid moves other fiber segments that are in registry with imperforate portion **20** into substantial alignment in positions bridging the continuous imperforate portions of the backing means from one discontinuous permeable area **19** to another.

This fiber rearrangement produces a first pattern of nubs of randomly oriented fibers arranged in accordance with the pattern of arrangement of permeable portions **19** of backing means **15**, a second pattern of yarn-like bundles of fiber segments that corresponds with the pattern of substantially aligned fiber segments interconnecting the portions of the fabric in the first pattern with each other, as well as connecting some of them with the yarn-like bundles in the second pattern.

FIG. **4** is a perspective view of a portion of an apertured forming means that can be used in the practice of the present invention, if in the apparatus of FIG. **1** nozzles **29** are mounted inside the rotatable drum so that the streams of rearranging liquid are directed first against the inside of the drum. (Such an apparatus is basically similar to that illustrated in FIGS. 7 and 8 of U.S. Pat. No. 2,862,251, issued Dec. 2, 1958). In such case, the drum constitutes apertured forming means **30**, which as seen in FIG. **4** may comprise hexagonal shaped apertures **31** defined by land areas **32**.

With this embodiment of the apparatus of this invention, the endless belt of FIG. **1** serves as the backing means, being comprised of discontinuous, spaced permeable portions, with continuous imperforate portions lying between and interconnecting the permeable portions. The rearranging fluid from the spray nozzles is directed through apertures **31** of the drum formed as indicated in FIG. **4**, and then through the layer of fibrous starting material, some portions striking the imperforate portions of the backing belt and other portions moving toward the permeable exit regions of the backing belt. At those exit regions, all portions of the fluid are actively mingled, and pass out of the fiber rearranging zone through the permeable portions of the belt. The results of the use of apparatus as just outlined are described in the specific example given below.

The rearranged web or fabric produced by the practice of this invention may be treated with an adhesive, dye or other impregnating, printing, or coating material in a conventional manner. For example, to strengthen the rearranged web, any suitable adhesive bonding materials or binders may be included in an aqueous or non-aqueous medium employed as the rearranging fluid. Or an adhesive binder may, if desired, be printed on the rearranged web to provide the necessary fabric strength. Thermoplastic binders may, if desired, be applied to the fibrous web in powder form before, during or after rearrangement, and then fused to bond the fibers.

The optimum binder content for a given fabric according to this invention depends upon a number of factors, including the nature of the binder material, the size and shape of the binder members and their arrangement in the fabric, the nature and length of the fiber, total fiber weight, and the like. In some instances, because of the strength of the fibers used or the tightness of their interentanglement in the rearranged web or fabric, or both, no binder at all need be employed to provide a usable fabric.

The following is an illustrative example of the use of the method and apparatus of this invention to produce a patterned nonwoven fabric:

EXAMPLE

In apparatus basically similar to that illustrated in FIGS. **7** and **8** of U.S. Pat. No. 2,862,251, but operated in accordance with the specific mode of the present invention, a web **43** of loosely assembled fibers, such as may be obtained by carding, is fed between an apertured forming drum having a construction such as illustrated in FIG. **4** above, and a backing belt. The web weight is about 400 grains per square yard, and its fiber orientation ratio approximately 7 to 1 in the direction of travel. The web contains viscose rayon fibers approximately 1 9/16 inches long, of 1½ denier.

The metal apertured forming drum has hexagonal apertures each measuring, on the side of the drum adjacent the fiber rearranging zone, approximately five-sixteenths inch between opposite parallel sides. The hexagonal apertures are defined by strips of metal approximately one thirty-second inch thick and approximately 1 inch deep, arranged to form a rigid cylindrical drum with six side openings disposed throughout its surface. The one thirty-second inch or 0.033 inch thickness of the metal strips separates each hexagonal aperature from its immediately adjacent apertures by a distance equal to about 22 times the 0.0015 inch average diameter of 1½ denier fibers of the fibrous starting material.

The backing belt comprises a perforated plastic belt having approximately 74 holes or permeable portions per square inch. Each hole has a diameter of approximately 0.068 inch. The holes are arranged in a diamond pattern, with the distance between them at their points of closest spacing being about one-sixteenth inch or 0.063 inch, which is about 42 times the 0.0015 inch average diameter of the fibers of the fibrous starting material.

The width of each 0.068 inch hole or permeable portion of the backing belt is equal to about 45 times the average fiber diameter. The permeable portions of the backing means constitute about 9 percent of the total area of the backing means. The area of each hexagonal aperture of the apertured forming means is approximately 0.100 sq. in., or about 30 times the 0.0033 sq. in. area of each permeable portion of the backing belt.

Water is projected from nozzles within the rotating drum through the apertures in the apertured forming drum, and thence through the fibrous web and the backing belt.

After a given portion of fibrous web passes through the rearranging zone, in which streams of water are directed against it as just described, the rotation of the sandwich comprised of the apertured drum, the rearranged nonwoven fabric, and the backing belt brings the rearranged fabric over a vacuum drying means, which helps to remove the water remaining in the fabric. The rearranged fabric is then carried forward to the takeoff zone, where it leaves the apparatus.

With the conditions indicated, good fiber rearrangement and bundling are obtained, and an excellent nonwoven fabric such as shown in the photograph of FIG.

5, which has a plurality of patterns that alternate and extend throughout the fabric, is produced. FIG. 6 is a photomicrograph of the same fabric, showing a small portion thereof at an original enlargement of five times, and FIG. 7 gives a cross sectional view of the same fabric at an original enlargement of ten times.

Nonwoven fabric 50 of FIGS. 5 through 7 contains a first pattern of nubs of tightly packed, randomly oriented fiber segments 51, each of which nubs overlies a discontinuous permeable portion of the backing belt. The fabric also contains a second pattern of yarn-like bundles of closely associated and substantially parallel fiber segments 52, arranged in a pattern complementary to the hexagonal apertures of the forming drum. Finally, non-woven fabric 50 contains a third pattern of flat, ribbon-like groups of substantially aligned fiber segments 53. These latter groups of fiber segments interconnect nubs of fiber segments 51 with each other, as well as interconnecting some of them with the yarn-like bundles 52.

The non-woven fabric of this example has excellent properties, and the three patterns of groups of fiber segments that alternate and extend throughout the area of the fabric contribute substantially to the esthetic appearance of the product.

The above detailed description has been given for clearness of understanding only. No unnecessary limitations are to be understood therefrom, as modifications will be obvious to those skilled in the art.

I claim:

1. Apparatus for producing a patterned nonwoven fabric having a plurality of patterns that alternate and extend throughout said fabric, from a layer of fibrous starting material whose individual fibers are in mechanical engagement with one another but are capable of movement under applied fluid forces, which comprises: backing means having portions that are permeable and portions that are imperforate, said permeable portions being arranged in a discontinuous pattern, and the remainder of said backing means being imperforate and lying between and interconnecting said discontinuous permeable portions, each of said permeable portions having a width at its narrowest part of at least 0.04 inch and being spaced from adjacent permeable portions by a distance of from 0.04 inch to 0.5 inch; apertured forming means spaced from said backing means to provide a zone in which fiber movement in directions parallel to said backing means is permitted in response to applied fluid forces, the apertures in said forming means being longitudinally and transversely spaced with land areas therebetween, the distance between immediately adjacent apertures being at least .015 inch, each of said permeable portions of the backing means having an area less than about one-half the area of one of said apertures of the apertured forming means; means for moving said backing means and apertured forming means, with a layer of fibrous starting material positioned therebetween, through a rearranging zone without any translatory movement between said two means and the fibrous layer; and means for projecting streams of fluid through said apertures in the apertured forming means, and then against the fibrous layer to pass therethrough, and thereafter through and beyond said permeable portions of the backing means.

2. The apparatus of claim 1 in which the area of each of said discontinuous permeable portions of the backing means is less than about one-quarter of the area of one of said apertures in the apertured forming means.

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