

[54] **METHOD AND APPARATUS (CONTINUOUS IMPERFORATE PORTIONS ON BACKING MEANS OF OPEN SANDWICH)**

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Related U.S. Application Data

[63] Continuation of Ser. No. 22,314, March 24, 1970, abandoned.

[52] U.S. Cl. **19/161 P**
[51] Int. Cl. **D04h 11/00**
[58] Field of Search 19/161 P; 28/72 NW; 161/169, 109

References Cited

UNITED STATES PATENTS

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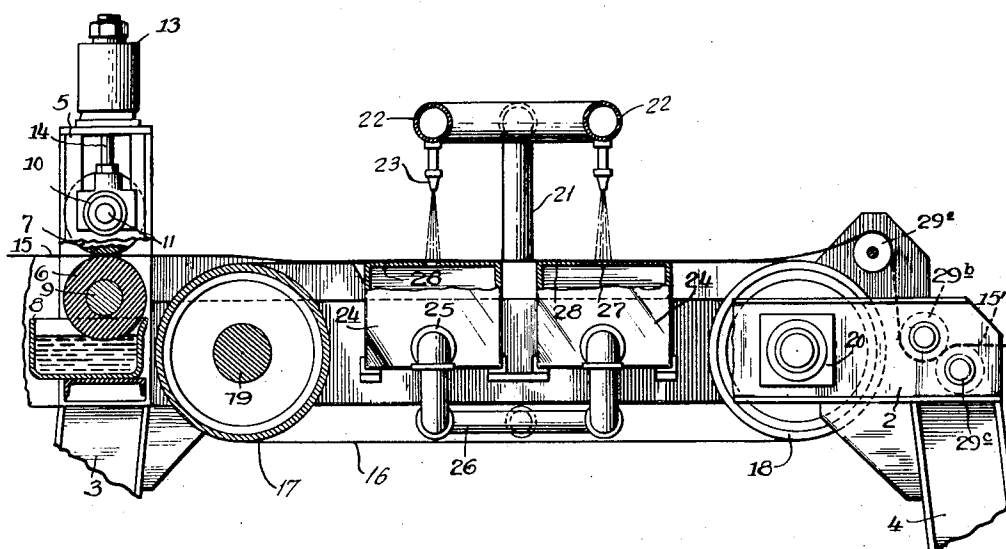
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[57] **ABSTRACT**

A method and apparatus for producing, from a layer of fibrous material such as a fibrous web, nonwoven fab-

rics 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 supporting the starting web upon a backing means that is imperforate except for a discontinuous pattern of foraminous portions that have protuberances and troughs alternating across them, then directing fluid rearranging forces substantially uniformly and continuously across the surface of the web, causing some of the fluid streams to strike the imperforate portions of the backing means, and others to strike the protuberances on the foraminous portions of the backing means, to deflect the same, all of the fluid streams ultimately passing through the foraminous portions of the backing means. Each discontinuous foraminous portion extends along the surface of the backing means in each direction a distance that includes at least one protuberance and a trough on each side thereof. The imperforate portions of the backing means may rise above the foraminous portions. The resulting fabric consists of fibers that have been rearranged to provide a first pattern of yarn-like bundles of fiber segments in discontinuous portions of the fabric, which bundles define areas of low fiber density arranged in accordance with the pattern of arrangement of the protuberances on the foraminous portions of the backing means, and a second pattern of groups substantially aligned fiber segments extending between and interconnecting adjacent pairs of the discontinuous portions of the fabric in the first pattern.

2 Claims, 13 Drawing Figures



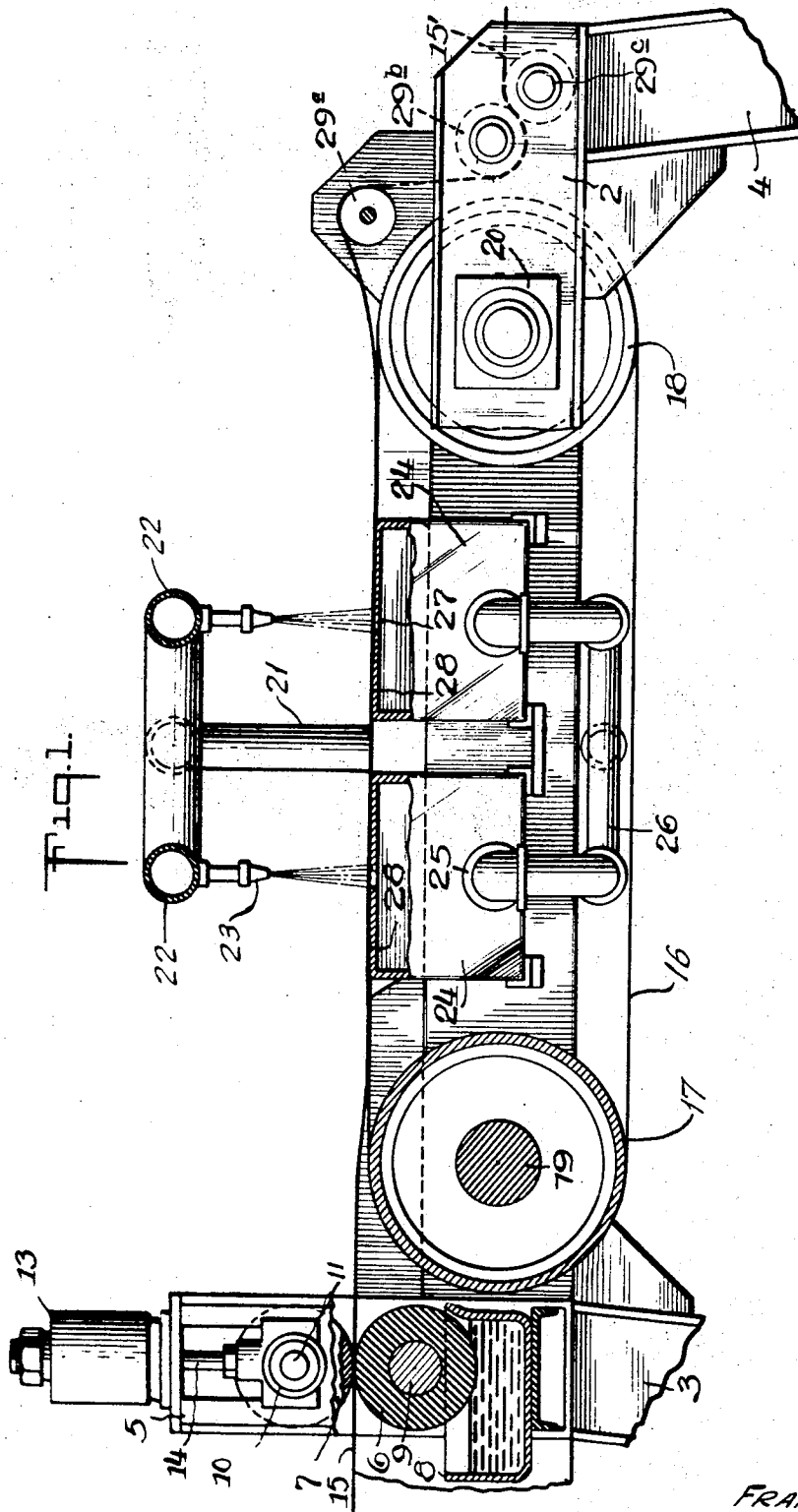


Fig. 1.

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Fig. 2.

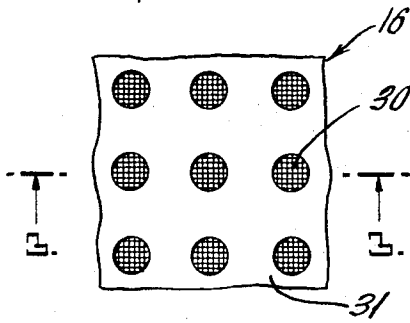


Fig. 3.

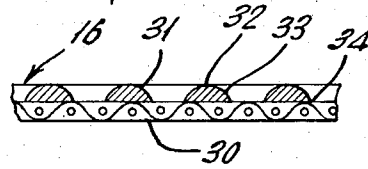


Fig. 4.

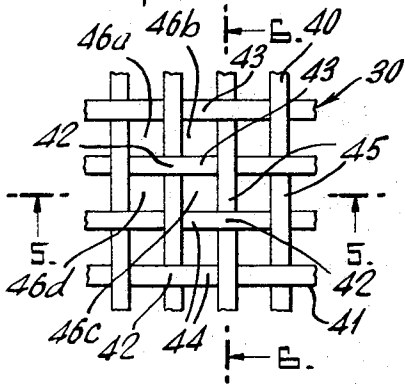


Fig. 5.

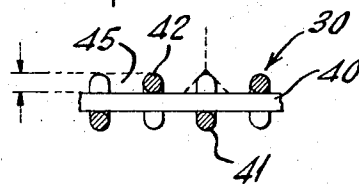
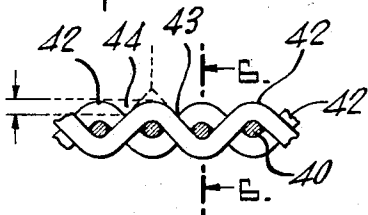


Fig. 6.



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Fig. 7

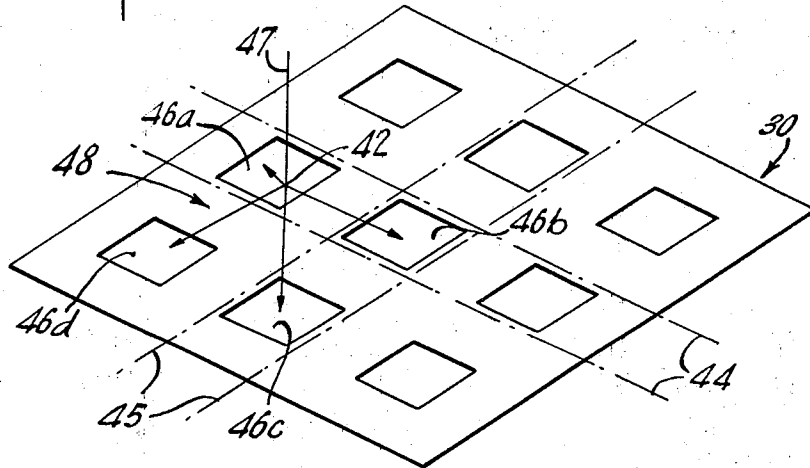
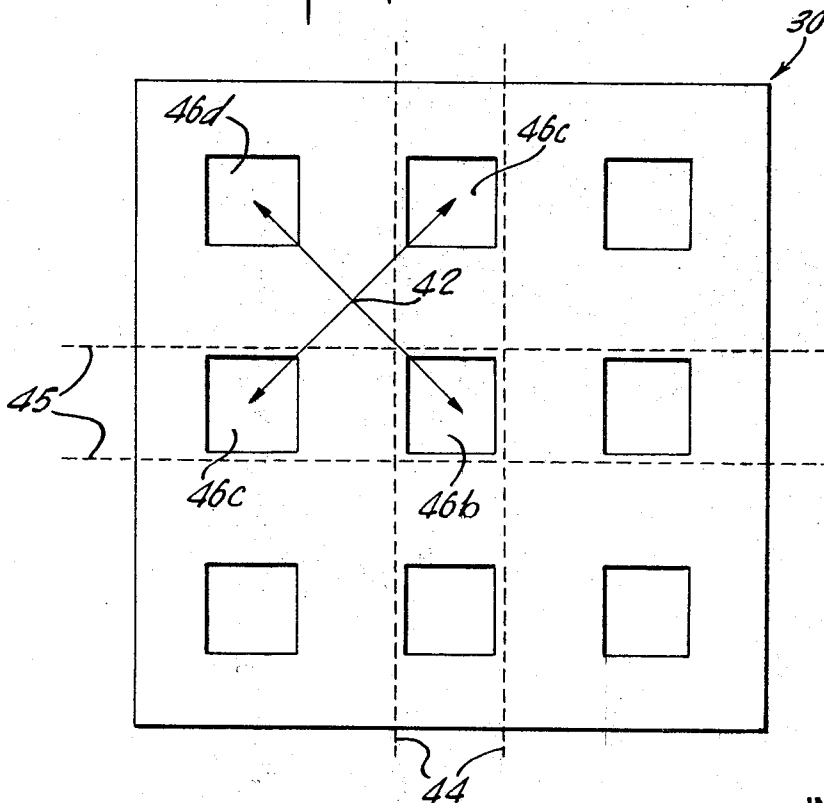
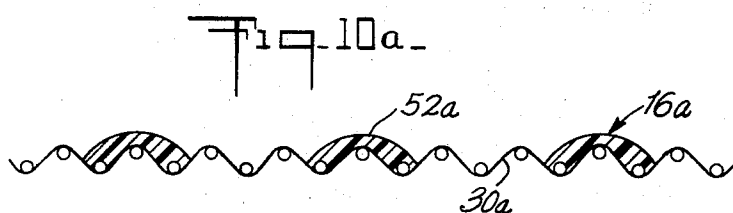
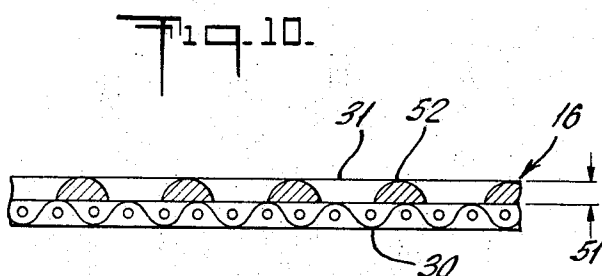
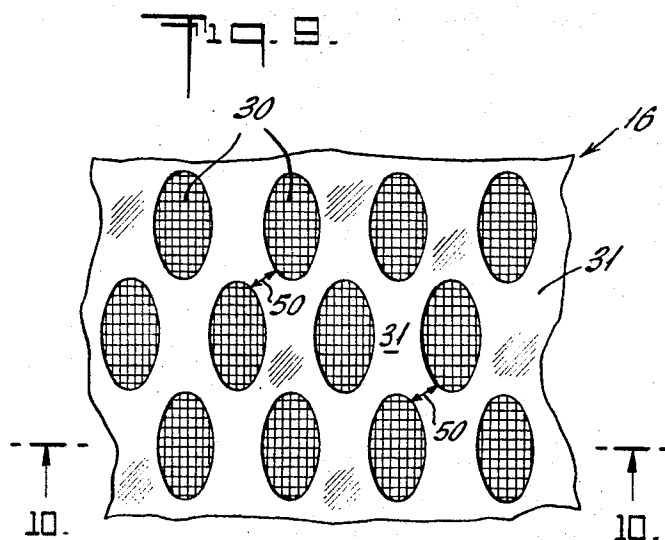


Fig. 8



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Fig 11

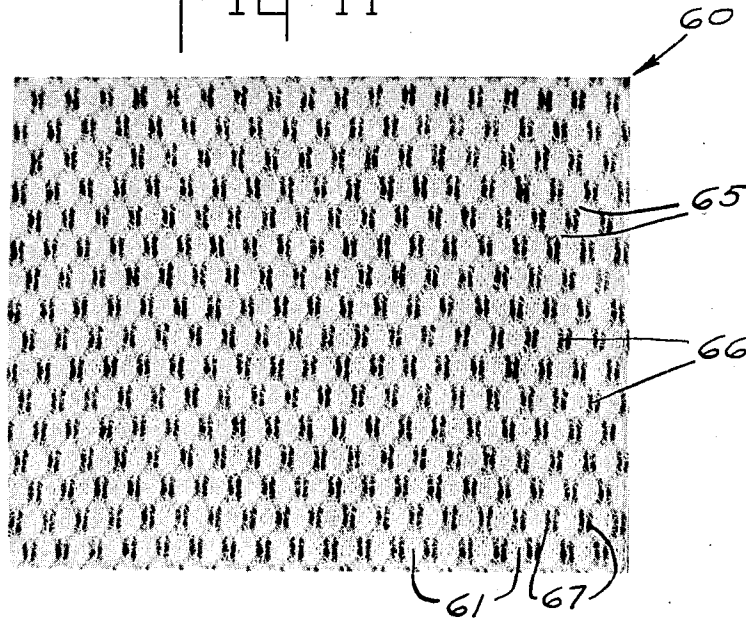
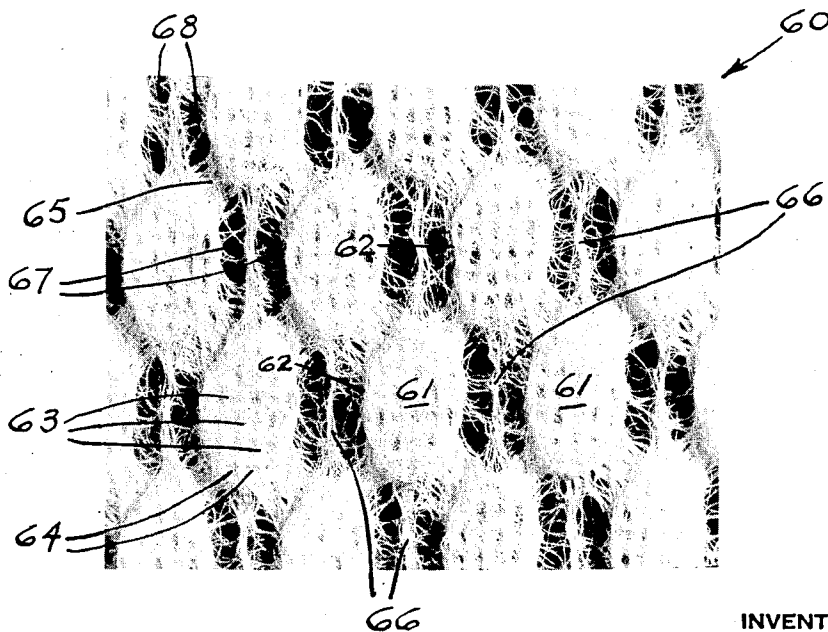


Fig 12



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METHOD AND APPARATUS (CONTINUOUS IMPERFORATE PORTIONS ON BACKING MEANS OF OPEN SANDWICH)

This is a continuation application of my co-pending application Ser. No. 22,314, 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 nonwoven fabrics made by the methods and apparatus disclosed in those patents contain apertures or 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 in this specification and claims to include both (1) areas in which relatively few fibers are found in comparison to the rest of the fabric, and (2) apertures (holes) that are substantially or entirely free of fibers.)

One of the specific known methods for producing rearranged nonwoven fabrics is to support a loose fibrous web or layer upon a formaminous backing member that has protuberances spaced across its surface, with troughs or low areas between the protuberances. Streams of rearranging fluid are applied substantially uniformly and continuously over the entire surface of the loose fibrous web or layer, and after the streams pass through the fibrous material some of them strike the protuberances on the backing means and are diverted in sidewise directions to cause fiber segments to move from the area adjacent the high point of each protuberance into the immediately adjacent troughs. All the streams then pass through the openings in the foraminous backing means and leave the rearranging zone.

The effect of these fluid rearranging forces is to pack groups of fiber segments into interconnected yarnlike bundles of closely associated and substantially parallel fiber segments and to position them in the troughs on the backing means so as to define a pattern of areas of low fiber density throughout the resulting nonwoven fabric.

In this prior art method, the backing member is uniformly permeable throughout its area in order to provide an unimpeded route by which the streams of rearranging fluid can be quickly carried away after they have moved fiber segments from the protuberances

into the troughs of the backing means. Care is always taken in any fluid rearrangement to avoid loss of web identity through "flooding" (U.S. Pat. No. 2,862,251, col. 2, line 60 to col. 3, line 12), and with the specific prior art method under discussion it is said to be essential that the backing member be "permeable to the passage of fluid from the applied streams, so that the fluid may pass freely through the backing member and away from the layer of fibers rather than having some or all of the fluid reflected back in the same general direction from which it is applied" (U.S. Pat. No. 3,025,585, col. 2, lines 38-48).

Another known method for producing rearranged nonwoven 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.

A significant feature of this 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 fiber accumulations, with the individual fibers thereof having entirely random orientation.

Another significant feature of this second method is that the apertures in the otherwise solid backing means, if they are single openings, cannot be too large or fibers will be washed through the apertures and the fabric will be destroyed.

SUMMARY OF THE INVENTION

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

Thus, I have discovered that one can block off continuous portions of substantial size of the otherwise permeable backing or support member in the first prior art method described, to interrupt and impede the flow of rearranging fluid through the backing member, and still not impede satisfactory fiber rearrangement brought about by the impact of the rearranging fluid against the protuberances on the backing means, to be deflected sidewise and thereby move fibers of the fibrous starting material into a rearranged nonwoven fabric having well defined areas of low fiber density. And one can at the same time mix the controlled rearranging forces of that first method with the turbulent forces that are characteristic of the second prior art method, and still maintain the integrity of both types of fiber rearrangement in the very same nonwoven fabric.

Moreover, the size of the apertures defined by the continuous solid portions of the backing member in the combined method is no longer limited by the danger of washing fibers through the backing means, and those apertures can be made just as large as is required for any desired pattern of this particular type in the resulting nonwoven fabric.

In the practice 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 that has an entry side and an exit side and in which fiber movement in directions parallel to the plane of the fibrous material is permitted in response to applied fluid forces. The fiber rearranging zone is subdivided into deflecting regions that are arranged in a discontinuous pattern, and barrier regions that are continuous and lie between and interconnect the deflecting regions.

Streams of rearranging fluid, preferably water, are projected into the fibrous starting material substantially uniformly and continuously across its surface, in a direction perpendicular to the fibrous layer at the entry side of the rearranging zone. The streams of rearranging fluid are comprised of three categories — first portions that pass through the deflecting regions of the rearranging zone, second portions that pass through the barrier regions, and third portions that pass through the deflecting regions but in a different manner from the first portions.

The first portions of the rearranging fluid are passed through the initial part of each deflecting region as the layer of fibrous starting material lies in said region, toward at least one dispersal point in the deflecting region adjacent the exit side of the rearranging zone. Each of these dispersal points is surrounded by fiber accumulating zones.

At each dispersal point, the first portions of rearranging fluid are deflected diagonally and downwardly away from the perpendicular direction of their entry into the rearranging zone, and are moved into the area immediately surrounding the dispersal point. This movement of the rearranging fluid moves fiber segments lying adjacent the dispersal point into the area around that point, and positions them there in yarn-like bundles of closely associated and substantially parallel fiber segments. At least some of these yarnlike bundles lie in fiber accumulating zones that are located in peripheral portions of the deflecting regions, and when there is a plurality of dispersal points in a single deflecting region, some of the yarn-like bundles lie in accumulating zones that are located between immediately adjacent dispersal points.

The second portions of rearranging fluid are passed through the parts of the layer of fibrous starting material that lie in the continuous barrier regions of the fiber rearranging zone, and cause movement of at least some segments of the fibers in those regions transverse to the direction of travel of the projected streams. At the exit side of the rearranging zone, the passage of these second portions of rearranging fluid out of the parts of the fibrous layer that lie in the barrier regions is blocked, and the fluid is deflected sidewise into the discontinuous deflecting regions of the rearranging zone. This movement of the rearranging fluid moves some of the fiber segments that lie in the barrier regions into at least

some of the yarn-like bundles of closely associated and substantially parallel fiber segments mentioned above. At the same time, it moves other fiber segments lying in the barrier regions into substantial alignment with each other in bridging positions extending between adjacent discontinuous deflecting regions.

The first and second portions of the rearranging fluid that have been deflected as described are then actively mingled, and the intermingled fluid is passed out of the fiber rearranging zone through spaced exits in the deflecting regions at the exit side of the rearranging zone. At the same time, third portions of fluid are intermingled with the first and second portions, to be passed out of the same exits. The third portions of fluid are projected into the fibrous starting material and are moved to the exits referred to without passing through a dispersal point or a barrier region.

To assist in moving all the rearranging fluid through the layer of fibrous starting material and in rearranging the fiber segments of that layer, a vacuum is applied at the exit side of the fiber rearranging zone.

The result of application of the fluid rearranging forces just described is to form a nonwoven fabric having a first pattern of yarn-like bundles of fiber segments in discontinuous portions of the fabric, which bundles define areas of low fiber density arranged in accordance with the pattern of arrangement of the dispersal points in the deflecting regions of the fiber rearranging zone, and a second pattern of flat, ribbon-like groups of substantially aligned fiber segments extending between the interconnecting pairs of immediately adjacent discontinuous portions of the fabric in the first pattern.

In one form of the method and apparatus of this invention, the fibrous starting layer is supported on backing means having foraminous portions arranged in a discontinuous pattern, with continuous imperforate portions lying between and interconnecting the foraminous portions. The discontinuous foraminous portions of the backing means include protuberances the troughs alternating across the surface of such portions in both the longitudinal and the transverse directions. Each of the foraminous portions extends along the surface of the backing means a distance that includes at least one of the protuberances and a trough on each side of the protuberance. There is no maximum limit on the size of the discontinuous foraminous portions except what is required to achieve the desired pattern in the resulting nonwoven product.

Each imperforate portion of the backing means may, if desired, rise above the top surface of the foraminous portions of the backing means. However, they may if desired be flush with that surface, depending upon the type of rearranged fabric that is to be produced. If the imperforate members are higher than the foraminous portions of the backing means, the central portions of the imperforate members are preferably higher than the edge portions thereof.

In the practice of this invention, streams of rearranging fluid, preferably water, are applied substantially uniformly and continuously across the surface of the layer of fibrous starting material as it is supported on the backing means just described. The streams pass through the fibrous layer and strike the backing or support means, some striking the imperforate portions of the backing means and others striking the protuberances on the foraminous portions of the backing

means. In either case, the streams are deflected in side-wise directions and join other streams of rearranging fluid that pass through the openings of the discontinuous foraminous portions of the backing means without striking the backing means. A vacuum is applied on the opposite side of the backing means from the layer of fibrous starting material, to assist in moving the rearranging fluid through that layer and in rearranging the fibers of the layer.

As the various streams of rearranging fluid follow their courses described, they cause fiber segments that overlie each protuberance on the foraminous portions of the backing means to move into the troughs surrounding the protuberance, and to be positioned there in yarnlike bundles of closely associated and substantially parallel fiber segments. At the same time, the streams of rearranging fluid cause some of the fiber segments that overlie the continuous imperforate portions of the backing means to be moved into the adjacent areas of the fibrous layer that overlie the discontinuous foraminous portions of the backing means, and to be positioned there, under the influence of the protuberances on the foraminous portions, in the yarn-like bundles of closely associated and substantially parallel fiber segments that, as just mentioned, are formed in the troughs surrounding the protuberances. Meanwhile, the streams of rearranging fluid move other fiber segments that overlie the continuous imperforate portions of the backing means into substantial alignment in positions bridging those imperforate portions.

The result of these actions of the rearranging fluid is to produce a nonwoven fabric having two patterns of fiber segments that alternate and extend throughout the fabric. The first pattern is a pattern of yarnlike bundles of fiber segments in discontinuous portions of the fabric, which yarn-like bundles define areas of low fiber density arranged in accordance with the pattern of arrangement of the protuberances on the discontinuous foraminous portions of the backing means. The second is a pattern of flat, ribbon-like groups of substantially aligned fiber segments interconnecting the portions of the fabric in the first pattern; this pattern corresponds to the configuration of the continuous imperforate portions of the backing means.

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 feature peculiar to the method and apparatus of the present invention — which is the provision of deflecting regions arranged in a discontinuous pattern, each such region including dispersal points surrounded by fiber accumulating zones (for example, discontinuous foraminous portions of a backing means which have alternating protuberances and troughs) in a fiber rearranging zone the remainder of which is comprised of continuous barrier regions to block and deflect portions of the streams of rearranging fluid at the exit side of the rearranging zone (defined, for example, by continuous imperforate portions lying between and interconnecting the discontinuous foraminous portions of a backing means) — is 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, air-laid 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 fibers having a length from about one-fourth 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. With heavier web weights, as discussed below, the difference in elevation between the dispersal points and the fiber accumulating zones in the deflecting region of a fiber rearranging zone (for example, the protuberances and troughs, respectively, on the foraminous portions of a backing means) must be more pronounced in order to achieve the bundling that is a necessary part of this invention.

Discontinuous foraminous portions of backing means. As already indicated, in one form of this invention a backing means is employed that has discontinuous portions that are foraminous and continuous imperforate portions lying therebetween to provide barrier regions in the fiber rearranging zone. The discontinuous foraminous portions of the backing means are provided with a plurality of protuberances and troughs that alternate throughout their surfaces, and thus comprise deflecting regions containing dispersal points each of which is surrounded by fiber accumulating zones.

As illustrated in the drawings below, for improved results the tops of the protuberances rise above the bottoms of the immediately adjacent troughs by a distance equal to at least about three times the average diameter of the fibers in the layer of fibrous starting material or at least 0.005 inch. Preferably, the distance is equal to about ten times the average diameter of those fibers, especially when the web weight of the fibrous starting material is of the order of 800 grains per square yard or higher. It also becomes more important to have prominent protuberances on the foraminous portions of the backing means the greater is the width of the imperforate portions of the backing means, since a wide imperforate portion increases the number of loose fiber ends that will be washed off those imperforate portions to be added to the fibrous web already lying above the foraminous portions of the backing means.

The fibrous starting material used with the method and apparatus of this invention is comprised of closely

intertwined and interentangled fibers arranged (depending upon the degree of fiber orientation in the layer) in a more or less helter-skelter fashion. Some of the fibers of the starting material will by random chance lie generally parallel to the troughs on the foraminous portions of the backing means over which they lie, but the great majority of the fibers will lie at an angle to the longitudinal axes of the troughs, and a substantial number of these will lie at angles of 45° or more to such an axis.

In the practice of this invention, the movement of fiber segments into closer association and substantial parallelism with each other in yarn-like bundles in the troughs of the backing means is more likely to occur with those fiber segments in the starting material that already lie only a relatively few degrees away from a position parallel to the longitudinal axis of a trough. To put it the other way, this type of movement is more difficult the greater the angle between a given fiber segment and the axis of the trough, and when fiber segments lie at too great an angle to the longitudinal axis of a trough, they simply continue to lie at that angle, matted down against the backing means by the force of the rearranging fluid. For the greater the angle between the fiber segment and the trough axis, the shorter is the portion of the fiber that bridges the trough, and the more difficult it is for the rearranging fluid forces to get a "purchase" on the fiber segment to turn it around into a position parallel with the trough axis.

Likewise, the narrower the troughs are on the backing means, the more difficult it is for the rearranging fluid forces to get a "purchase" on the short portion of the fiber segment that bridges the trough, to swing that segment around into a position parallel to the axis of the trough to be consolidated there to form a yarn-like bundle with other similarly positioned fiber segments. The force of the vacuum assist employed with this invention is of course added to the force of the other rearranging fluid. With the use of a vacuum assist, the distance between immediately adjacent protuberances on the backing means, which determines the width of a trough from the top of one side to the other, is ordinarily equal to at least about 15 times the average diameter of the fibers of the fibrous starting material or at least 0.025 inch.

The minimum spacing of protuberances just mentioned, which affects the width of the troughs lying between immediately adjacent protuberances, also assists in providing good visual resolution between various yarnlike bundles of fiber segments in the fabric resulting from the practice of this invention. For if the protuberances are too closely spaced and the troughs between them are too narrow, yarnlike bundles of fiber segments may be accumulated in the troughs but will not be discernible one from the other, because each one merges into the next adjacent similar bundle of fiber segments. If the web weight of the fibrous starting material is high, the distance between immediately adjacent protuberances on the backing means should be increased, or otherwise the yarn-like bundles of fiber segments will be masked out by the same merging phenomenon just mentioned.

The discontinuous foraminous portions of the backing means are of sufficiently large area that, with the appropriate web weight in the starting material, good formation of yarnlike bundles of fiber segments can be effected above those foraminous portions. Thus, each

discontinuous foraminous portion extends in each direction along the surface of the backing means a distance that includes at least one protuberance and a trough on each side of the protuberance. This minimum size for the discontinuous foraminous portions of the backing means produces a minimum of one well defined hole or other area of low fiber density corresponding to the protuberance on the backing means, with yarnlike bundles of fiber segments positioned in the troughs surrounding the protuberance.

There is no maximum limit on the area of the foraminous portions of the backing means. That area is determined only by the pattern desired in the nonwoven fabric to be produced. Thus, the width of a discontinuous foraminous portion may be as much as five or 10 times the horizontal distance between adjacent troughs, or even more.

The foraminous portions of the backing means used in this invention are closely enough spaced to each other that they occupy together at least about 20 percent, and preferably about 30 percent or even more, of the total area of the backing means.

Continuous imperforate portions of backing means. The continuous imperforate portions of the backing means may have any shape desired, i.e., they may be formed of lines that are diagonal, perpendicular, curved, free form, etc. Their shape is complementary, of course, to the shapes of the discontinuous foraminous portions which they lie between and interconnect.

The continuous imperforate portions of the backing means may be flush with the top surface of the foraminous portions of the backing means, or at a different elevation. If a three-dimensional effect is desired for the fiber grouping accumulated at each foraminous portion of the backing means, the continuous imperforate portions of the backing means may be raised above the top surface of the foraminous portion of the backing means by about one thirty-second inch or one-sixteenth inch or even more, depending upon the web weight and how much three-dimensional effect is desired. The higher the imperforate portions rise above the foraminous portions of the backing means, the more marked the three-dimensional character of the resulting fabric will be.

In addition, with a foraminous portion at a lower elevation, generally a medium sized area for the foraminous portion of the backing means produces a more pronounced three-dimensional effect in the resulting fabric than an area for such portion that is too small or too large. 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.

In the practice of this invention, fiber segments are aligned in bridging positions between discontinuous portions of the nonwoven fabric containing yarn-like bundles of fiber segments by pulling them taut between adjacent groups in which they are anchored. This anchoring and pulling taut of fiber segments, with their resulting alignment in flat, ribbon-like groups of fiber segments, is achieved by limiting the maximum spacing between adjacent foraminous portions of the backing means. To establish two reliable anchor points for each individual fiber segment, the foraminous portions of the backing means are 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 $1\frac{1}{2}$ staple length fibers, each pair of foraminous portions of the backing means are spaced, at their closest points, no more than about one-half inch apart, and preferably no more than about one-fourth inch.

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

Application of vacuum. The vacuum applied to the opposite side of the backing means simultaneously with the application of fluid rearranging forces to the fibrous starting layer is of the order of about 1 inch to about 4 inches of mercury, preferably 2 inches of mercury.

Additional vacuum may be used to advantage after the rearranged fabric has moved out of the rearranging zone, in order to help remove excess liquid from the fabric before the fabric is removed from the backing means.

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 may 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.

FIG. 3 is a cross sectional view taken along the line 3—3 of FIG. 2.

FIG. 4 is an enlarged fragmentary diagrammatic plan view of one of the foraminous portions of the backing means of FIG. 2.

FIG. 5 is a cross sectional view taken along line 5—5 of FIG. 4.

FIG. 6 is a cross sectional view taken along line 6—6 of FIGS. 4 and 5.

FIG. 7 is a schematic perspective representation of the paths followed by various streams of rearranging fluid as they pass through the foraminous member shown in FIGS. 4 through 6.

FIG. 8 is a schematic plan representation of the paths followed by the streams of rearranging fluid shown in perspective in FIG. 7.

FIG. 9 is an enlarged diagrammatic plan view of a portion of a backing means that can be used in the apparatus of FIG. 1.

FIG. 10 is a cross sectional view taken along the line 10—10 of FIG. 9.

FIG. 10a is a cross-sectional view of a preferred embodiment of a backing member useful in the practice of the present invention.

FIG. 11 is a photograph of a nonwoven fabric made in accordance with the present invention, shown in the original drawing at actual size.

FIG. 12 is a photomicrograph of the nonwoven fabric of FIG. 9, shown at an original enlargement of five times.

DETAILED DESCRIPTION OF SPECIFIC FORM OF THE INVENTION

FIG. 1 shows one form of apparatus that may be used in accordance with the present invention.

In this apparatus, horizontal frame members 2 are supported by legs 3 and 4. At the feed end of the machine (on the left hand side of FIG. 1), a pair of vertical frame members 5 extend upwardly above horizontal frame members 2, with a pair of wet-out rolls 6 and 7 rotatably mounted between them. Wet-out roll 6 is partially immersed in a water pan 8, and its shaft 9 is journaled in bearings (not shown) fixed to vertical frame members 5. Bearings 10, in which shaft 11 of wet-out roll 7 is journaled, are slidably mounted on vertical frame members 5.

The vertical position of wet-out roll 7 is adjustable, and is regulated by hydraulic positioning cylinders 13 mounted on the top of each vertical frame member 5.

In this way, the pair of wet-out rolls 6 and 7 cooperate to control the moisture content of a web or layer of fibrous material, of a type such as mentioned above as being a suitable starting material, that is fed through the nip between the wet-out rolls. Preferably the moisture content of the layer of fibers it is moved from the wet-out rolls is in the neighborhood of from 150 to 200 percent. (The term "percent moisture," when used in this specification, refers to percentage of moisture by weight of the dry web.)

The layer of fibers moves from the nip of the wet-out rolls to the fiber rearranging zone of the apparatus to effect the rearrangement of the fibers in the starting web or layer 15, to produce a rearranged fibrous web or layer 15' having a plurality of patterns of groups of fiber segments and areas of low fiber density as described above. Thus the starting layer of fibers moves from the wet-out rolls to be supported on a backing means in the form of endless belt 16 (described in detail below), which extends around a pair of parallel rolls 17, 18 rotatably mounted adjacent opposite ends of the frame. Each of the rolls 17, 18 is mounted on a shaft 19, the ends of which are journaled in bearings 20 carried on horizontal frame members 2. Conventional driving means (not shown) are connected to either one of shafts 19.

A water pipe 21, mounted in any suitable manner, supports a pair of headers 22 above the upper reach of endless belt 16. Each header extends transversely of belt 16, and has a row of jet nozzles 23 to provide water sprays across the width of that belt.

A pair of suction boxes 24 are mounted on and extend transversely across frame members 2 between the rolls 17 and 18 which carry endless belt 16, with one of the boxes located directly beneath each row of jet nozzles 23. Each suction box is closed on all sides except for an opening 25 to which a vacuum line 26 is connected, and a slot or group of perforations 27 which extend across top wall 28 of the suction box. The top wall of each suction box is positioned adjacent the underside of the upper reach of endless belt 16.

Nonwoven fabric 15', after rearrangement but before reaching the position where endless belt 16 starts to track around roll 18, is lifted off the belt by causing it to pass upwardly and over a horizontal cylindrical doffing member 29a that extends transversely of the machine and is supported at its ends in the side frame. The fabric then passes downwardly and around through the nip between guide rolls 29b and 29c on its way to a suitable drying area (not shown). Guide rolls 29b and 29c are parallel to doffing member 29a, and like it are supported at their ends in the side frame members of the machine.

Backing means. Endless belt or backing means 16, as shown in FIG. 2, has foraminous portions 30 arranged in a discontinuous pattern, and continuous imperforate portions 31 lying between and interconnecting the discontinuous foraminous portions. In FIG. 2, the foraminous portions are round and arranged such that four of them lie in a square pattern over the surface of the backing means, the remainder of the member being imperforate. As already indicated above, the foraminous portions of the backing member may have any shape desired. They may also be arranged in any discontinuous pattern over the backing means, 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. As seen, each continuous imperforate portion 31 of backing means 16 has a curved top surface that rises slightly above the top surface of foraminous portions 30 of the backing means. Because of the curved top surface, central portion 32 rises above edge portions 33 of each imperforate portion 31 of the backing means. Extreme edge portions 34 of each imperforate portion 31 are slightly rounded.

In FIG. 10a there is shown a cross-sectional view of a preferred embodiment of a backing means 16a in accordance with the present invention. In this embodiment the permeable portion of the backing means 30a has superimposed on it impermeable portions 52a. The outer edges of the impermeable portions terminate in substantially the same place as the permeable portions whereas the central portion of the impermeable portions rise above the high points or protuberances of the permeable portions.

Discontinuous foraminous portions 30, as shown in FIGS. 4 through 6, are formed of a coarse woven screen, preferably metal. In the embodiment shown, wires 40 running vertically in FIG. 4 are straight, while wires 41 running horizontally in that figure weave alternately over and under wires 40. Protuberances 42 are present throughout foraminous portion 30 as the top-most part of each "knee" of a given strand 41 of the screen that is formed as the strand weaves over and under the strands 40 that lie perpendicular to it.

As a given strand 41 slants downward to pass under a strand 40 perpendicular to it, it crosses two other strands 41 disposed on either side of it, as those strands slant upward to pass over the same perpendicular strand that the given strand will pass under. Each series of such "crossing points" 43 form a trough, such as trough 44 in FIGS. 4 and 5, that lies between adjacent protuberances 42. The effective cross sectional shape of troughs 44, as can be best seen in FIG. 5 (which shows a cross section of element 30 of which a plan view is given in FIG. 4), is substantially an inverted triangle.

A series of slightly deeper troughs 45 is formed between adjacent protuberances 42 extending at right angles to troughs 44. As best seen in FIG. 6, the bottom of each trough 45 is formed by portions of straight strands 40, with successive protuberances 42 on each side of the trough forming the tops of the trough. As seen in FIG. 6, the effective cross sectional shape of troughs 45 may be characterized as a shallow U-shape.

As shown in FIG. 4, troughs 44 and protuberances 42 alternate in one direction across the surface of each foraminous portion 30 of backing means 16. FIG. 4 also shows that troughs 45 and protuberances 42 alternate

in a direction perpendicular to troughs 44. Hence troughs and protuberances alternate in both the longitudinal and transverse directions across the surface of each discontinuous foraminous portion 30 of backing means 16.

To produce good rearrangement of fibers into yarn-like bundles of closely associated and substantially parallel fiber segments positioned in troughs 44 and 45, the vertical distance between the tops of protuberances 42 and the bottoms of the immediately adjacent troughs should be at least about three times, and preferably about ten times, the average diameter of the fibers in the layer of fibrous starting material. For troughs 44, this distance is the vertical distance indicated in FIG. 5 by the pair of dashed lines that pass, respectively, through the tops of protuberances 42 and the crossing points 43 that define the troughs. The vertical distance from the bottom of each trough 45 to the tops of protuberances 42, on the other hand, is somewhat larger, being shown by FIGS. 5 and 6 to be equal to the diameter of a strand 41.

In the embodiment shown, each protuberance 42 has a directional effect in one direction because of its proximity to other similar protuberances on foraminous portions 30 of the backing means, and in the other direction for the same reason and in addition because of the cross sectional shape of the protuberance. Thus, each protuberance 42 is effective in both the longitudinal and transverse directions. An example, the protuberance 42 to which the designator line runs in the upper left hand corner of FIG. 4, through cooperation with the protuberance 42 to which the designator line runs in the left central part of the bottom of that same figure, is effective as a protuberance that defines one wall of trough 44 running vertically down the middle of the figure. At the same time, the first named protuberance 42, through cooperation with protuberance 42 to which the designator line runs in the upper right hand part of FIG. 4, is effective as a protuberance that defines one wall of trough 45 running horizontally across the middle of the figure. In addition, the cross sectional shape of each protuberance 42 (as best seen in FIGS. 4 and 6) exerts a directional effect on the fibers of the fibrous starting material by its sharp definition of the side walls of each trough extending horizontally across FIG. 4, i.e., on the side walls of each trough 45.

Each discontinuous deflecting region or foraminous portion 30 is wide enough to include at least one dispersal point or protuberance 42 and a fiber accumulating zone or trough 44 or 45 on each side thereof. In the embodiment of FIGS. 2 and 3, each foraminous portion 30 includes in each direction about five protuberances 42 and their associated troughs or fiber accumulating zones.

Three portions of rearranging fluid. The directions the projected streams of rearranging fluid take as they move into and through the fibrous web determine the types 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 as they move through the fibrous layer are determined in part by the pattern of the solid wires that make up discontinuous foraminous portions 30 of backing means 16, and in particular the pattern of protuberances and troughs distributed across the surface of foraminous portions 30, it follows that the pattern of these areas helps deter-

mine the patterns of holes or other areas of low fiber density in the resultant fabric.

As is seen from FIG. 4, first portions of the streams of rearranging fluid that have been projected into the fibrous web strike the wires of woven screen 30, at protuberances 42 or at other portions of the wire, and are deflected sidewise before they pass out of the rearranging zone through openings 46. The streams of rearranging fluid that strike protuberance 42 in the upper left hand part of FIG. 4, for example, leave the fiber rearranging zone through openings 46a, 46b, 46c and 46d in the respective sectors or quadrants of the area surrounding that protuberance.

FIGS. 2 and 3 show that second portions of the rearranging fluid projected into the layer of starting material strike continuous imperforate portions 31 of backing means 16, and are deflected sidewise into the areas above discontinuous foraminous portions 30, where they are mingled with the first portions of rearranging fluid and are passed out of the rearranging zone through openings 46.

Third portions of the rearranging fluid projected into the fibrous web pass directly through openings 46 in foraminous backing portions 30, without being deflected either by protuberances 42 or imperforate portions 31.

Flow of first portions of rearranging fluid through deflecting regions. The dotted lines in FIGS. 5 and 6 give a schematic showing of the path followed by a stream of rearranging fluid 47 that is directed into the layer of fibrous starting material, in a direction perpendicular to that layer, to strike protuberance 42 in the upper left hand corner of FIG. 4. As is seen, the stream of fluid is deflected downwardly and outwardly away from its perpendicular direction of entry into the fiber rearranging zone, and then moves out of the rearranging zone through the openings between wires 40 and 41.

The flow of streams of rearranging fluid after being deflected sidewise upon striking protuberances 42 of foraminous portions 30 of backing means 16 produces sets of counteracting components of force that act in the plane of the web until the fluid passes out through the foramina in portions 30. The counteracting fluid forces in each of these sets work in conjunction with one another to rearrange fiber segments into yarn-like bundles positioned in troughs 44 and 45 of portion 30 of backing means 16. Some of these yarnlike bundles of fiber segments lie in fiber accumulating zones in peripheral portions of foraminous portions 30 adjacent discontinuous imperforate portions 31 of backing means 16, while some lie in troughs or fiber accumulating zones between one protuberance 42 and another protuberance that is immediately adjacent to it.

When the layer of fibrous starting material is first positioned in that part of the fiber rearranging zone located above foraminous portion 30 of backing means 16, and before a rearranging fluid has been directed into the layer, the fibrous web of course lies upon the tops of protuberances 42. After fiber rearrangement has proceeded under the impact of the streams of rearranging fluid, the fibers are moved down the sloping sides of protuberances 42 into troughs 44 and 45. At this juncture, the layer of rearranged fibers that comprises the nonwoven fabric ordinarily lies largely, if not altogether, below the tops of protuberances 42.

FIGS. 7 and 8 provide schematic representations of the flow of streams of rearranging fluid 47 that has been described in connection with FIGS. 4 through 6.

As explained above, in the practice of this invention the layer of fibrous starting material is supported in a fiber rearranging zone in which fiber movement in directions parallel to the plane of the fibrous material is permitted in response to applied fluid forces. The fiber rearranging zone has an entry side and an exit side, and is subdivided into deflecting regions 30 arranged in a discontinuous pattern and barrier regions 31 that are continuous and lie between and interconnect the discontinuous deflecting regions. FIGS. 7 and 8 depict a part of a deflecting region 30.

In FIGS. 7 and 8, the fiber rearranging zone is indicated as being defined by a foraminous portion 30 of backing means 16. Streams of rearranging fluid are projected into the fibrous layer as thus supported, in a direction perpendicular to said layer, substantially uniformly and continuously across the surface of the layer. In FIGS. 7 and 8, streams 47 represent first portions of those rearranging streams that take a particular path through the fiber rearranging zone.

First portions 47 of the rearranging fluid are passed through initial part 48 of the rearranging zone, as the fibrous layer lies in the zone. The streams of fluid 47 are passed toward dispersal points 42 lying adjacent the exit side of the rearranging zone, two of which dispersal points are shown for illustrative purposes in FIGS. 7 and 8.

At each dispersal point 42, streams of rearranging fluid 47 are deflected diagonally and downwardly away from the perpendicular direction of entry of streams 47 into the fibrous starting material, into the area immediately surrounding the dispersal point. In FIGS. 7 and 8, fluid stream 47 that is directed toward dispersal point 42 in the upper left hand portion of FIG. 8 is directed upon deflection into sectors or quadrants 46a, 46b, 46c and 46d of the area surrounding that dispersal point.

A few of the fiber segments of the fibrous starting material that lie in deflecting region 30 of the rearranging zone remain, after treatment with streams of rearranging fluid, in substantially the positions they occupied by random chance in the starting layer. Most of the fiber segments lying in the deflecting region, however, are moved by the deflection of rearranging fluid just described into the area surrounding the dispersal point 42 at which each fluid stream 47 was deflected.

The fiber segments moved by deflected streams of rearranging fluid 47 are positioned in yarn-like bundles of closely associated and substantially parallel fiber segments in fiber accumulating zones 44 and 45 in the area surrounding each dispersal point 42. As an example, fiber segments that are moved so that they extend between areas 46a and 46b of FIG. 8 are positioned there in fiber accumulating zone 44 which extends vertically in that figure between the two dispersal points 42, lying adjacent each other, that are shown in FIG. 8. Likewise, fiber segments that are moved so that they extend between areas 46b and 46c are positioned in fiber accumulating zone 45 which extends horizontally in FIG. 8, and so on. Fiber accumulating zones 44 and 45 correspond to troughs 44 and 45 shown in FIGS. 4 through 6. The yarnlike bundles of fiber segments positioned in the fiber accumulating zones form a pattern of yarnlike bundles corresponding to the pattern of the fiber accumulating zones, which in turn is determined, among other things, by the position of the various dispersal points 42 throughout the fiber rearranging zone.

The deflected portions of rearranging fluid 47 are then passed out of the fiber rearranging zone through spaced exits such as 46a through 46d, and similar exit areas, in FIGS. 7 and 8.

At the same time, other portions of rearranging fluid that are projected into the layer of fibrous starting material, for example those portions entering the entry zone in direct registry with exit 46b, are moved to and through the exits on the exit side of the rearranging zone without passing through a dispersal point 42 to be deflected from the perpendicular direction at which they enter the fibrous starting layer.

In the embodiment shown diagrammatically in FIGS. 4 through 6 and in the schematic representations of FIGS. 7 and 8, the spaced exits on the exit side of the rearranging zone are located in the fiber accumulating zones.

Flow of second portions of rearranging fluid through barrier regions. The directions taken by the second portions of the streams of rearranging fluid, which are projected into the fibrous starting material lying in the continuous barrier regions of the fiber rearranging zone, are of course also important. The directions those portions of the rearranging fluid take as they move into and through the fibrous web determine the types of forces applied to the fibers and, in turn, help determine the extent of rearrangement of the fibers throughout the barrier regions, and thus help determine the pattern of holes or other areas of low fiber density in the resultant fabric.

The second portions of the rearranging fluid which are projected into each barrier region — for example, each part of the fiber rearranging zone overlying an area 31 where backing means 16 is imperforate — are deflected sidewise out of the barrier region into adjacent deflecting regions. Thus, such streams strike continuous imperforate portions 31 in FIG. 2, to be deflected sidewise and effect movement of fiber segments transverse to the direction of travel of the projected streams.

This fluid flow causes some of the fiber segments that overlie the continuous imperforate portions 31 of backing means 16 to be moved into the adjacent areas of the fibrous layer that overlie the discontinuous foraminous portions 30 of the backing means, and to be positioned there in the above mentioned yarnlike bundles of fiber segments in areas adjacent the periphery of those imperforate portions, and elsewhere in the deflecting regions overlying foraminous portions 30 of the backing means. At the same time, the fluid flow described moves other fiber segments that overlie the continuous imperforate portions 31 of the backing means into flat, ribbonlike groups of substantially aligned fiber segments that bridge those imperforate portions.

Flow of third portions of rearranging fluid through deflecting regions. As indicated above, the passage of rearranging fluid through the fiber rearranging zone and the layer of fibrous starting material supported therein is completed by the flow of third portions of the fluid through the deflecting regions of the rearranging zone.

As is seen from FIG. 4, third portions of rearranging fluid that are projected into the fibrous web in a direction perpendicular to the plane of the web (i.e., perpendicular to the plane of the drawing in that figure) pass through the fibrous layer and, after being intermingled with the first and second portions of fluid discussed

above, pass directly out of the fiber rearranging zone through spaced exits such as openings 46a, 46b, 46c and 46d. These third portions of fluid do not strike protuberances 42 to be deflected sidewise, and thus do not pass through any dispersal points in the deflecting region. Likewise, since they do not enter the barrier regions of the fiber rearranging zone, they do not strike imperforate portions 31 of backing means 16.

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 rearranged 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 fibers, 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 factors, 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 as illustrated in FIG. 1, a web 15 of loosely assembled fibers, such as may be obtained by carding, is fed between wet-out rolls 6 and 7, and from there onto endless backing means 16. 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.

Discontinuous foraminous portions 30 of backing means 16 used in this example are comprised of a woven nylon screen of approximately 28 × 34 mesh or substantially 952 openings per square inch. The top of each protuberance 42 on the backing means rises above the bottoms of troughs 44 immediately adjacent to it by approximately 0.007, inch or almost five times the 0.0015 inch average diameter of the 1½ denier fibers of the starting material. They rise approximately 0.010 inch above the bottoms of troughs 45, or about seven times the average fiber diameter.

Each foraminous portion 30 is oval in shape, measuring approximately one-eighth inch in one direction and approximately one-fourth inch in the other, and is spaced diagonally about one-sixteenth inch from the immediately adjacent foraminous portions. Foraminous portions 30 are distributed in a diamond pattern, approximately 16 to the square inch, over backing means 16.

Continuous imperforate portions 31 of backing means 16 comprise a nylon knitted mesh known as Raschel knit fabric, of the form shown in plan view in FIG. 9 and in cross-section in FIG. 10. The width 50 of

each imperforate portion 31 at its narrowest part is approximately one-sixteenth inch or about 0.063 inch. Together the grid of imperforate portions defines foraminous portions 30. The height 51 of each imperforate portion 31 is approximately one thirty-second inch at its rounded top portion 52.

The distance measured across foraminous portions 30 of backing means 16 between the center of one fiber accumulating zone or trough and the center of the zone or trough immediately adjacent and parallel to it is about 0.029 inch in one direction, and in the other direction about 0.034 inch. Hence the 0.063 inch width of each imperforate portion 31 at its narrowest part is about two times the distance between trough centers.

In the practice of this invention, water is projected from nozzles 23 against fibrous web 15 in a direction perpendicular to the plane of the web, to pass through the fibrous layer and through backing means 16. After given portions of backing means 16 and fibrous web 15 pass through the rearranging zone in which streams of water are directed against them in this invention, the movement of the upper reach of endless belt 16 (towards the right as seen in FIG. 1) brings the rearranged fabric to doffer roll 29a and guide rolls 29b and 29c, from whence 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. 11, which has a plurality of interesting patterns of groups of fiber segments that alternate and extend throughout the fabric, is produced.

Nonwoven fabric 60 of FIG. 11 is shown with an original enlargement of five times in the photomicrograph of FIG. 12. As seen in the latter figure, fabric 60 contains a first pattern of yarn-like bundles of closely associated and substantially parallel fiber segments in discontinuous portions 61 of the fabric corresponding to foraminous portions 30 of backing means 16. Some of the yarn-like bundles 62 lie in fiber accumulating zones located in the peripheral portions of the deflecting regions of the fiber rearranging zones, as for example in the peripheral portions of each foraminous portion 30 where it abuts the perimeter of continuous imperforate portions 31 of the backing means. Other yarnlike bundles 63 lie in fiber accumulating zones located between immediately adjacent dispersal points in the deflecting regions, as for example between immediately adjacent protuberances 42 on foraminous portions 30.

Yarn-like bundles 62 and 63 together define areas of low fiber density 64. Most of these areas of low fiber density 64 contain some fiber segments that bridge across the area.

In addition, nonwoven fabric 60 contains a second pattern of flat, ribbon-like groups of substantially aligned fiber segments 65 that extend diagonally between and interconnect pairs of immediately adjacent discontinuous portions 61 of the fabric. Groups of fiber segments 65 correspond to the pattern of arrangement of imperforate portions 31 of backing means 16.

In the embodiment of FIGS. 10 and 11, there is also a third pattern of groups of substantially aligned fiber segments 66 that extend in the machine direction between longitudinally adjacent pairs of discontinuous portions 61 of the fabric. Groups of aligned fiber segments 66 are of lighter weight than are groups 65. In the fabric shown, areas of low fiber density 67, each containing a few stray fibers 68, are defined by fabric

portions 61 and groups of aligned fiber segments 65 and 66.

Each discontinuous fabric portion 61 appears from FIG. 12 to be approximately 100 times the size of each area of low fiber density 64. This is consistent with the relative size of discontinuous foraminous portions 30 and protuberances 42 on those foraminous portions in the apparatus with which the fabric of FIGS. 11 and 12 is made.

Each discontinuous fabric portion 61 includes a plurality — specifically, about 20 to 25 — of areas of low fiber density 64. This follows from the fact that each foraminous portion 30 of the backing means employed in the production of the fabric of this example contains approximately 20 to 25 protuberances 42.

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

I claim:

1. A method of producing a patterned nonwoven fabric having a plurality of patterns of groups of fiber segments 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 liquid forces, which comprises: supporting said layer of fibrous starting material 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 liquid forces, said rearranging zone having an entry side and an exit side and being subdivided into deflecting regions arranged in a discontinuous pattern and barrier regions that are continuous and lie between and interconnect said deflecting regions; projecting streams of liquid into the fibrous layer substantially uniformly and continuously across the surface thereof in a direction perpendicular to said layer at the entry side of said rearranging zone; passing first portions of said streams of liquid through the initial part of each of said deflecting regions, as the fibrous layer lies in said region, toward a plurality of dispersal points in said deflecting region adjacent the exit side of the rearranging zone, said dispersal points being surrounded by fiber accumulating zones; at each such dispersal point, deflecting said first portions of liquid diagonally and downwardly away from said perpendicular direction into the area immediately surrounding said dispersal point, to move fiber segments lying adjacent said dispersal point into said area surrounding the dispersal point; positioning fiber segments thus moved in said fiber accumulating zones located in peripheral portions of said deflecting region, to form in those locations yarn-like bundles of closely associated and substantially parallel fiber segments; simultaneously passing second portions of said liquid through the parts of said layer of fibrous starting material that lie in said barrier regions of the rearranging zone to effect movement of at least some segments of the fibers therein transverse to the direction of travel of the projected streams; at the exit side of the rearranging zone, blocking the passage of said second portions of liquid out of said parts of the fibrous layer that lie in the barrier regions and deflecting the same sidewise into said deflecting regions, at least some of said sidewise deflection and some of said diagonal and downward deflection occurring in the same plane to move some of the fiber seg-

ments that lie in said barrier regions into said deflecting regions to position them there in the aforementioned yarn-like bundles of closely associated and substantially parallel fiber segments and to move others of the fiber segments that lie in said barrier regions into substantial alignment with each other in bridging positions extending between said discontinuous deflecting regions; actively mingling said first and second portions of liquid after they have been thus deflected; passing said intermingled first and second portions of liquid out of said fiber rearranging zone through spaced exits in the deflecting regions at the exit side of the rearranging zone; at the same time and intermingled therewith passing out of said exits third portions of liquid that upon being projected into said fibrous layer were moved to said exits without passing through a dispersal point or a barrier region; and applying a vacuum at the exit side of said fiber rearranging zone to assist in moving all said liquid through the fibrous starting material and in rearranging said fiber segments, thereby forming a nonwoven fabric having a first pattern of yarnlike bundles of fiber segments in discontinuous portions of said fabric, which yarn-like bundles define areas of low fiber density arranged in accordance with the pattern of arrangement of said dispersal points, and a second pattern of groups of substantially aligned fiber segments extending between and interconnecting pairs of said discontinuous portions of the fabric immediately adjacent each other.

2. Apparatus for producing a patterned nonwoven fabric having a plurality of patterns of groups of fiber segments 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 for said layer of fibrous starting material, said means having portions that are foraminous and portions that are imperforate, said foraminous portions comprising at

least 20 percent of the total area of the backing means the remaining area being imperforate, said foraminous portions being arranged in a discontinuous pattern and said imperforate portions being continuous and lying between and interconnecting the discontinuous foraminous portions, the continuous imperforate portions rising above the plane of the tops of said discontinuous foraminous portions with the edges of said imperforate portions lying in substantially the same plane as said foraminous portions and the central portion of said imperforate portions rising higher than the edge portions, the maximum distance between adjacent foraminous portions being less than about 0.5 inch, said discontinuous foraminous portions having a plurality of protuberances with troughs surrounding each protuberance alternating across the surface thereof in both the longitudinal and transverse direction, the top of each of said protuberances rising above the bottom of the troughs immediately adjacent to it by at least 0.005 inch, and the top of each protuberance being spaced from the tops of adjacent protuberances by a horizontal distance of at least 0.025 inch; means for moving said backing means, with a layer of fibrous starting material positioned thereon, through a rearranging zone; means for projecting streams of rearranging fluid against said fibrous layer substantially uniformly and continuously across the surface thereof to pass therethrough, some of said fluid streams striking said imperforate portions of the backing means, and others of said fluid streams striking said protuberances on the backing means, all to be deflected thereby in sidewise directions, and all of said fluid streams, together with other streams of fluid that do not strike said backing means, passing through and beyond said foraminous portions of the backing means; and means to apply vacuum on the side of said backing means opposite to said fibrous layer to assist in moving all said rearranging fluid through the fibrous layer and in rearranging the fibers of said layer.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,769,659 Dated November 6, 1973

Inventor(s) Frank Kalwaites

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Abstract, Column 2, line 28, after "groups" insert --- of ---.

Column 4, line 40, "tne" should read --- and ---.

Column 7, line 55, "ohter" should read --- other ---.

Column 9, line 4, after "1 1/2" insert --- inch ---.

Column 12, line 30, "An" should read --- As ---.

Column 12, line 44, after 4"ad" should read --- and ---.

Column 14, line 45, "desribed" should read --- described ---.

Column 15, line 34, "measn" should read --- means ---.

Signed and sealed this 10th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents