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July 25, 1972 F. KALWAITES 3,679,536

NONWOVEN FABRIC COMPRISING BUDS PLUS BUNDLES CONNECTED BY ALIGNED FIBERS INCLUDING BUNDLES

Filed March 24, 1970 5 Sheets-Sheet 1

Fig. 1.

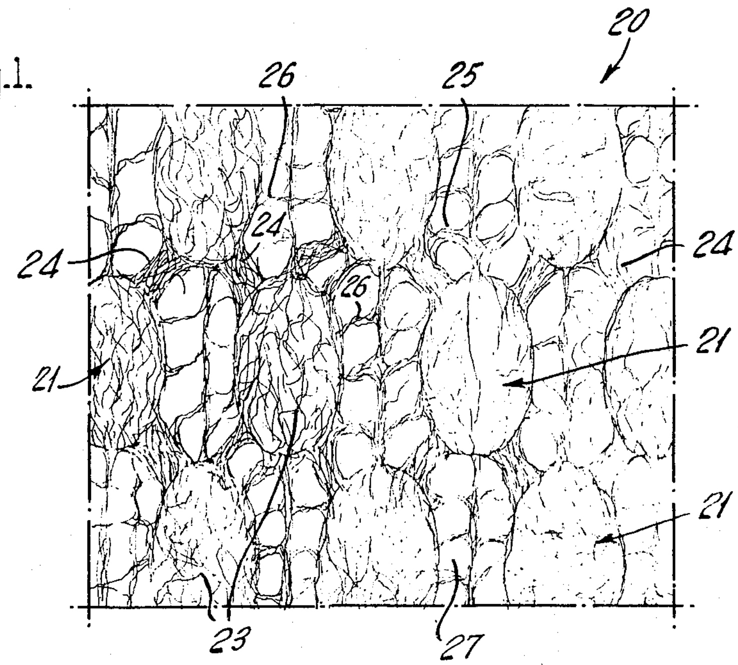
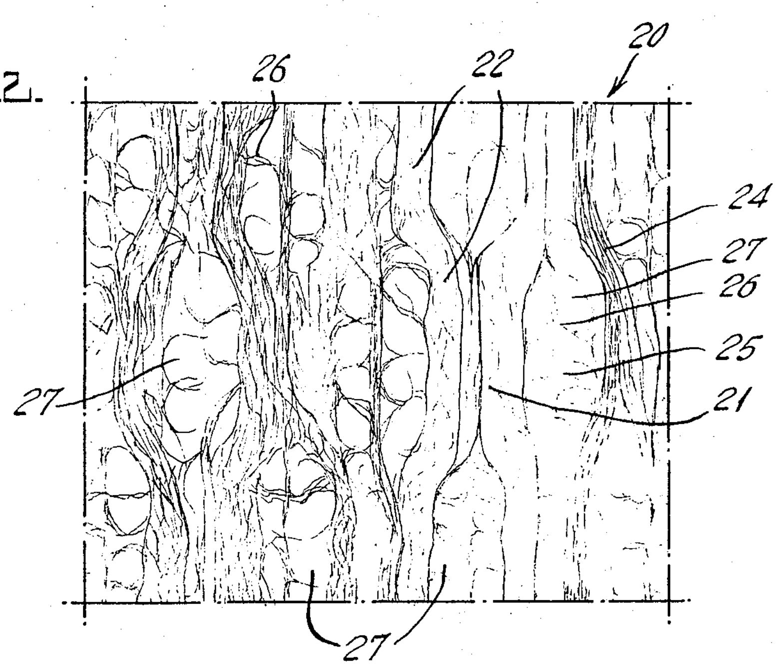


Fig. 2.



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ATTORNEY

Fig. 3.

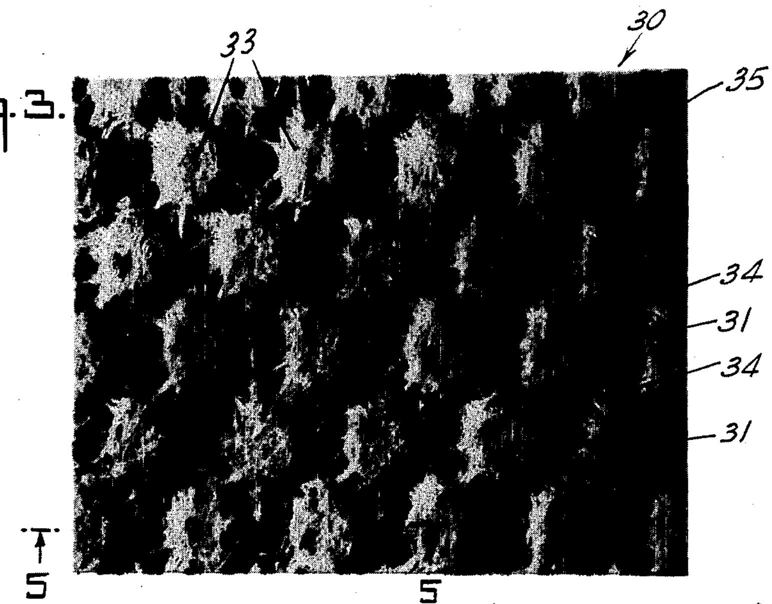

Fig. 4.

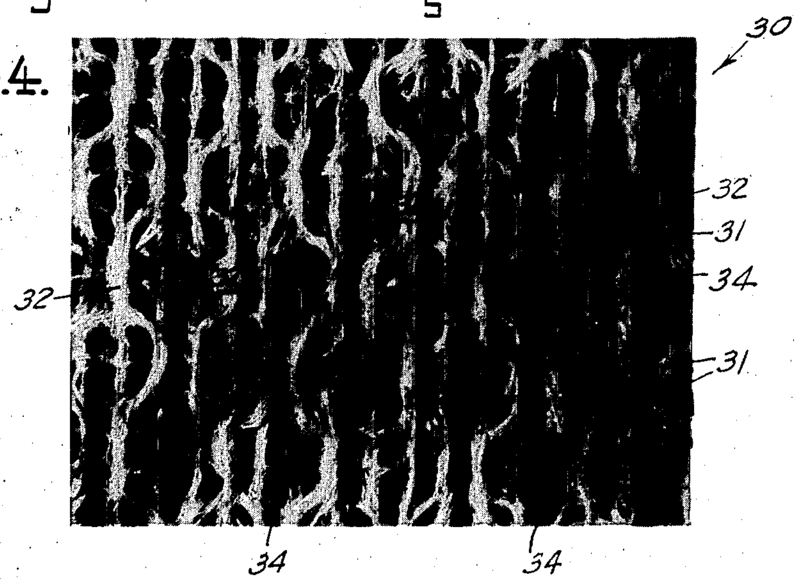

Fig. 5.

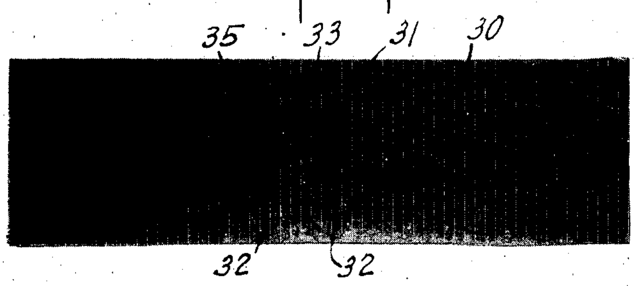

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Fig. 6.

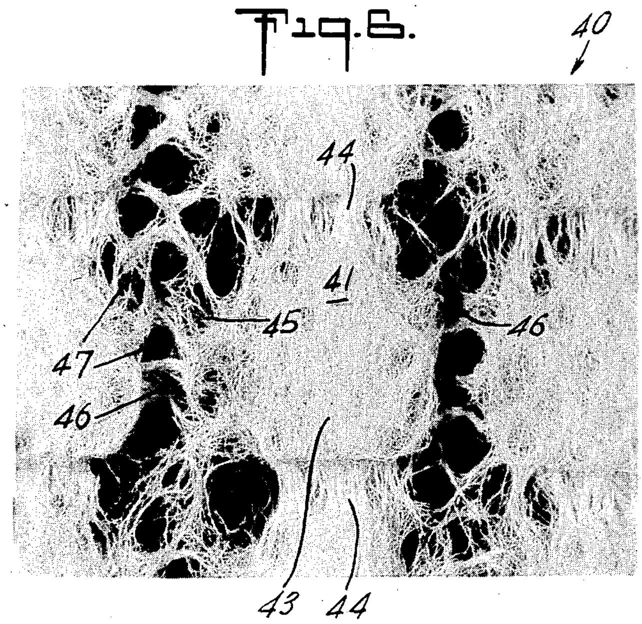

Fig. 7.

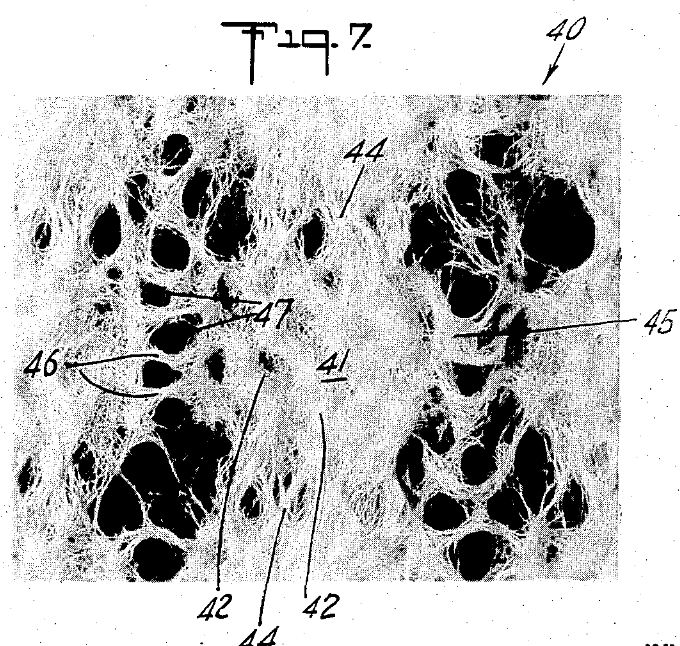

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Fig. 8.

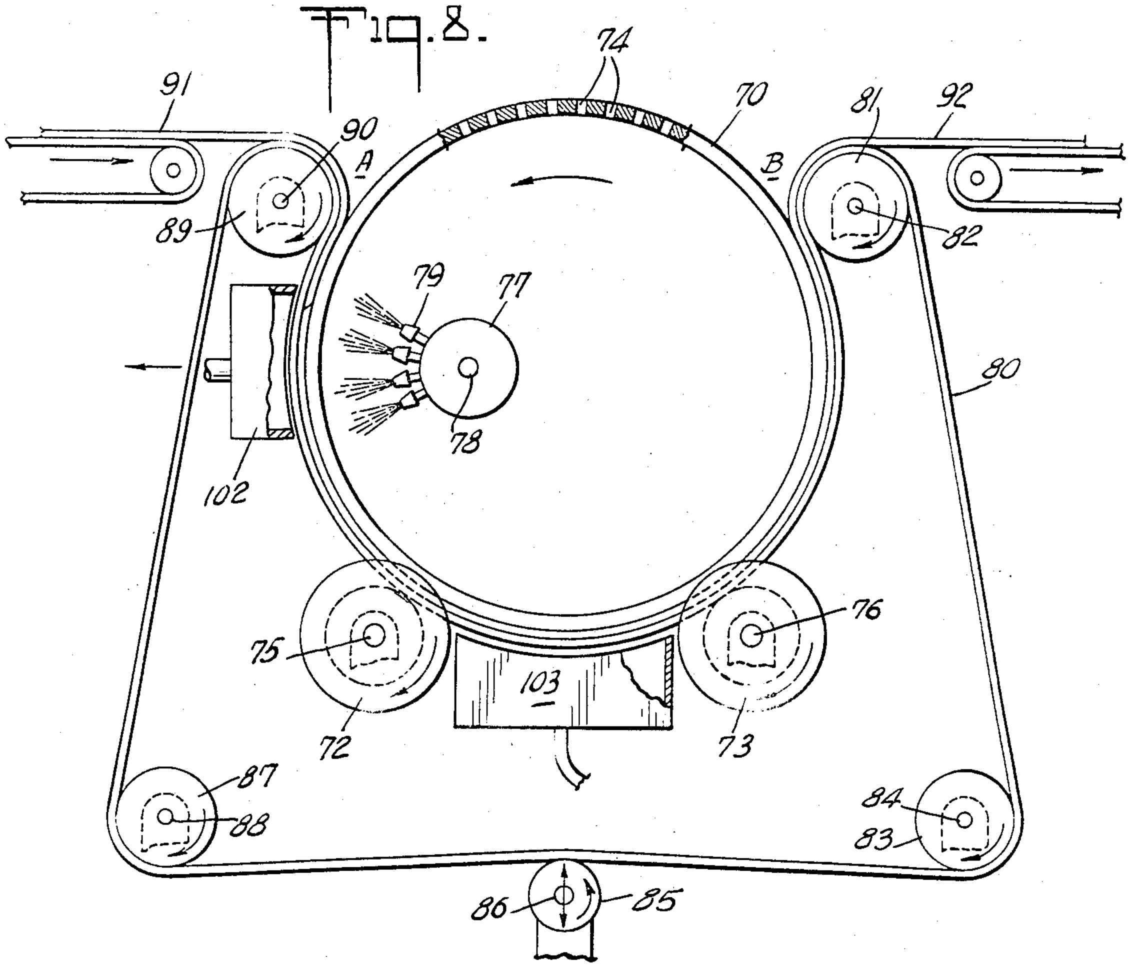

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Fig. 9.

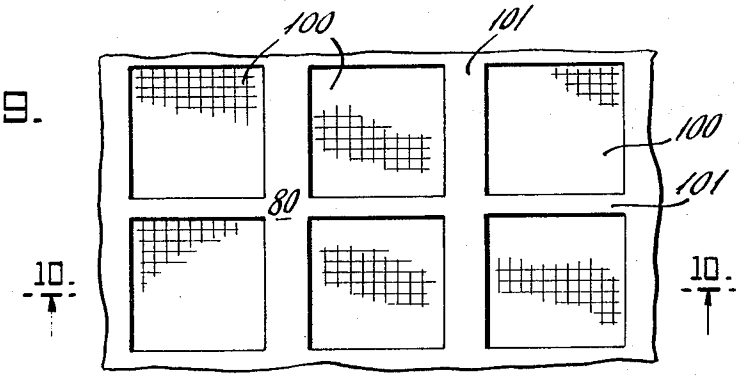


Fig. 10.

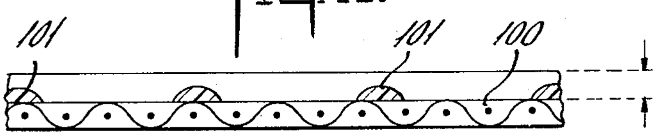


Fig. 11.

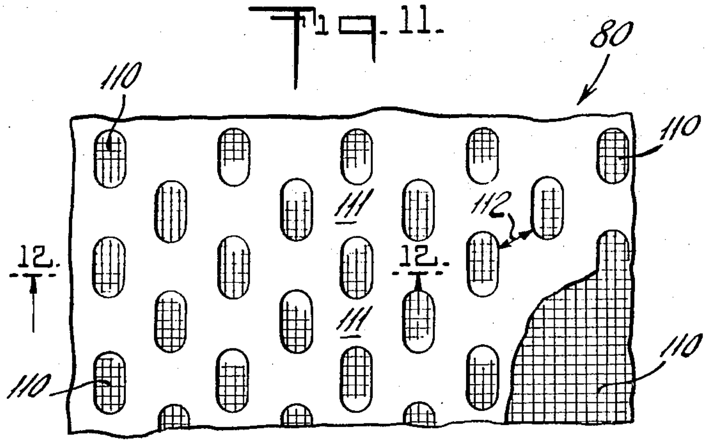
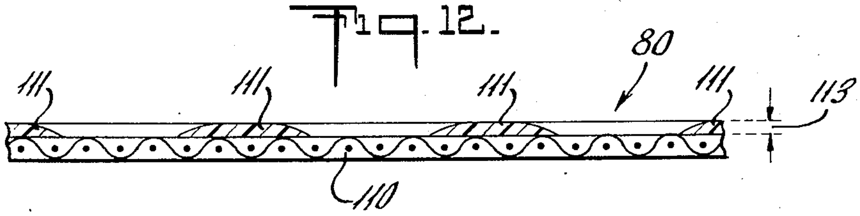


Fig. 12.



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United States Patent Office 3,679,536
Patented July 25, 1972

3,679,536

NONWOVEN FABRIC COMPRISING BUDS PLUS BUNDLES CONNECTED BY ALIGNED FIBERS INCLUDING BUNDLES

Frank Kalwaites, Somerville, N.J., assignor to Johnson & Johnson

Filed Mar. 24, 1970, Ser. No. 22,291
Int. Cl. D04h 1/46, 1/70
U.S. Cl. 161—109 14 Claims

ABSTRACT OF THE DISCLOSURE

A nonwoven fabric having a plurality of patterns of groups of fiber segments that alternate and extend throughout the fabric. One of the patterns is disposed in first discontinuous portions of the fabric each of which portions comprises at least one yarn-like bundle of fiber segments and a mat of interentangled helter-skelter fiber segments. These first discontinuous portions of the fabric are interconnected by groups of substantially aligned fiber segments lying in second portions of the fabric which form a second pattern. The groups of substantially aligned fiber segments in this second pattern may be flat, ribbon-like groups or yarn-like bundles of fiber segments.

The present invention relates to nonwoven fabrics and more particularly to patterned nonwoven fabrics made from a layer of fibrous material such as a fibrous web wherein the individual fiber elements are capable of movement under the influence of applied fluid forces. The fabric contains a plurality of patterns of different types of groups of fiber segments that alternate and extend throughout the fabric.

BACKGROUND OF INVENTION

For a number of years now, there have been known various types of foraminous or apertured, nonwoven fabrics made by processes involving the rearrangement of fibers in a starting web or layer of nonwoven fibers.

Some of these fabrics and methods of manufacture are illustrated, shown and described in U.S. Patents 2,862,251; and 3,081,500. The fabrics disclosed and claimed in the patents just listed contain apertures or holes or other areas of low fiber density, outlined by interconnected bundles of fibrous elements wherein the fiber segments within the bundle are closely associated and substantially parallel and have a yarn-like configuration. The term "areas of low fiber density" is used in this specification and claims to include both areas in which relatively few fibers in comparison to the rest of the fabric are found and apertures (holes) that are substantially or entirely free of fibers. Such fabrics are sometimes referred to as bundled rearranged nonwoven fabrics.

Another type of rearranged fabric is shown, illustrated and described in U.S. Patent 3,033,721. The fabric disclosed in that patent contains nubs or groups of interentangled fiber segments with these nubs and groups connected by substantially aligned fibers. Such fabrics will be hereinafter referred to as "rosebud" nonwoven fabrics.

Bundled rearranged nonwoven fabrics have been made commercially for many years. In most instances, these fabrics have had an overall pattern of holes or low fiber density areas throughout the fabric. A method for producing bundled rearranged nonwoven fabrics is to support a loose fibrous web or layer on a permeable backing member and apply sets of opposing fluid forces to the layer while thus supported. The fluid by which such forces are applied passes through the fibrous layer, over the backing member, and then through the backing member to pack various groups of the fiber elements and place these elements into closer proximity and substantial parallelism to form interconnected bundles of fiber segments. In accomplishing this result, the fluid forces usually are applied over the entire surface of the loose fibrous web or layer and uniformly over and through the permeable backing or support member to produce fiber bundles uniformly over the entire fabric. In some instances, patterns can be made in the fabric by not applying fluid forces to predetermined areas of the fibrous layer thereby preventing rearrangement in these areas.

Rosebud nonwoven fabrics are made by somewhat similar techniques in that fluid forces are used to pack portions of fibers into an interentangled mass of fiber portions or nubs of fiber portions. These nubs are connected by ribbons of fiber segments which have been aligned by the fluid forces.

SUMMARY OF INVENTION

I have discovered a novel nonwoven fabric which comprises a layer of intermingled fibers with the fibers arranged in a plurality of patterns that alternate and extend throughout the fabric. One of these patterns comprises groups of fiber segments which are disposed in first discontinuous portions of the fabric. Each of these groups includes at least one yarn-like bundle of fiber segments with the fiber segments in the bundle being closely associated with other segments in the bundle and aligned generally parallel to the longitudinal axis of the bundle. Each of these same groups also includes a mat of interentangled helter-skelter fiber segments. This mat protrudes out of the general place of the fabric.

These groups or areas in the discontinuous portions of the fabric are interconnected by groups of substantially aligned fiber segments located in second portions of the fabric. In most instances, the groups of aligned fiber segments aid in defining holes or apertures or other areas of low fiber density in these second portions of the fabric lying between the first discontinuous portions.

In many instances, the first discontinuous portions of the fabric include a plurality of yarn-like bundles of fiber segments.

In certain embodiments of the present invention, aligned fiber segments in the second portions of the fabric are closely associated with other such segments to form yarn-like bundles of fiber segments which define a plurality of holes or apertures or other areas of low fiber density therebetween. The longitudinal axis of each of these bundles extends between adjacent pairs of a discontinuous portion of the fabric.

In one embodiment of the fabric of the present invention, the second portions of the nonwoven fabric are continuous and the substantially aligned fiber segments in the second portions of the fabric are closely associated with other segments to form yarn-like bundles of fiber segments which are interconnected at junctures with other such bundles by groups of fibers common to a plurality of the bundles, to form a latticework of yarn-like bundles. This latticework of yarn-like bundles of fiber segments defines a plurality of areas of low fiber density, all of which are of substantially the same size.

Surprisingly, even though my new fabric has a plurality of patterns that alternate throughout the fabric, the patterns have substantial regularity, which aids in giving the fabric considerable aesthetic appeal. Not only does my new fabric have substantial uniformity in its arrangement of areas of low fiber density, but unexpectedly, my new fabric has uniformity in the patterns of bundles of fiber segments which occur along with the nubs or mats of interentangled helter-skelter fibers in the first discontinuous portions of the fabric, and also has uniformity in the pattern of groups of substantially aligned fiber segments that interconnect the first discontinuous portions of the fabric. My new nonwoven fabric can be made with patterns which simulate fancy woven and knitted fabrics, and which even simulate lace, crocheted fabrics and the like.

METHOD OF MAKING THE FABRIC OF THIS INVENTION

The basic method and apparatus of this invention are shown and described fully in my U.S. Patent No. 2,862,-251, issued Dec. 2, 1958. Full particulars of the basic invention are 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 for making the fabrics of the present invention—which is the use of a fiber rearranging zone having spaced entry zones (for example, the apertures of an apertured forming means) on one side, and continuous barrier zones and discontinuous, foraminous fiber accumulating zones on the other side (for example, a backing means that is imperforate except for discontinuous foraminous portions)—is described in detail in this application.

In the method of making the fabrics 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, each of the entry zones having a width at its narrowest part equal to at least about ten times, and preferably about twenty or more times, the average diameter of the fibers of the fibrous starting material. 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 continuous barrier zones 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. Each of the barrier zones has a width at its narrowest part equal to at least about the width of one of the entry zones at its narrowest part. All the portions of intermingled rearranging fluid are then passed out of the rearranging zone through spaced, discontinuous, foraminous major fiber accumulating zones defined by the continuous barrier zones and each having an area at least about three times, and preferably about four or more times, 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 zones into the major fiber accumulating zones, and positions those fiber segments with other fiber segments in at least one yarn-like bundle of closely-associated and substantially parallel fiber segments in each major fiber accumulating zone in a location therein complementary to the entry zones. In addition, the rearranging fluid moves other fiber segments that are in registry with the barrier zones into substantial alignment in bridging positions extending between the discontinuous major fiber accumulating zones.

In one method of manufacturing my new nonwoven fabric, a starting layer of fibrous material, the individual fibrous elements of which are capable of movement under the influence of applied forces, is subjected to fluid rearranging forces, preferably liquid while the layer is supported on a permeable backing member. The backing member has a predetermined topography and has foraminous portions arranged in a pattern over its surface, with continuous imperforate portions lying between and interconnecting the foraminous portions. The fluid flows over and through the foraminous areas and only over the imperforate areas.

This fluid flow causes counteracting components of force to act to rearrange fibers into yarn-like fiber bundles in those areas of the fibrous layer that lie above the foraminous portions of the backing member. The fluid flow also causes certain forces to act in these same areas to rearrange fibers into a mat of interentangled helter-skelter fiber segments. Simultaneosuly therewith, this fluid flow also causes other components of force to act on the fibrous layer to align fiber portions into groups of substantially aligned fiber segments in bridging positions across the imperforate portions of the backing member, and in some instances, may rearrange the fibers into yarn-like bundles in these areas.

Starting material.—The starting material used with the method or apparatus for making the fabrics 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 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 1/4 inch to about 2 to 2 1/2 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.—The apertured forming means used with the method and apparatus for making the fabrics of this invention, is solid throughout its area except for the forming apertures disposed longitudinally and transversely across the member. The forming apertures may have any desired shape, i.e., round, square, diamond, oblong, free form, etc.

The width at the narrowest part of each of the apertures of the apertured forming means must be large enough that streams of rearranging fluid passing through those apertures will be effective to separate groups of fiber segments into yarn-like bundles spaced sufficiently far apart to permit reliable visual resolution. Without such resolution, any bundle of fiber segments produced would seem to the person viewing the fabric to fuse or merge together with other such bundles, with the result that no clear pattern would be apparent in the fabric. To achieve such resolution, the width of each aperture at its narrowest part should be equal to at least about ten times, and preferably at least about twenty times, the average diameter of the fibers in the fibrous starting material.

The maximum dimensions of each aperture of the apertured forming means are limited by the requirement mentioned below as to the ratio between the areas of the forming apertures and the foraminous portions of the backing 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.

Backing means having discontinuous foraminous portions.—As already indicated, the fibrous starting layer is supported on a backing means having foraminous portions arranged in a discontinuous pattern, and continuous imperforate portions that lie between and interconnect the discontinuous foraminous portions to provide barrier zones against the passage of rearranging fluid out of the fiber rearranging zone. The width of each imperforate portion of the backing means at its narrowest part is equal to at least about the width of the narrowest part of an aperture of the apertured forming means with which the backing means is used. The foramina of the foraminous portions of the backing means are substantially smaller than the apertures of the apertured forming means.

The bridging of the imperforate portions of the backing means by aligned fiber segments is brought about by three factors—good drainage of the rearranging fluid from the fiber rearranging zone with no uncontrolled washing away of fibers, the accumulation and retention of groups of fiber segments at spaced points across the backing means, and the pulling taut of other fiber segments that extend between such groups and are anchored by them at a plurality of points along their lengths.

Good drainage is achieved by avoiding the use of too much rearranging fluid and by employing discontinuous foraminous portions in the backing means that are large enough and not too widely spaced. The area of each of the discontinuous foraminous portions of the backing means should be at least about three times, and preferably four times, the area of an aperture of the apertured forming means. These foraminous portions should be 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.

Accumulation and retention of fiber segments at spaced points across the backing means takes place when each foraminous portion of the backing means is large enough that a group of fibers can be accumulated and retained there, whether in the form of a group of fiber segments including only a single yarn-like bundle or a plurality of yarn-like bundles of fiber segments.

The pulling taut of fiber segments between adjacent groups in which they are anchored is achieved by limiting the maximum spacing of the foraminous portions of the backing means. To establish two reliable anchor points for each individual fiber segment, the foraminous portions of the backing means should be spaced from other such portions immediately adjacent thereto by no more than about ⅓ the average length of the fibers being rearranged, and preferably no more than about ⅕ or ⅙ the length of the fibers. In general, this means that with 1½" staple length fibers, each pair of foraminous portions of the backing means should be spaced, at their closest points, no more than about ½" apart, and preferably no more than about ¼".

In plan view, the discontinuous foraminous portions of the backing means may have any shape desired, i.e., circular, oval, diamond, square, etc.

The continuous imperforate portions of the backing means should lie above the foraminous portions by at least about $\frac{1}{32}$", or as much as $\frac{1}{16}$" if desired.

Generally speaking, the greater the difference in elevation between the foraminous and imperforate portions and the larger the area of the foraminous 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.

During the use of the method or apparatus, 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 used in making the fabrics of this invention is preferably water or a similar liquid, but it may be other fluids such as a gas, as described in my Patent No. 2,862,251.

If desired, a vacuum may be applied at the exit side of the fiber rearranging zone to assist in moving the rearranging fluid through the fibrous starting material and in rearranging the fibers of the material into a patterned nonwoven fabric. This feature is most useful when the rearranging fluid is a liquid.

Even through some of the rearranging forces applied to the loose fibrous web in making my fabric are considerably different in magnitude than other forces applied to the loose fibrous web, these rearranging forces of disparate magnitude cooperate with and complement each other to produce uniformity and regularity in the patterns of groups of fiber segments produced.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully described in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic drawing of a nonwoven fabric in accordance with the present invention.

FIG. 2 is a schematic drawing of the opposite surface of the fabric depicted in FIG. 1.

FIG. 3 is a photomicrograph of a fabric of the present invention at an original enlargement of 5 times.

FIG. 4 is a photomicrograph of the opposite side of the fabric of FIG. 3 at an original enlargement of 5 times.

FIG. 5 is a photomicrograph of a cross-sectional view of the fabric of FIGS. 3 and 4 taken along a line similar to that shown as line **5—5** in FIG. 3, at an original enlargement of ten times.

FIG. 6 is a photomicrograph of another fabric of the present invention at an original enlargement of 5 times.

FIG. 7 is a photomicrograph of the opposite surface of the fabric depicted in FIG. 6 at an original enlargement of 5 times.

FIG. 8 is a diagrammatic showing in elevation of one type of apparatus for carrying out a method for making the fabric of the present invention.

FIG. 9 is an enlarged diagrammatic view of a portion of one type of support member which may be in the apparatus of FIG. 8.

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

FIG. 11 is an enlarged diagrammatic view of a portion of another type of support member which may be used in the apparatus of FIG. 8.

FIG. 12 is a cross-sectional view taken along line **12—12** of FIG. 11.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

Referring to FIGS. 1 and 2 of the drawings, there is shown a nonwoven fabric **20** of the present invention. The fabric comprises groups of fiber segments located in first discontinuous portions **21** of the fabric. Each of these portions **21** has yarn-like bundles **22**, more clearly seen in FIG. 2. Also in the exact same portions **21**, there are mats **23** of helter-skelter interentangled fiber segments sitting on top of the yarn-like bundles and these mats are more clearly shown in FIG. 1. The yarn-like bundles **22** of fiber segments have fiber segments closely associated with one another in the bundle and the fiber segments are generally parallel to the longitudinal axis of the bundle. The discontinuous portions of the fabric are connected to each other by groups **24** of substantially aligned fiber segments. Generally, these groups of substantially aligned fiber segments connect the discontinuous portions of the fabric either between the 1 and 7 o'clock positions of adjacent discontinuous portions or the 5 and 11 o'clock positions. The aligned groups, plus the discontinuous portions, define areas of low fiber density **25** therebetween. Though in many instances, these areas **25** may be free of fibers, in the drawing depicted, there are a few fiber segments **26** in these areas some of which are more substantially aligned with adjacent fiber segments than others and these segments **26** define smaller areas of low fiber density **27** or holes within the area **25**.

Referring to the photomicrographs of FIGS. 3, 4, and 5, there is shown a nonwoven fabric **30** of the present invention. The fabric comprises discontinuous portions **31** of the fabric which are generally oval in shape and are aligned in staggered rows over the surface of the fabric. each of these areas, as is more clearly shown in FIG. 4, comprises a plurality of yarn-like bundles **32** and as is more clearly shown in FIG. 3, on top of these yarn-like bundles, is a mat **33** of interentangled helter-skelter fiber segments. The discontinuous areas of the fabric are interconnected by groups **34** of substantially aligned fiber segments and these groups define areas of low fiber density **35**. As is more clearly seen in FIG. 5, the mat **33** of helter-skelter fiber segments extends out of the general plane of the fabric with the yarn-like bundles **32** beneath the mat of helter-skelter fibers generally at the edges of the mat of fibers.

In the photomicrographs shown in FIGS. 6 and 7, there is another embodiment of the nonwoven fabric **40** of the present invention. In this embodiment, the discontinuous portions **41** are generally square in shape and are aligned both transversely and longitudinally of the fabric. The square discontinuous portions of the fabric comprise a plurality of yarn-like bundles **42** of fiber segments with the fiber segments in the bundles being closely associated with one another. On top of these yarn-like bundles is a mat **43** of interentangled helter-skelter fibers. These discontinuous areas are connected in the longitudinal direction by groups **44** of highly aligned fiber segments. The areas **41** are connected in the transverse direction by groups **45** of aligned fiber segments which are further divided into yarn-like bundles **46** of fiber segments which define areas of low fiber density **47** therebetween.

In all embodiments of the fabrics of the present invention the first, discontinuous areas contain at least one yarn-like bundle of fiber segments and usually more than one such bundle and on top of these bundles is a mat or nub of interentangled helter-skelter fibers. The discontinuous areas are connected to one another in second portions of the fabric by groups of substantially aligned fiber segments. The pattern of the discontinuous areas, the weight of the starting fibrous material, the fiber orientation of the starting layer, and the pattern of fluid forces applied to the starting material will determine the specific configurations of the substantially aligned fiber segments. These groups of aligned fiber segments may be in the form of a ribbon with the fiber segments generally uniformly disposed throughout the ribbon or they may be in the form of a single yarn-like bundle of fiber segments. They may also be in the form of a plurality of yarn-like bundles of fiber segments or a plurality of ribbons, or in other various combinations of these configurations. For example: the groups may be a single group of substantially aligned fiber segments connecting discontinuous areas in one direction of the fabric with a plurality of yarn-like bundles of fiber segments connecting the discontinuous areas in the opposite or perpendicular direction of the fabric.

DESCRIPTION OF MACHINE AND METHOD FOR MAKING FABRICS OF MY INVENTION

Referring to FIG. 8 in the drawings, there is shown one form of apparatus for carrying out methods to produce products in accordance with the present invention. Full particulars of this apparatus except for the details of the novel backing or supporting member on which rearrangement of fibers takes place in accordance with the present invention including methods of mounting, rotation, etc., are fully described in U.S. Pat. 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 herein. In view of this reference, the apparatus of FIG. 8 will be described in general terms insofar as its essential elements are the same as in the patent just mentioned, and the novel element of this apparatus, i.e., the backing or supporting member, will be described in more detail.

The apparatus includes a rotatable perforated drum **70** suitably mounted on flanged guide wheels **72** and **73**. The drum has apertures **74** uniformly spaced over its entire surface. The guide wheels are mounted for rotation on shafts **75** and **76**. Inside the drum there is stationarily mounted along the full width of the drum, a manifold **77** to which a fluid is supplied through conduit **78**. On one side of the manifold is a series of nozzles **79** for directing the fluid against the inside surface of the drum.

A novel backing or supporting member **80** is arranged to travel with rotatable drum **70** as will be described below. (The term backing member and support member are used interchangeably throughout this description.) Support member **80**, as shown in FIGS. 9 and 10 has a discontinuous pattern of foraminous portions **100** and a continuous pattern of imperforate portions **101**. In FIGS. 9 and 10, the foraminous portions are square and arranged in a square pattern over the surface of the support member, 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 support member, i.e., they may be aligned longitudinally and/or transversely, staggered, etc.

The support member passes about drum **70** and separates from the drum at the guide roll **81** which rotates on a shaft **82**. The support member passes downwardly around guide roll **83** rotating on shaft **84** and then rearwardly over a vertically adjustable tensioning and tracking guide roll **85** rotating on a shaft **86** and then around guide roll **87** on a shaft **88**. The member passes upwardly and around guide roll **89** rotating on shaft **90** to be returned about the periphery of the drum

The drum and supporting belt provide a rearranging zone between them through which a fibrous starting material may move, to be rearranged under the influence of applied fluid forces into a nonwoven fabric having a plurality of patterns throughout its area. Tension on the support member 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 support member. 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.

Apertured drum **70** rotates in the direction of the arrow shown, and support member **80** moves in the same direction and at the same peripheral linear speed as the drum 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 **91** to be rearranged is fed between the drum and support member at point A, passes through the fiber rearranging zone where fluid rearranging forces are applied to it, and is removed in its new, rearranged form as nonwoven fabric **92** between the support member and apertured drum at point B.

As fibrous material **91** passes through the fiber rearranging zone, a liquid such as water is directed against the inner surfaces of rotating apertured drum **70** through nozzles **79** mounted inside the drum. The liquid passes through drum apertures **74** and through the fibrous web and thence passes through the backing means thereby effecting rearrangement of the fibers of the web.

Vacuum assist box **102** is located against the outside surface of backing means **80**. Vacuum box **102** has a slotted surface located closely adjacent the outer surface of belt **80**, 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. Vacuum box **103** located below drum **70** also helps de-water the web after it is rearranged.

The directions the streams of rearranging fluid projected through apertured **74** of apertured forming drum **70** 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 **74** are determined by formaminous portions **100** and imperforate portions **101** of support member or backing means **80**, it follows that the patterns of these portions of the backing means help determine the patterns of fiber arrangement, as well as the patterns of holes or other areas of low fiber density in the resultant fabric.

When backing means **80** and apertured forming means **70** are employed, streams of rearranging fluid passing through forming apertures **74** cause some of the fiber segments that are in registry with continuous imperforate portions **101** of backing means **80** to move into areas of fibrous layer **91** overlying foraminous portions **100** of the backing means, to form groups of fiber segments there that include at least one yarn-like bundle of closely associated and substantially parallel fiber segments in each such area. At the same time, the stream of rearranging fluid move other fiber segments that are in registry with imperforate portions **101** into substantial alignment in positions bridging the continuous imperforate portions of the backing means from one discontinuous foraminous area **100** to another.

This fiber rearrangement produces a first pattern of fiber segments arranged in accordance with the pattern of arrangement of foraminous portions **100** of backing means **80**, including at least one yarn-like bundle of closely associated and substantially parallel fiber segments in each area of the fibrous web that overlies one of the foraminous portions **100** and a second pattern of substantially aligned fiber segments interconnecting the portions of the fabric in the first pattern. The second pattern corresponds to the configuration of continuous imperforate portions **101** of backing means **80**.

With imperforate portions **101** raised slightly above the foraminous portions of the backing means, it has been found that satisfactory formation of yarn-like bundles of fiber segments in the foraminous portions described above, along with mats of interentangled helter-skelter fibers, can be achieved with a fibrous starting material made up of fibers of 1½ denier that has a web weight of from 400 or about 500 grains per square yard to about 900 or 1,000 grains per square yard. The web weights in question may be somewhat higher, the higher the continuous imperforate portions rise above the discontinuous foraminous portions of the backing means or the higher the denier of the fibers used in the starting material.

The rearranged web or fabric produced by the 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 materials, 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, no binder at all need be employed to provide a usable fabric.

Further details and descriptions of methods and apparatus which may be used to produce the novel nonwoven fabric of the present invention are given in my commonly assigned patent application entitled Method and Apparatus for Producing Nonwoven Fabrics Having a Plurality of Patterns (Ser. No. 22,309 filed Mar. 24, 1970 and now abandoned). It is to be noted that not all embodiments of the apparatus disclosed in the abovementioned patent application will necessarily produce the novel nonwoven fabrics of the present invention.

The following are illustrative examples of the use of the method and apparatus of this invention to produce patterned nonwoven fabrics:

Example I

In apparatus as illustrated in FIG. 8, a web **91** of loosely assembled fibers, such as may be obtained by carding, is fed between apertured forming drum **70** and backing means **80**. The web weight is about 460 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$\frac{9}{16}$" long, of 1½ denier.

Apertured forming drum **70** has about 165 substantially round holes per square inch, each approximately 0.045" in diameter, or about 30 times the average diameter of the fibers of the fibrous starting material. The holes are arranged in a diamond pattern over the forming means. Each aperture **74** is spaced approximately 0.040" in the diagonal direction from the immediately adjacent aperture on the drum.

The discontinuous foraminous portions **100** of backing means **80** used in this example are comprised of a woven fiber glass screen of approximately 14 x 18 mesh or substantially 252 openings per square inch. Each foraminous portion **100** is square in shape, approximately $\frac{5}{16}$" on each side, and is spaced from the immediately adjacent similar foraminous portions by approximately $\frac{3}{32}$" in one direction and about $\frac{3}{64}$" in the other.

Continuous imperforate portions **101** of backing means **80** comprise a low density polyethylene mesh or grid of the form shown in plan view in FIG. 9 and in cross section in FIG. 10. The width of each imperforate portion **100** (running vertically in FIG. 9) is approximately $\frac{3}{32}$" or about 0.094", which is about two times the diameter of each aperture **74** of apertured forming means **70**. The width of each imperforate portion **100** (running horizontally in FIG. 9) is approximately $\frac{3}{64}$", or about equal to the diameter of each forming aperture **74**. Together the grid of imperforate portions defines foraminous portions **100** each of whose sides is approximately $\frac{5}{16}$". The heights of imperforate portions **100** are about $\frac{1}{32}$" in the vertical direction and $\frac{1}{16}$" in the horizontal direction respectively at their rounded top portions.

The resulting nonwoven fabric, as seen in FIGS. 6 and 7 is an excellent rearranged fabric having a plurality of patterns of fiber segments that alternate and extend throughout the fabric.

Nonwoven fabric 40 of FIG. 6 contains a first pattern of fiber segments 41 arranged in accordance with the pattern of arrangement of discontinuous foraminous portions 100 of backing means 80. The nonwoven fabric also contains a second pattern of yarn-like bundles of closely associated and substantially parallel fiber segments 44 that interconnect portions of the fabric in the first pattern 41 in the longitudinal direction of the fabric. A third pattern of yarn-like bundles 46, lighter in weight than bundles 44, forms a latticework that interconnects portions of the fabric in the first pattern 41 in the transverse direction of the fabric. The latticework defines areas of low fiber density 47.

The fabric also contains a fourth pattern of yarn-like bundles of closely associated and substantially parallel fiber segments 42 best seen in FIG. 7. These yarn-like bundles are arranged within the first pattern of fibers 41 in accordance with the pattern of land areas of apertured forming drum 70. On the other surface of the fabric, best seen in FIG. 6, over these yarn-like bundles in area 41 is a mat of interentangled helter-skelter fiber segments 43.

EXAMPLE II

In apparatus as illustrated in FIG. 8, a web 91 of loosely assembled fibers, such as may be obtained by carding, is fed between apertured forming drum 70 and backing means 80. The web weight is about 500 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$\frac{9}{16}$" long, of 1½ denier.

The apertured forming drum 70 used in this example has about 324 substantially round holes per square inch, each approximately 0.033" in diameter or about 20 times the average diameter of the fibers of the fibrous starting material. The holes are arranged in a square pattern over the forming means. Each aperture 74 is spaced approximately 0.022" from the immediately adjacent aperture on the drum.

The discontinuous foraminous portions of backing means 80 of the aparatus of this example are comprised of a woven nylon screen of approximately 28 x 34 mesh or substantially 952 openings per square inch. Each foraminous portion 110 as seen in FIG. 11, is oval in shape, measuring approximately $\frac{1}{16}$" in one direction and approximately ⅛" in the other, and is spaced about $\frac{1}{16}$" from the immediately adjacent foraminous portions. Foraminous portions 110 are distributed in a diamond pattern, 24 to the square inch, over backing means 80.

Continuous imperforate portions 111 of backing means 80 comprise a nylon knitted mesh known as Raschel knit fabric, of the form shown in plan view in FIG. 11 and in cross section in FIG. 12. The width 112 of each imperforate portion 111 at its narrowest part is approximately $\frac{1}{16}$" or about 0.063", which is about two times the diameter of each aperture 74 of apertured forming drum 70. Together the grid of imperforate portions defines foraminous portions 110. The height 113 of each imperforate portion 111 is approximately $\frac{1}{32}$" at its rounded top portion.

With the conditions indicated, good fiber rearrangement and bundling are obtained. An excellent nonwoven fabric such as shown in the photomicrograph of FIG. 3 which has a plurality of interesting patterns that alternate and extend throughout the fabric, is produced. Nonwoven fabric 30 of FIG. 3 contains a first pattern of fiber segments 31 arranged in accordance with the diamond shaped shaped pattern of arrangement of discontinuous foraminous portions 110 of backing means 80. The nonwoven fabric also contains a second pattern of yarn-like bundles of closely associated and substantially parallel fiber segments 34 that form a latticework interconnecting the portions of the fabric in the first pattern 31. This second pattern corresponds to the configuration of continuous imperforate portions 111 of backing means 80.

FIG. 4 is a photomicrograph of the nonwoven fabric of FIG. 3 taken from the opposite side of fabric 30, showing a different but similar portion thereof. The respective patterns of fiber segments, as well as areas of low fiber density, that extend throughout the nonwoven fabric of FIG. 4 are indicated by the same designators in that figure as are used for the corresponding parts of the fabric in FIG. 3.

The fabric of FIGS. 3 and 4 also contains a third pattern of yarn-like bundles of closely associated and substantially parallel fiber segments 32 best seen in FIG. 4, that is arranged within the first pattern of fibers 31 in accordance with the pattern of land areas of apertured forming drum 70. On the top of these yarn-like bundles 32 within first pattern 31 is a mat of helter-skelter interentangled fiber segments 33, best seen in FIG. 3.

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.

What is claimed is:

1. A nonwoven fabric with a plurality of patterns of groups of fiber segments that alternate and extend throughout said fabric which comprises: a first pattern of groups of fiber segments in first discontinuous portions of the fabric, each of said groups including at least one yarn-like bundle of fiber segments, the fiber segments in said bundle being closely associated with other fiber segments in the bundle and lying generally parallel to the longitudinal axis of the bundle, each of said groups also including a mat of interentangled, helter-skelter fiber segments, said mat protruding out of the plane of the fabric, said first discontinuous portions of the fabric being interconnected by groups of substantially aligned fiber segments, said segments lying in second portions of the fabric and forming a second pattern of fiber segments.

2. The nonwoven fabric of claim 1 wherein each of said first discontinuous portions of the fabric is substantially square in shape.

3. The nonwoven fabric of claim 2 wherein said first discontinuous portions of the fabric are located in rows disposed in the longitudinal direction and the transverse direction of the fabric.

4. The nonwoven fabric of claim 1 wherein each of said first discontinuous portions of the fabric is substantially oval in shape.

5. The nonwoven fabric of claim 4 wherein said first discontinuous portions of the fabric are located in rows disposed diagonally across the fabric.

6. The nonwoven fabric of claim 1 in which the substantially aligned fiber segments in said second portions of the fabric define a plurality of areas of low fiber density in said second portions of the fabric.

7. The nonwoven fabric of claim 1 in which each of said groups of fiber segments in said first discontinuous portions of the fabric includes a plurality of said yarn-like bundles of fiber segments.

8. The nonwoven fabric of claim 7 in which the substantially aligned fiber segments in said second portions of the fabric define a plurality of areas of low fiber density in said second portions of the fabric.

9. The nonwoven fabric of claim 8 in which substantially aligned fiber segments in said second portions of the fabric are closely associated with other such segments to form a plurality of yarn-like bundles of fiber segments defining areas of low fiber density therebetween.

10. The nonwoven fabric of claim 9 in which said second portions of the fabric are continuous and said areas of low fiber density therein are all of substantially the same size.

11. The nonwoven fabric of claim 10 in which each of said plurality of yarn-like bundles of fiber segments in said

second continuous portions of the fabric is interconnected at junctures with other such bundles by groups of fibers common to a plurality of bundles, the fibers at said junctures being oriented in a plurality of diverse directions, to form a latticework of yarn-like bundles of fiber segments extending throughout said second portions of the fabric.

12. The nonwoven fabric of claim **9** in which the longitudinal axis of each of said last mentioned bundles extends between and connects immediately adjacent pairs of said first discontinuous portions of the fabric.

13. The nonwoven fabric of claim **9** in which said second portions of the fabric are discontinuous and said areas of low fiber density therein are all of substantially the same size, and said second portions of the fabric define between them other, larger areas of low fiber density in third, discontinuous portions of the fabric.

14. The nonwoven fabric of claim **9** in which said areas of low fiber density in said second portions of the fabric are apertures substantially free of fibers.

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