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(54) METHOD FOR IMPROVED APERTURE CLARITY IN THREE-DIMENSIONAL NONWOVEN FABRICS AND THE PRODUCTS THEREOF

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(57) **ABSTRACT**

The present invention is directed a nonwoven fabric which is imparted with a three-dimensional image or pattern, and apertures essentially devoid of fiber, during the fabrication stage. The nonwoven fabric exhibits a fibrous extension out of the plane of the material, while apertures are present that have a pronounced uniformity and a significant reduction in fibrous occlusion.

FIG. 1

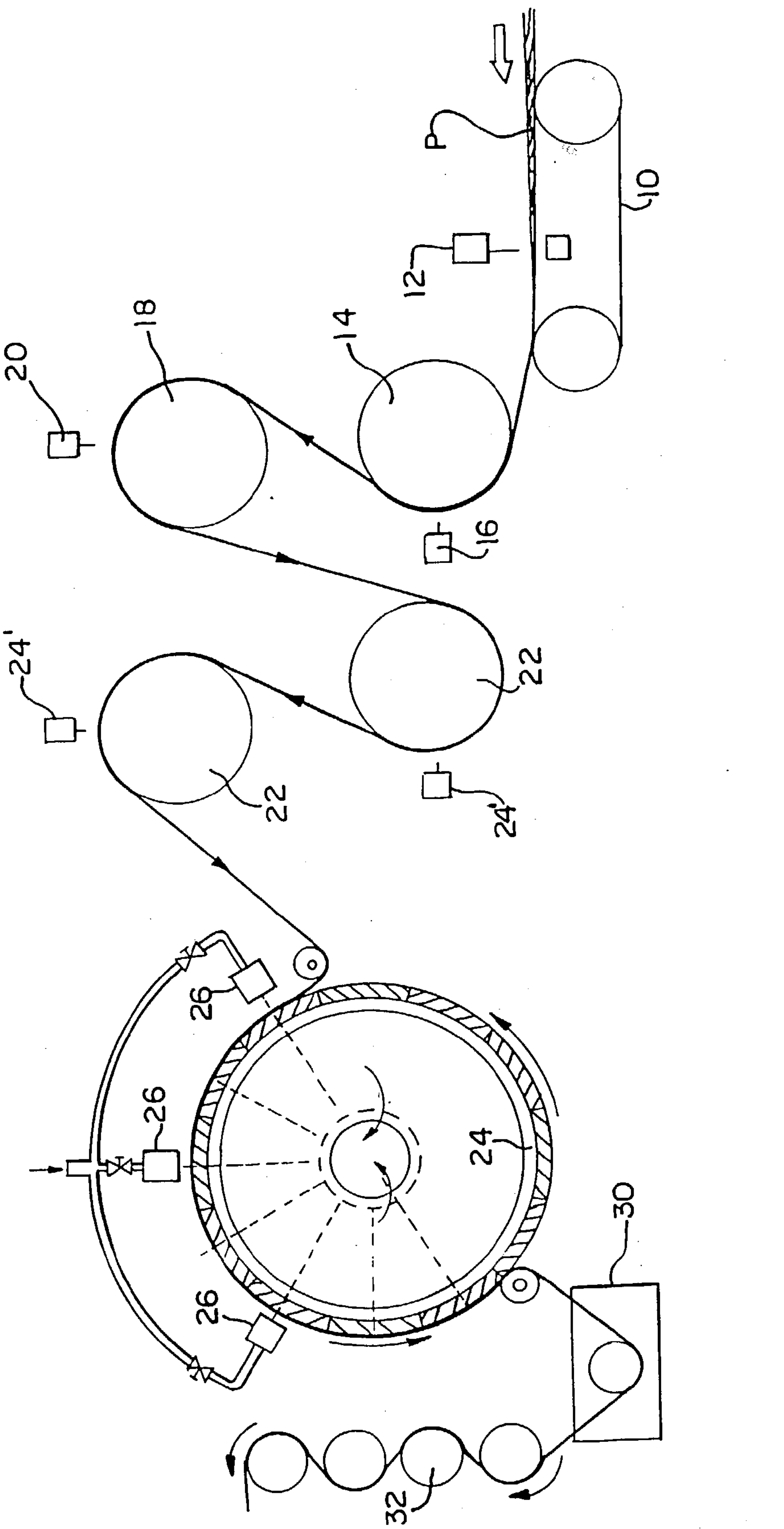


FIGURE 2

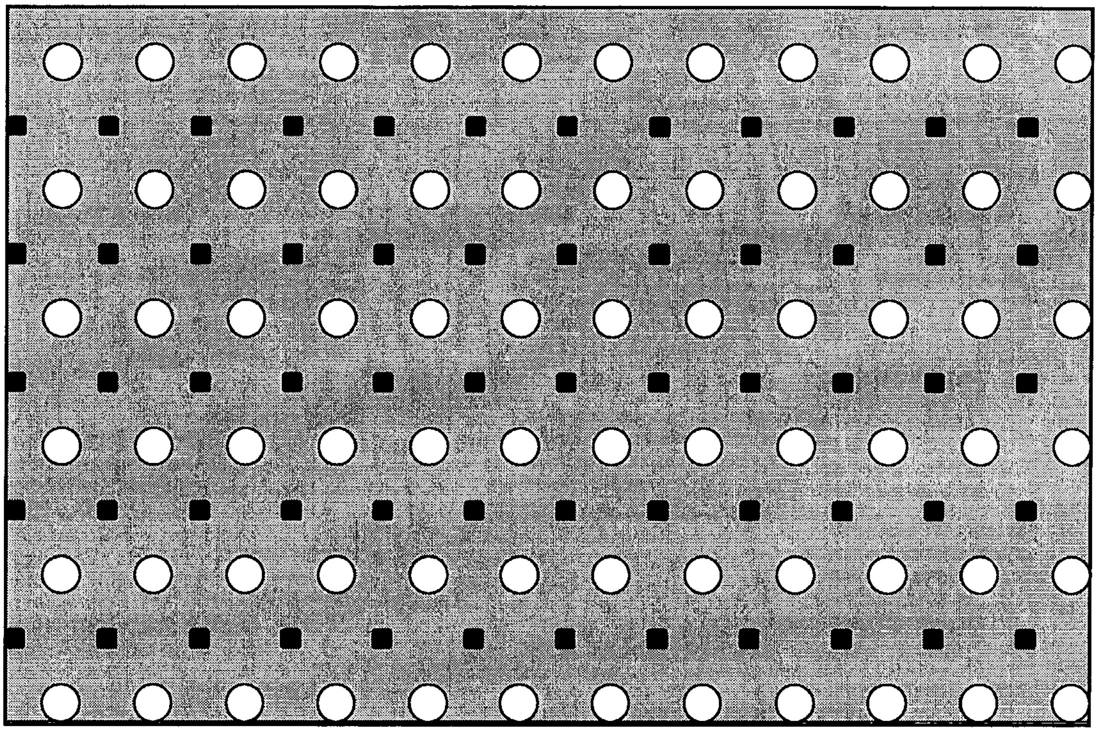


FIGURE 3

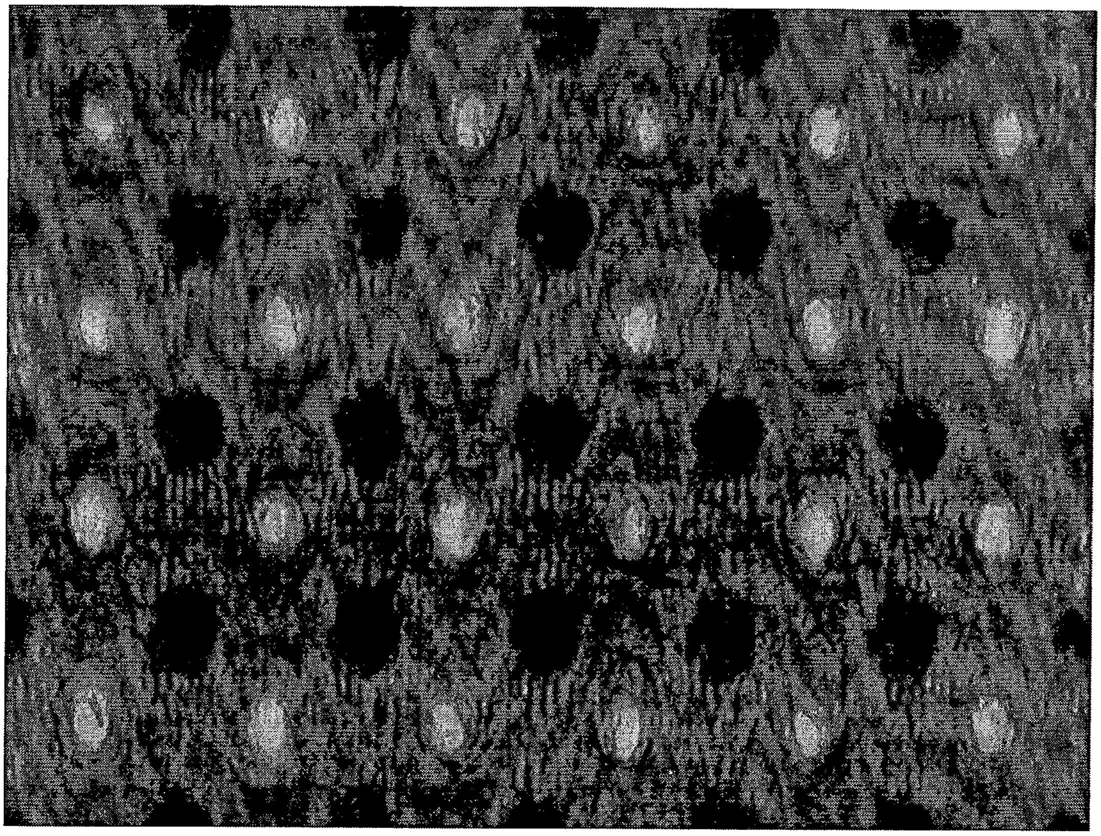


FIGURE 4

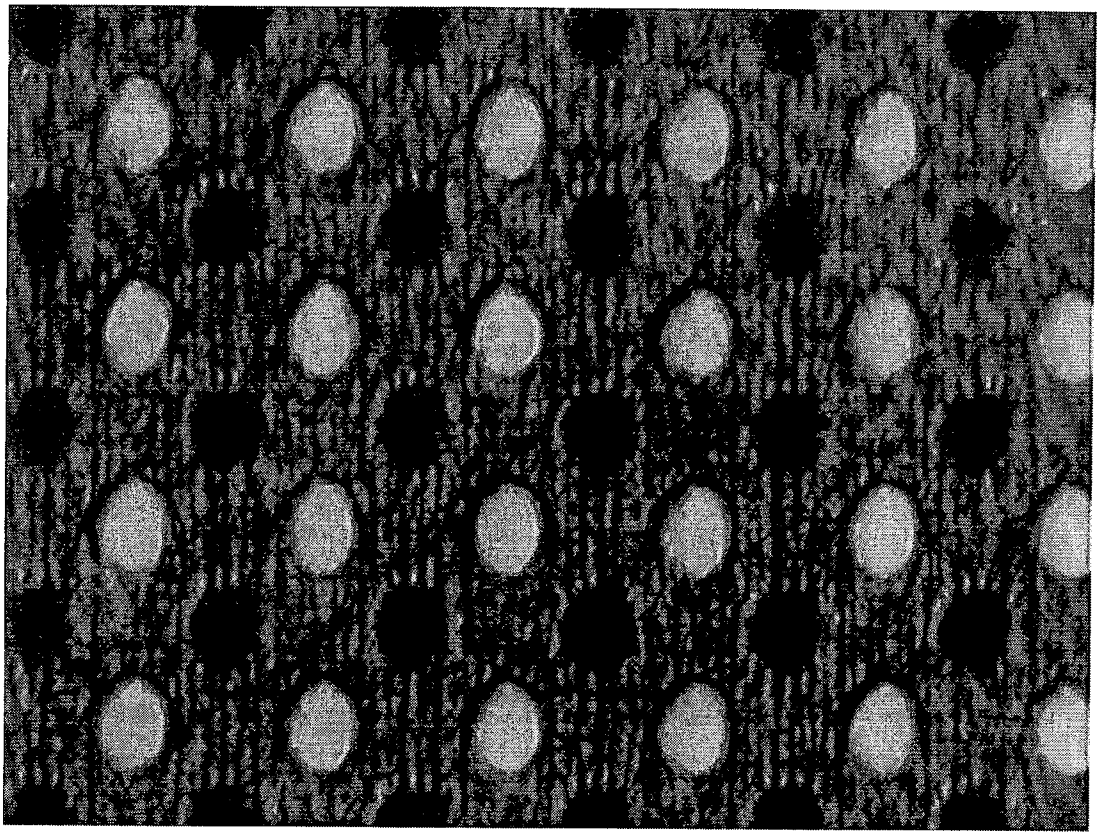


Figure 5a

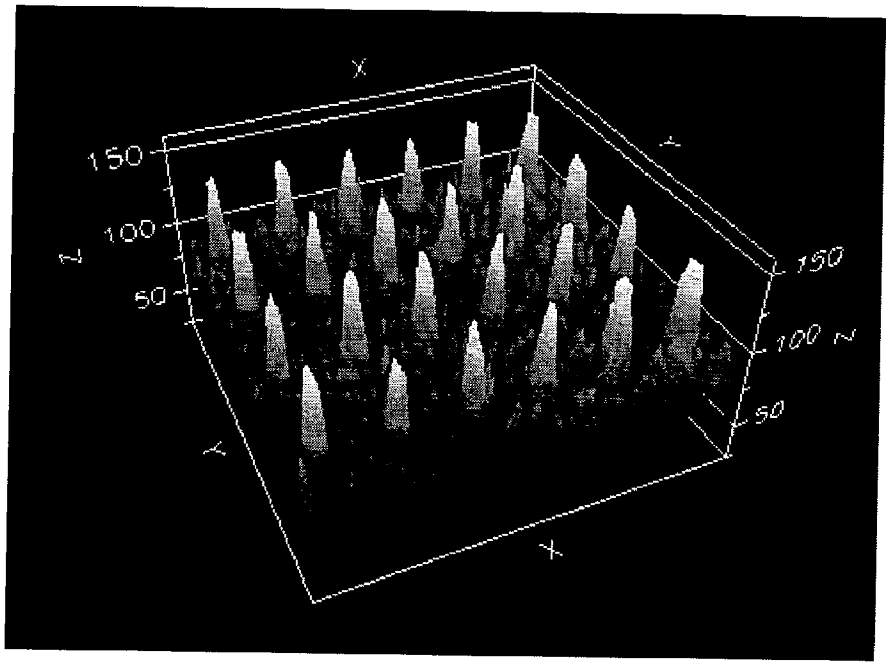


Figure 5b

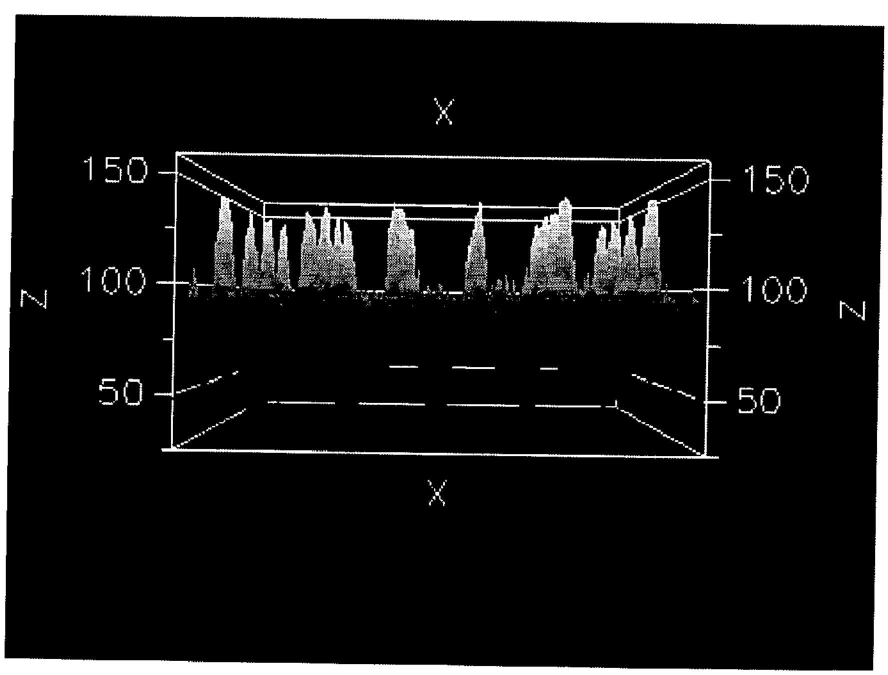


Figure 6a

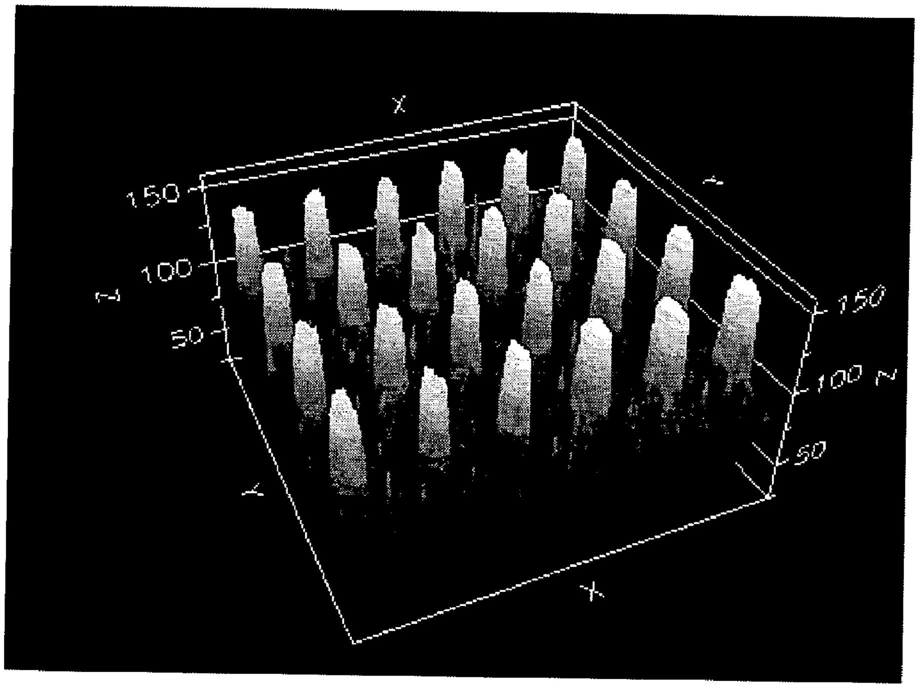
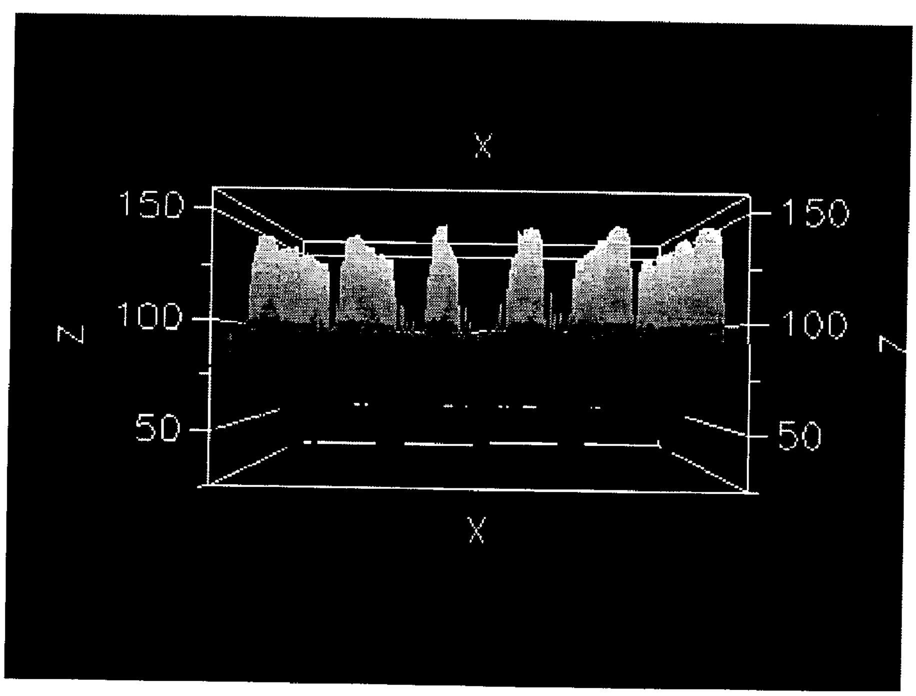


Figure 6b



METHOD FOR IMPROVED APERTURE CLARITY IN THREE-DIMENSIONAL NONWOVEN FABRICS AND THE PRODUCTS THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application Serial No. 60/362,225, filed Mar. 6, 2002.

TECHNICAL FIELD

[0002] The present invention relates generally to a nonwoven fabric, and specifically to a nonwoven fabric imparted with a three-dimensional pattern, said three-dimensional pattern further including at least one aperture, wherein the aperture exhibits a pronounced uniformity and significant reduction of fibrous occlusion.

BACKGROUND OF THE INVENTION

[0003] The production of conventional textile fabrics is known to be a complex, multi-step process. The production of fabrics from staple fibers begins with the carding process where the fibers are opened and aligned into a feedstock known as sliver. Several strands of sliver are then drawn multiple times on a drawing frames to further align the fibers, blend, improve uniformity as well as reduce the sliver's diameter. The drawn sliver is then fed into a roving frame to produce roving by further reducing its diameter as well as imparting a slight false twist. The roving is then fed into the spinning frame where it is spun into yarn. The yarns are next placed onto a winder where they are transferred into larger packages. The yarn is then ready to be used to create a fabric.

[0004] For a woven fabric, the yarns are designated for specific use as warp or fill yarns. The fill yarns (which run on the y-axis and are known as picks) are taken straight to the loom for weaving. The warp yarns (which run on the x-axis and are known as ends) must be further processed. The large packages of yarns are placed onto a warper frame and are wound onto a section beam were they are aligned parallel to each other. The section beam is then fed into a slasher where a size is applied to the yarns to make them stiffer and more abrasion resistant, which is required to withstand the weaving process. The yarns are wound onto a loom beam as they exit the slasher, which is then mounted onto the back of the loom. The warp yarns are threaded through the needles of the loom, which raises and lowers the individual yarns as the filling yarns are interested perpendicular in an interlacing pattern thus weaving the yarns into a fabric. Once the fabric has been woven, it is necessary for it to go through a scouring process to remove the size from the warp yarns before it can be dyed or finished. Currently, commercial high-speed looms operate at a speed of 1000 to 1500 picks per minute, where a pick is the insertion of the filling yarn across the entire width of the fabric. Sheeting and bedding fabrics are typically counts of 80×80 to 200×200, being the ends per inch and picks per inch, respectively. The speed of weaving is determined by how quickly the filling yarns are interlaced into the warp yarns; therefore looms creating bedding fabrics are generally capable of production speeds of 5 inches to 18.75 inches per minute.

[0005] In contrast, the production of nonwoven fabrics from staple fibers is known to be more efficient than traditional textile processes as the fabrics are produced directly from the carding process.

[0006] Nonwoven fabrics are suitable for use in a wide variety of applications where the efficiency with which the fabrics can be manufactured provides a significant economic advantage for these fabrics versus traditional textiles. However, nonwoven fabrics have commonly been disadvantaged when fabric properties are compared, particularly in terms of surface abrasion, pilling and durability in multiple-use applications. Hydroentangled fabrics have been developed with improved properties, which are a result of the entanglement of the fibers, or filaments in the fabric providing improved fabric integrity. Subsequent to entanglement, fabric durability can be further enhanced by the application of binder compositions and/or by thermal stabilization of the entangled fibrous matrix.

[0007] U.S. Pat. No. 3,485,706, to Evans, hereby incorporated by reference, discloses processes for effecting hydroentanglement of nonwoven fabrics. More recently, hydroentanglement techniques have been developed which impart images or patterns to the entangled fabric by effecting hydroentanglement on three-dimensional image transfer devices. Such three-dimensional image transfer devices are disclosed in U.S. Pat. No. 5,098,764, hereby incorporated by reference, with the use of such image transfer devices being desirable for providing a fabric with enhanced physical properties as well as an aesthetically pleasing appearance.

[0008] Over the years, the use of nonwoven fabrics specifically in cleaning applications has been well practiced. Suitable substrates have included sponges, woven and nonwoven fabrics, and various combinations thereof. Further, such substrates have been impregnated with cleaning agents such as astringents, solvents, detergents and other chaotropes. The resulting cleaning products fabricated from such impregnated substrates have found acceptance with the general public as a convenient and practical means for the cleaning of surfaces. In particular, such constructs have been reasonably successful in the facial cleansing market.

[0009] Substrates of particular importance in the facial cleansing market include those fabrics that are imparted with apertures, or otherwise exhibit regions devoid of substrate matrix. It is has been conjectured by the fabricators of facial cleansing products practicing the use of such apertured fabric that the presence of the apertures improve the ability of the substrate to quickly build a beneficial lather during the cleansing process.

[0010] The presence of apertures in a facial cleansing product has been found to be a difficult and complex material to fabricate due to a need to have an absolute minimum in the occurrences of occluded apertures. Occlusion, for example by the fibrous matrix of a nonwoven substrate, and non-uniformity of the aperture has multiple deleterious affects. First, the occlusion results in an expected reduction of efficacy during a lather generation procedure due to the further constriction of the occlusion by the buildup of applied detergent agents. Second, an apertured substrate is difficult to fabricate so as to be functional and at the same time aesthetically pleasing. The very real problem of aesthetic appeal to the end-user is based on the fact that the human eye is attracted to variation in repeating patterns. An intermittent occlusion, even if only subtle in degree, will result in the user perception of a low quality product. The need for uniformity of aperture must be anticipated during the fabrication process and substrate material rejected should the aperture clarity at any time fall outside of predetermined specifications, thus leading to an exceedingly high level of potential material being rejected.

[0011] There remains a need for a nonwoven fabric which exhibits a combination of three-dimensionality and at least one aperture, and which does not suffer from the inherent problems of aperture occlusion.

SUMMARY OF THE INVENTION

[0012] The present invention is directed a nonwoven fabric which is imparted with a three-dimensional image or pattern, and apertures essentially devoid of fiber, during the fabrication stage. The nonwoven fabric exhibits a fibrous extension out of the plane of the material, while apertures are present that have a pronounced uniformity and a significant reduction in fibrous occlusion.

[0013] The uniformity and significant reduction in fiber occlusion have heretofore been unattainable in a three-dimensionally imaged or patterned nonwoven fabric. The nonwoven fabric of the present invention has a bulk of at least 1.5 millimeters and a clarity of opening value of 0.06 or less, and preferably a bulk of at least 1.8 millimeters and a clarity of opening value of 0.055 or less, and most preferably, a bulk of 2.0 millimeters and a clarity of opening value of 0.05 or less.

[0014] In accordance with the present invention, a method of making the nonwoven fabric embodying the present invention includes the steps of providing a precursor web comprising a fibrous matrix. In a particularly preferred form, the fibrous matrix is carded and cross-lapped to form a precursor web. It is also preferred that the precursor web be subjected to pre-entangling on a foraminous forming surface prior to imaging and patterning.

[0015] A method of making the present durable nonwoven fabric comprises the steps of providing a precursor web, which is subjected to hydroentangling. The precursor web is formed into an imaged and patterned nonwoven fabric by hydroentanglement on a three-dimensional image transfer device. The image transfer device defines three-dimensional elements against which the precursor web is forced during hydroentangling, whereby the fibrous constituents of the web are imaged and patterned by movement into regions between the three-dimensional elements of the transfer device. Apertures are induced by pronounced surface asperities that extend out of the plane of the image transfer device. The formation of the aperture-inducing asperities, and the associated fluidic drainage, is controlled such that a recessed region peripheral to each of the asperities aids in redirecting the fibrous matrix of the substrate down and into the recessed region.

[0016] In the preferred form, the precursor web is hydroentangled on a foraminous surface prior to hydroentangling on the image transfer device. This pre-entangling of the precursor web acts to integrate the fibrous components of the web, but does not impart imaging and patterning as can be achieved through the use of the three-dimensional image transfer device.

[0017] Other features and advantages of the present invention will become readily apparent from the following detailed description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] **FIG. 1** is a diagrammatic view of an apparatus for manufacturing a nonwoven fabric, embodying the principles of the present invention;

[0019] **FIG. 2** is a plan view of a three-dimensional image transfer device of the type used for practicing the present invention;

[0020] **FIG. 3** is a plan view of a three-dimensional nonwoven fabric, made using conventional image transfer practices; the magnification level is about 6.5×;

[0021] **FIG. 4** is a plan view of a three-dimensional nonwoven fabric, made in accordance with the present invention, the magnification level is about 6.5×;

[0022] **FIGS. 5***a* and **5***b* are luminosity plots of the nonwoven fabric depicted in **FIG. 3**; and

[0023] **FIGS. 6***a* and **6***b* are luminosity plots of the nonwoven fabric depicted in **FIG. 4**.

DETAILED DESCRIPTION

[0024] While the present invention is susceptible of embodiment in various forms, there is shown in the drawings and will hereinafter be described a presently preferred embodiment of the invention, with the understanding that the present disclosure is to be considered as an exemplification of the invention, and is not intended to limit the invention to the specific embodiment illustrated.

[0025] The present invention is directed a nonwoven fabric which is imparted with a three-dimensional image or pattern, and apertures essentially devoid of fiber, during the fabrication stage. The nonwoven fabric exhibits a fibrous extension out of the plan of the material, while apertures are present that have a pronounced uniformity and a significant reduction in fibrous occlusion.

[0026] With reference to **FIG. 1**, therein is illustrated an apparatus for practicing the present method for forming a nonwoven fabric. The fabric is formed from a fibrous matrix, which typically comprises staple length fibers. The fibrous matrix is preferably carded and cross-lapped to form a precursor web, designated P. In a current embodiment, the precursor web comprises a majority of cross-lap fibers, that is, most of the fibers of the web have been formed by cross-lapping a carded web so that the fibers are oriented at an angle relative to the machine direction of the resultant web.

[0027] **FIG. 1** illustrates a hydroentangling apparatus for forming nonwoven fabrics in accordance with the present invention. The apparatus includes a foraminous-forming surface in the form of belt **10** upon which the precursor web P is positioned for pre-entangling by entangling manifold **12**. Pre-entangling of the precursor web, prior to imaging and patterning, is subsequently effected by movement of the web P sequentially over a drum **14** having a foraminous forming surface, with entangling manifold **16** effecting entanglement of the web. Further entanglement of the web is effected on the foraminous forming surface of a drum **18** by entanglement manifold **20**, with the web subsequently passed over successive foraminous drums **22**, for successive entangling treatment by entangling manifolds **24'**, **24'**.

[0028] The entangling apparatus of **FIG. 1** further includes an imaging and patterning drum **24** comprising a three-dimensional image transfer device for effecting imaging and patterning of the now-entangled precursor web. The image transfer device includes a moveable imaging surface which moves relative to a plurality of entangling manifolds **26** which act in cooperation with three-dimensional elements defined by the imaging surface of the image transfer device to effect imaging and patterning of the fabric being formed.

[0029] Hydroentanglement results in portions of the precursor web being displaced from on top of the three-dimensional surface elements of the imaging surface to form an imaged and patterned nonwoven fabric. Enhanced surface fiber extension is desirably achieved, thus providing improved cleaning properties for the resultant fabric, while uniform a relatively unoccluded apertures are obtained.

EXAMPLES

Example 1

[0030] Using a forming apparatus as illustrated in **FIG. 1, a** nonwoven fabric was made in accordance with the teachings of U.S. Pat. No. 5,098,764 by providing a precursor web comprising polyester staple fibers and rayon staple fibers.

[0031] Prior to patterning and imaging of the precursor web, the web was entangled by a series of entangling manifolds such as diagrammatically illustrated in **FIG. 1. FIG. 1** illustrates disposition of precursor web P on a foraminous forming surface in the form of belt **10**, with the web acted upon by an entangling manifold **12**. The web then passes sequentially over a drum **14** having a foraminous forming surface, for entangling by entangling manifold **16**, with the web thereafter directed about the foraminous forming surface of a drum **18** for entangling by entanglement manifold **20**. The web is thereafter passed over successive foraminous drums **22**, with successive entangling treatment by entangling manifolds **24'**, **24'**.

[0032] The entangling apparatus of **FIG. 1** further includes an imaging and patterning drum **24** comprising a three-dimensional image transfer device for effecting imaging and patterning of the now-entangled precursor web. The entangling apparatus includes a plurality of entangling manifolds **26**, which act in cooperation with the three-dimensional image transfer device of drum **24** to effect patterning of the fabric.

[0033] The three-dimensional imaged nonwoven fabric was configured with an image, as illustrated in **FIG. 2**, wherein drain openings in the image transfer device are illustrated as white circular regions, and surface asperities are illustrated as black squares.

Example 2

[0034] An exemplary material was made in accordance with the present invention wherein the same fibrous matrix as used in Example 1, was imparted with a three-dimensional topography and coinciding apertures, wherein the aperture-forming asperities of the image transfer device further each included a Peripheral recessed region, such as shown in phantom line in **FIG. 2**.

[0035] Without being held to a specific mode of operation, it is believed that the circumferential recessed region allows for hydraulic turbulents formed off of the aperture-forming asperity during application of hydraulic to inter-entangle the fibrous matrix displaced from the asperity. This inter-entanglement of the displaced fibers imparts a durable integration of the fibers, and thus restrains these same fibers from displacement into the newly formed aperture in the resulting fabric.

[0036] Photometric analysis of Example 1 and Example 2 are provided in **FIGS. 5***a*/*b* and **6***a*/*b*, respectively. As can be seen in the luminosity plots **6***a* and **6***b*, the material of the present invention presents a more pronounced aperture versus the materials made without specific control of the fibrous matrix on the periphery of the aperture. Values for clarity of opening are determined in the manner described in the U.S. Pat. No. 5,098,764, herein incorporated by reference.

[0037] The luminosity plots show graphical projections which represent the clearity of the apertures within the corresponding fabrics. As shown in **FIGS. 5***a* and **5***b*, the graphical projections consist of shades of grey that start out dark at the base and gradually lighten while tapering from the base of the projection so as to form a pointed apex. The area of the projection at its apex is less than 50% of the area at the base of the projection. The tapering of the projections that occurs is due to fiber interference within the aperture, indicating that only a minimal portion of the aperture is completely devoid of fibers.

[0038] The luminosity plots of **FIGS. 6***a* and **6***b* show the graphical projections that correspond with the fabric of the present invention. The graphical projections of **FIGS. 6***a* and **6***b* also consist of shades of grey that start out dark at the base and gradually lighten toward the apex of the projections. It should be noted that the projections demonstrate only minimal tapering from the base to the apex. Further, the area of the projection at its apex is greater than 50% of the area at the base of the projection. The broader apex of the graphical projections in **FIGS. 6***a* and **6***b* are due the lack of fiber interference within the aperture, indicating that the aperture has improved clearity.

[0039] From the foregoing, it will be observed that numerous modifications and variations can be affected without departing from the true spirit and scope of the novel concept of the present invention. It is to be understood that no limitation with respect to the specific embodiments illustrated herein is intended or should be inferred. The disclosure is intended to cover, by the appended claims, all such modifications as fall within the scope of the claims.

What is claimed is:

1. A nonwoven fabric, comprising;

a prebond fibrous matrix of staple length fibers,

a three-dimensional transfer device,

hydroentangling the prebond fibrous matrix on the three-dimensional transfer device so as to impart a three-dimensional and at least one aperture into the resultant nonwoven fabric, and

the three-dimensional nonwoven fabric exhibiting a bulk of at least 1.5 millimeters and a clarity of aperture of at least 0.06.

2. A nonwoven fabric, comprising;

a prebond fibrous matrix of staple length fibers,

a three-dimensional transfer device,

hydroentangling the prebond fibrous matrix on the three-dimensional transfer device so as to impart a three-dimensional and at least one aperture into the resultant nonwoven fabric, and

the three-dimensional nonwoven fabric exhibiting a bulk of at least 1.5 millimeters and a clarity of aperture wherein the area of the apex of a graphical projection is greater than 50% of the area at the base of the projection when measured in a Photometric Analysis.

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