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Proporadas con propiedades Mejoradas.

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☒ Capítulo I. ☐ Capítulo II.

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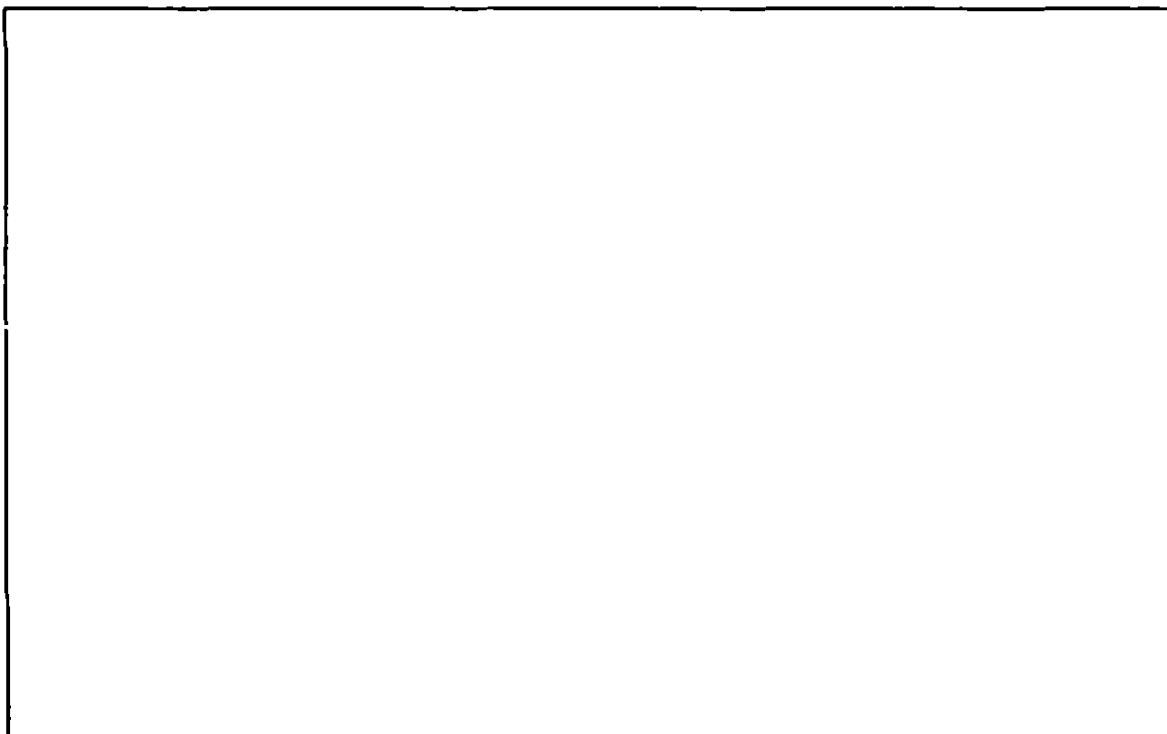
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ANEXOS

- ☒ Comprobante de pago de la tasa de presentación de la solicitud
- ☐ Comprobante de pago por reivindicación de prioridad
- ☐ Documento que acredite la existencia y representación legal cuando el solicitante sea persona Jurídica
- ☐ Poderes, si fuera el caso
- ☐ Documento de cesión del inventor al solicitante o a su causante
- ☐ Declaraciones
- ☒ Copia de la solicitud Internacional. (Resumen, descripción, reivindicación, Dibujos).
- ☒ Traducción de la solicitud internacional al castellano. (Resumen, descripción, reivindicación, Dibujos)
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- ☐ De ser el caso, certificado de depósito del material biológico
- ☐ Arte final 12 x 12 y 6 x 6 cm
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- ☒ Otros:
1. Notificación del reporte de búsqueda
 2. Patente USA Nr. 5,195,979
 3. Patente USA Nr. 4,863,779
 4. Patente USA Nr. 4,741,841
 5. Patente USA Nr. 5,731,062

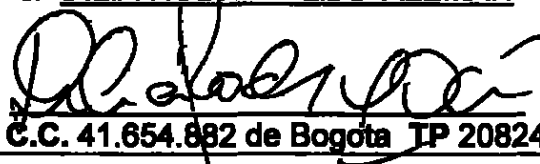
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NOMBRE: DILIA RODRÍGUEZ D'ALEMAN

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PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

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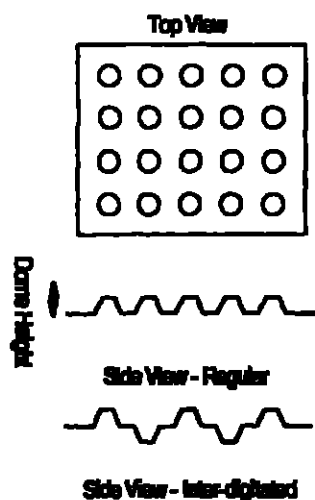
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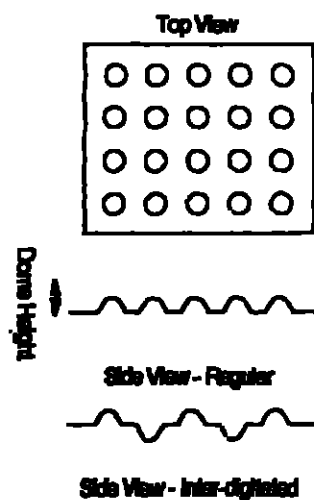
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[Continued on next page]

(54) Title: THREE-DIMENSIONAL DEEP MOLDED STRUCTURES WITH ENHANCED PROPERTIES



A



B

(57) Abstract: A three-dimensional deep molded structure made from planar knits or wovens composed of homo-component, bicomponent or multi-component fibers having a fiber diameter of less than 100 microns and nonwovens composed of fibers or filaments of any size. Most suitably, nonwovens with a random fiber orientation distribution and a high degree of crimp with partially oriented fibers are preferred for use in forming the deep molded structure.

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Description**THREE-DIMENSIONAL DEEP MOLDED STRUCTURES WITH
ENHANCED PROPERTIES**Related Applications

- 5 This application claims the benefit of U.S. Provisional Patent Application Serial No. 60/467,943, filed May 5, 2003, and U.S. Patent Application Serial No. 10/771,924, filed February 4, 2004, the disclosures of each of which are incorporated herein in their entirety.

Field of the Invention

- 10 The present invention relates to three-dimensional molded structures preferably comprising of a nonwoven substrate formed of small diameter fibers and/or filaments.

Background Art

- 15 Three-dimensional molded nonwoven structures are used in a variety of applications. Most notably, automotive parts account for a great majority of such applications including headliners, door liners, carpets, and the like. Most of these structures however, are molded to conform to the shape of the object they surround or support. The degree to which the fibers in the structure are extended is somewhat limited. Furthermore, these structures are molded to a
- 20 given shape and recovery from extension or compression is not a concern. Many nonwovens that are used in these applications are composed of fibers that have the ability to be drawn further during the molding process to accommodate the shapes required without being ruptured. For example, spunbonded structures composed of fibers that are not fully drawn during the
- 25 fabric manufacturing process make ideal candidates for such molding applications. Most other structures however, do not readily lend themselves to molding and often rupture during the molding process.

- 30 Another area of molding relates to honeycomb-like structures that are intended as compression supports in various structures including automotive seats, sports shoes and the like. These, however, use woven and knitted structures manufactured by intersecting or interlooping heavy monofilament fibers to achieve the desired properties.

- 2 -

Representative related art in the technology of the invention includes the following patent references: U.S. Patent No. 2,029,376; U.S. Patent No. 2,627,644; U.S. Patent No. 3,219,514; U.S. Patent No. 3,691,004; U.S. Patent No. 4,104,430; U.S. Patent No. 4,128,684; U.S. Patent No. 4,212,692; U.S. Patent No. 4,252,590; U.S. Patent No. 4,584,228; U.S. Patent No. 5,731,062; U.S. Patent No. 5,833,321; U.S. Patent No. 5,851,930; U.S. Patent No. 5,882,322; U.S. Patent No. 5,896,680; U.S. Patent No. 5,972,477; U.S. Patent No. 6,007,898; and U.S. Patent No. 6,631,221. The teachings of these prior art references are incorporated by reference herein.

The present invention is intended to overcome many of the well-known deficiencies of prior art deep molded structures and to meet a long-felt need for a new and improved material that possesses unique properties.

Summary of the Invention

Applicants have discovered deep molded three-dimensional structures fabricated from flat planar nonwoven substrates of various types in a variety of shapes. The present invention comprises a deep molded structure that is made from nonwovens comprising filaments or staple fibers of any size to create the nonwoven structure. Additionally, the present invention could comprise a deep molded structure that is made from knitted or woven materials comprising filament or staple fibers smaller than 100 microns in diameter. The fibers in all structures can be homo-component or multi-component as in sheath-core, side-by-side, striped, tipped trilobal, segmented-pile, and others.

The structure can be high in porosity or can be quite dense. The key to the invention for a wide range of products is to ensure that during the heating process, the fibers approach their onset of melting and are only partially melted. This invention also anticipates structures formed from complete melting of the fibrous structure which will result in a structure that does not have much resilience and will form a rigid structure used as a spacer fabric and the like. The structure relies on the thermoplastic components in the structure for moldability. However, the structure may be composed of both thermoplastic and non-thermoplastic components as well. The drawing characteristics of the

- 3 -

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constituent fibers are important as is the process for molding the structure. The structures are formed by a combination of heat and pressure such as those commonly used in solid phase pressure forming, vacuum bladder match plate molding, stamping, pressing or calendaring.

5 It is an object of the present invention to provide a nonwoven planar material comprising small diameter filaments or staple fibers to permanently form a multiplicity of raised projections from the plane of the nonwoven material.

10 It is another object of the present invention to provide a knitted or woven planar material comprising small diameter staple fibers or filaments molded to permanently form a multiplicity of raised projections from the plane of the material.

15 It is another object of the present invention to provide a deep molded structure wherein the local structure (from the raised portions to the depressions) retains its textile nature and remains functional.

 It is another object of the present invention to provide a deep molded structure wherein the planar structure to be molded can be selected from a variety of nonwovens but wherein a component in the structure must be thermoplastic.

20 It is another object of the present invention to provide additional stiffness to the deep molded structure by laminating or joining another planar substrate to the deep molded structures.

25 It is still another object of the present invention to provide additional stiffness to the deep molded structure by nesting two or more deep molded structures face-to-face or face-to-back.

30 It is another object of the present invention to provide additional properties to the deep molded structure by adding thermosetting resins, fibrous and non-fibrous coatings, and functionality such as electroactivity, waterproofing, mildew resistance, barrier materials, layer-shedding, and the like.

- 4 -

Some of the objects of the invention having been stated other objects will become apparent with reference to the detailed description and the drawings as described hereinbelow.

Description of the Drawings

5 Figures 1A, and 1B are schematic views of two representative deep molded structures;

Figures 2A, and 2B are schematic views of two representative processes making use of (1) flat sheet molding and (2) calendar molding, respectively;

10 Figure 3 is a schematic view of a representative dome shape formed on a substrate;

Figure 4 is a graph of draw ratio as a function of dome size;

Figure 5 is a top plan view of a sample deep molded structure with holes in the structure due to substrate failure;

15 Figure 6 is a side elevation view of typical dome deformation at high strain levels;

Figure 7 is a graph of loading and unloading for spunbonded substrates at three different basis weights;

Figure 8 is a bar graph of compression stiffness values for various deep molded structures formed from different nonwoven samples; and

20 Figures 9A and 9B are photographs of a sample deep molded structure after twenty-five (25) launderings.

Detailed Description of the Invention

25 The invention is a deep molded nonwoven structure comprising filaments or staple fibers having a diameter of any suitable size. Applicants also contemplate that the novel structure could be formed from knitted and woven fabrics comprising fibers and/or filaments measuring less than 100 microns in staple fiber or filament diameter. This provides a deep molded structure that retains its textile like hand, but will have significantly different texture and three-dimensionality as well as resilience and compression recovery. The three-dimensional textile structure has improved functionality with respect to heat and moisture management, small particle management,

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- 5 -

detection and decontamination of hazardous agents, force and impact management, air circulation, personal protection, personal comfort in transportation and confinement.

Natural and synthetic textile fibers are available in a wide range of cross-sectional shapes including, circular, triangular, multi-lobed, ribbon, hollow, irregular and the like. While measuring fiber diameter is a common means of describing fibers with circular cross-section, it is often necessary to measure fiber dimensions other than the diameter. In the case of trilobal cross-sections, the longest fiber dimension would be along an edge forming the trilobal cross-section or in the case of ribbon fibers, the cross-section would have two distinct measures (width and thickness). The intended invention may use fibers of any cross-sectional shape and have a size less than 100 microns in diameter (e.g., a round cross-section fiber of 80 microns in diameter) or wherein at least one of the principal dimension is less than 100 microns (e.g., a ribbon fiber of 100 microns x 10 microns).

Figures 1A, 1B and 2A, 2B show typical products and processes that can be used for making these deep molded structures. The manufacturing starts with a specific planar fabric. These fabrics are then stabilized and thermo-formed to create the three-dimensional novel structure of the invention. Multiple layers or composites can be constructed after the thermo-forming stage as a matter of choice. The thermo-forming process can use conventional sheet thermo-forming equipment (Figure 2A) or calendar molding equipment (Figure 2B), and typical processes are shown in Figures 2A and 2B.

In a nonwoven substrate, a number of structure variables can be controlled to form the desired structure. In particular, fiber orientation distribution (ODF), fiber crimp and fiber diameter are important controlling elements. The ODF ψ is a function of the angle θ . The integral of the function ψ from an angle θ_1 to θ_2 is equal to the probability that a fiber will have an orientation between the angles θ_1 to θ_2 . The function ψ must additionally satisfy the following conditions:

- 6 -

$$\psi(\theta + \pi) = \psi(\theta)$$

$$\int_0^\pi \psi(\theta) d\theta = 1$$

To describe the alignment of the fibers, applicants use a ratio known as the Anisotropy Ratio, f_p defined as:

$$f_p = 2\langle \cos^2 \theta \rangle - 1$$

$$\langle \cos^2 \theta \rangle = \frac{\int_0^\pi \psi(\theta) \cos^2(\theta_{ref} - \theta_i) d\theta}{\int_0^\pi \psi(\theta) d\theta}$$

- 5 The anisotropy parameter varies between -1 and 1. A value for f_p of 1 indicates a perfect alignment of the fibers parallel to a reference direction and a value of -1 indicates a perfect perpendicular alignment to that direction. f_p is zero for a random assembly. The degree of moldability changes with the structure's anisotropy. The best structures for the current inventions are obtained when
- 10 the nonwoven structure is random or when $f_p = 0$ or very close to 0. Nonwoven substrates suitable for molding generally have a value for f_p between $-\frac{1}{2}$ to $\frac{1}{2}$.

Note that an increase in fiber crimp will also result in improved moldability. This occurs because an increase in crimp increases the degree to which the structure may be drawn. Fiber diameter is important in determining

15 and controlling the structure because it affects stiffness and porosity properties.

The present invention most suitably uses filaments, and/or fibers having a diameter less than 100 microns, and preferably about 1-20 microns, to form the nonwoven, woven or knitted substrate thereof. Applicants surprisingly discovered that use of a nonwoven substrate formed from such small diameter

20 fibers results in highly resilient three-dimensional structure without adversely affecting the surface properties of the base material. Additionally, these structures can recover well from repeated compression and retain their shape and three-dimensionality. The present invention also contemplates using filaments, and/or fibers having a diameter greater than 100 microns to form a

25 significantly more rigid nonwoven. Applicants surprisingly discovered that such

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- 7 -

rigid nonwoven structures are also resilient and have significant recovery from compression.

The same has also been found to be the case with wovens and knits formed in accordance with the invention from the small diameter fibers and/or
5 filaments.

Thermo-forming of nonwoven substrates is accomplished through a combination of two material phenomena: (1) rheological and (2) mechanical deformation. Rheological deformation implies that a certain amount a molecular movement is induced through the application of heat to the substrate
10 thus softening the fiber to the point of laminar movement. To maintain fibrous characteristics without considerable change to molecular orientation and crystallinity, the forming temperature must be maintained to be above the glass transition and below the melting temperature (e.g., thermoplastic fibers or polymers have a melting temperature between 70 – 450 °C). Fibers used in
15 thermo-forming nonwoven substrates can include (co-polyetherester elastomer, poly (ethylene terephthalate), poly (trimethylene terephthalate), nylon 6, nylon 6,6, polypropylene, polyethylene, polyesters, polyamides, thermoplastic co-polyetherester elastomers, polyolefines, polyacrylonitriles, polyacrylates and thermoplastic liquid crystalline polymers); they can be homo-component, bi-
20 component or multi-component; and they can be tipped trilobal, side by side or sheath/core wherein one component melts at a lower temperature. In thermo-forming involving deep draws, four fundamental modes of mechanical deformation are observed. These are in-plane tension, transverse compression, in-plane shear and out-of-plane bending. The complexity in
25 mechanical deformation will vary with the complexity of the molds used during the thermo-forming process.

The present invention differs from other molded structures in that the total drawing of the substrate is significant both locally and in the bulk. Applicants use the term "drawability" to express the largest possible draw ratio
30 or limiting draw ratio obtained before failure occurs. For the present invention, the draw ratio is defined as the surface area of the formed product to that of the

- 8 -

substrate. Specifically, the surface area at which failure occurs could be used to determine the limiting draw ratio of the substrate with the following equation:

$$DR = \frac{A_{\text{sf}}}{A_i}$$

Where the initial surface area (A_i) is the pre-molding area and the final surface area (A_{sf}) is the increase in surface area achieved post molding. To demonstrate the extent to which the substrate is drawn, applicants use the frusto-conical dome geometry shown in Figure 3. In determining the Draw Ratio, several assumptions are made. It is assumed that a perfect grid of "domes" of right circular cones normal to the substrate plane describe the geometric shape produced utilizing a male/female mold geometry.

Applicants have discovered that fibers and/or filaments used to form the substrate normally achieve a better result during the molding process if the fibers and/or filaments are partially oriented fibers and/or filaments. This has been shown to achieve substantially improved fiber and/or filament orientation after molding.

Referring to Figure 3, within a unit cell, the final surface area (A_f) is comprised of the lateral surface area (L) of the frustum, the area of the top base (A_t), and the difference of the initial surface area (A_i) the area of the bottom base (A_b), and is given by:

$$A_{\text{sf}} = [a(L) + a(A_t)] + [(A_i) - a(A_b)]$$

Where a , is the total number of domes in a give area; in the unit cell $a=1$.

The lateral surface area (see Figure 3) is given by $L = \pi(r+R)s$ where $s = \sqrt{[(R-r)^2 + h^2]}$. The area of top base (A_t) is given by $A_t = \pi r^2$ and the area of the bottom base (A_b) is given by $A_b = \pi R^2$. Thus, the final surface area is given by $A_{\text{sf}} = [a(\pi(r+R)s) + a(\pi r^2)] + [(A_i) - a(\pi R^2)]$ where A_i = initial surface area.

Consider a three-dimensional structure as described herein with an initial length and width of 101.6 mm. Utilizing a 9.525 mm (3/8") male pin diameter in

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conjunction with a 15.875 mm (5/8") female hole. The following parameters apply:

Length (L _i), mm	101.6
Width (W _i), mm	101.6
# of "Domes"	16
Radius @ Dome Base, mm	7.9375
Radius @ Dome Top, mm	4.7625
Dome Height (h), mm	12

Consequently, $DR = \frac{A_{pr}}{A_i} = \frac{12639.849mm^2}{10322.56mm^2} = 1.222$

5 For a given substrate, the final draw ratio is a function of dome size. Figure 4 shows that the final draw ratio can be as much as 3 for various pin diameters. These draw ratios are significantly higher than the strain to failure of the substrates. The properties of the test structure used to create the data shown in Figure 4 are set forth in Table 1 below.

10 Table 1

Sample	Fiber Type	Weight g/m ²	Thickness (mm)	Fiber Cross Section	Fiber Diameter (μ)
Spunbond	PP	160	0.46	R	40-50

Applicants contemplate that the projections or depressions within the substrate will have a height between 0.1 – 10.0 mm and a width between 0.1 – 100 mm.

15 Applicants believe that formability of the substrates described herein for use with the present invention are affected by the structure anisotropy (fiber orientation distribution, ODF, in nonwovens) as well as the drawability of

- 10 -

individual fibers or filaments, and in the case of nonwovens the method of bonding. The strain to failure of the substrate tested at ambient is not an indicator. Applicants' invention allows the use of substrates with as little as 5.0% strain to failure and strains higher than 100%. Common anisotropic structures with strain to failures lower than 5.0% cannot be deep molded and holes are formed at moderate dome heights as shown in Figure 5. The properties of the test structure shown in Figure 5 are set forth in Table 2 below.

Table 2

Sample	Fiber Type	Weight g/m ²	Thickness (mm)	Fiber Cross Section	Fiber Diameter (μ)
Hydroentangled	PET	100	1.0	R	20

10 Generally, applicants have discovered that the draw ratio will increase as a function of product thickness increases and pin diameter decreases.

For a single layer structure, the structure's stiffness and strength is a function of the properties of the constituent fibers in the structure as well as the weight per unit area (basis weight) of the samples. This is especially true for
15 spunbonded nonwoven structures.

Maintaining the formed shape of the molded structure is of equal importance. There are no standard test methods for determining the compressive properties of formed deep molded structures. Applicants have tested a method that utilizes a constant rate of extension (CRE) tensile testing
20 machine in compression mode with the following conditions:

Platen Separation: 10 mm
Crosshead Speed: 1mm/min to 40 % strain
Specimen thickness: measured under .005 kgf
Sample Size: 10cm²

25 At a strain of approximately 40%, the dome projection changes from a more

11

cylindrical shape to a more conical shape as shown in Figure 6. The ability to recover to the original shape from this type of deformation was determined by cyclic loading. Figure 7 shows typical loading unloading behavior of spunbonded samples at three different basis weights (e.g., 320 gsm; 160 gsm; and 90 gsm). Note that the energy absorption and stiffness of the deep molded structure increase rapidly with basis weight. It is also evident that no permanent deformation is evident under compression loading. The properties of the test structures used to create the data shown in Figure 7 are set forth in Table 3 below.

10

Table 3

Sample	Fiber Type	Weight g/m ²	Thickness (mm)	Fiber Cross Section	Fiber Diameter (μ)
<u>Spunbond</u>	PP	90	0.38	R	40-50
<u>Spunbond</u>	PP	160	0.46	R	40-50
<u>Spunbond</u>	PP	320	0.75	R	40-50

Figure 8 shows the compressive stiffness of eight deep molded structures normalized by the weight of the specimens. It is evident that the stiffness increases with the basis weight of the specimens as seen for the PP samples. Note that these structures are composed of partially oriented fiber (POF) and are better suited for deep molding. These structures tend to form deeper and more uniform projections. Additionally, during the molding process the fibers go through solid state crystallization improving their mechanical properties. Note that the PET spunbonded samples out-perform the PP samples with the hydroentangled products providing the softest specimens. These were composed of fully drawn fibers and the molding process is not expected to result in improvements in the fiber properties. The properties of the eight test substrates shown in Figure 8 are described in Table 4 below.

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Table 4

Sample	Fiber Type	Weight g/m ²	Thickness (mm)	Fiber Cross Section	Fiber Diameter (μ)
<u>Spunbond</u>	PP	90	0.38	R	40-50
<u>Spunbond</u>	PP	160	0.46	R	40-50
<u>Spunbond</u>	PP	320	0.75	R	40-50

Figures 9A & 9B show the before and after photographs of a knitted fleece formed of 50/50 blend of cotton and multifilament polyester fiber and laundered fifty (50) times. The shape and appearance can be seen to be retained very well. The properties of the test structure are as follows: 50/50 polyester cotton knitted fleece.

Summarily, the invention discovered by applicants is a three-dimensional deep molded product made from planar nonwoven fabrics formed from staple fibers or filaments of any size. Also, knitted and woven fabrics comprising fibers and/or filaments smaller than 100 microns in diameter are contemplated by the invention. Preferably, the filament and fiber diameter are about 1–20 microns. The best nonwoven structures are those with a random fiber orientation distribution. While common anisotropic structures can also be molded, the degree to which they can be drawn becomes more limited with increasing anisotropy. Tufted, stitchbonded and flocked fabrics can also be used to make the deep molded product.

The stiffness of the structure can be controlled by employing larger diameter fibers and/or a higher basis weight. Higher porosities can be achieved by using thicker fibers. However, the overall flexibility of the structure will also reduce making it more difficult to cut. These attributes can be balanced to achieve the highest resilience, highest porosity, and highest flexibility.

12

- 13 -

The nonwoven web formation processes (e.g., carding, airlay, wetlay, spunbond and meltblown) typically lead to an oriented structure wherein the majority of fibers are parallel to the direction in which the web is being formed and collected (machine direction). The introduction of crimp into the fibers
5 tends to randomize the orientation distribution locally which leads to improved moldability.

It will be understood that various details of the invention may be changed without departing from the scope of the invention. Furthermore, the foregoing description is for the purpose of illustration only, and not for the
10 purpose of limitation—the invention being defined by the claims.

CLAIMS

What is claimed is:

1. A three-dimensional flexible fibrous network comprising a flexible textile substrate having a multiplicity of compressible projections which return to their shape after being substantially compressed, wherein the substrate is selected from the group consisting of nonwovens, wovens, knits and braids manufactured from filaments and/or fibers with a diameter of less than 100 microns or at least one principal cross-sectional dimension of less than 100 microns.
2. The fiber network recited in claim 1 wherein the substrate is a single layer or multilayer composite.
3. The fiber network recited in claim 1 wherein the substrate is wholly or partially made up of a thermoplastic fiber or polymer with melting temperature in the range of 70 C to 450 C.
4. The fiber network recited in claim 3 wherein the thermoplastic polymer is a co-polyetherester elastomer with long chain ether-ester units and short chain ester units joined head to tail through ester linkages.
5. The fiber network recited in claim 3 wherein the thermoplastic polymer is a poly(ethylene terephthalate) or poly(trimethylene terephthalate).
6. The fiber network recited in claim 3 wherein the thermoplastic polymer is selected from nylon 6, nylon 6,6, polypropylene or polyethylene.
7. The fiber network recited in claim 3 wherein the thermoplastic fiber is homo-component, bicomponent, or multi-component.
8. The fiber network recited in claim 3 wherein the thermoplastic fiber used in the substrate is selected from the group consisting of: polyesters, polyamides, thermoplastic copolyetherester elastomers, polyolefines, polyacrylates, and thermoplastic liquid crystalline polymers.
9. The fiber networks recited in claim 1 wherein the substrate may further comprise tufted, stitchbonded and flocked substrates.
10. The fiber network recited in claim 1 wherein the fibrous network has projections or depressions measuring 0.1 mm to 5 cm in height.

- 15 -

11. The fiber network recited in claim 1 wherein the fibrous network comprises projections or depressions measuring between 0.1 mm and 100 mm in width.
- 5 12. The fiber network recited in claim 1 wherein the projections have a frusto-conical shape.
13. The fiber network recited in claim 1 wherein the fibrous network most suitably comprises filaments and/or fibers with diameters of about 1-20 microns for soft structures and 20-100 microns for rigid structures.
- 10 14. The fiber network recited in claim 1 wherein the fibrous network comprises partially oriented fibers and/or filaments.
- 15 15. The fiber network recited in claim 1 wherein the fibrous network also contains a thermoset resin.
16. The fiber network recited in claim 1 wherein the fibrous network is stiffened by nesting head-to-head or head-to-tail two or more layers of said network.
17. The fiber network recited in claim 1 wherein the fibrous network can be stiffened by laminating a planar nonwoven, woven or knitted or other planar structure such as a film or a polymeric or metallic sheet to the network.
- 20 18. The fiber network recited in claim 1 wherein the fiber comprises a tipped trilobal cross-section wherein one component melts at a lower temperature.
19. The fiber network recited in claim 1 wherein the fiber comprises a sheath/core cross-section wherein the sheath melts at a lower temperature than the core.
- 25 20. The fiber network recited in claim 1 wherein the fiber comprises a side-by-side cross-section wherein one sheath melts at a lower temperature than the other.
- 30 21. The fiber network recited in claim 1 wherein the fiber is formed into a nonwoven web by carding, airlay, wetlay, spunbond or meltblown or any

- 16 -

combinations thereof, or by knitting, weaving and braiding or any combination thereof.

22. The fiber network recited in claim 1 wherein the nonwoven has an Anisotropy Ratio between - $\frac{1}{2}$ to $\frac{1}{2}$.
- 5 23. A method to form the fiber network recited in claim 1, including forming the fiber network by thermo-forming, stamping, calendaring, deep-draw molding, pressing, or a combination thereof.
24. The method recited in claim 23 Including adding additional function-ability to the fiber network by including barrier layers, additional fibrous and non-fibrous layers, thermosetting resins, functional finishes such as waterproofing, mildew resistance, and/or permeability modification.
- 10 25. A three-dimensional flexible fibrous network comprising a molded flexible textile substrate having a multiplicity of compressible projections which return to their shape after being substantially compressed, wherein the substrate is selected from the group consisting of wovens, knits and braids manufactured from filaments and/or fibers with a diameter of less than 100 microns or at least one principal cross-sectional dimension of less than 100 microns and nonwovens manufactured from filaments and/or fibers with a diameter of greater than 100 microns where the fiber-to-fiber crossover intersections are partially or fully fused during the molding process to provide substantial rigidity to the flexible textile substrate.
- 15 26. The fiber network recited in claim 25 wherein the substrate is a single layer or multilayer composite.
- 20 27. The fiber network recited in claim 25 wherein the substrate is wholly or partially made up of a thermoplastic fiber or polymer with melting temperature in the range of 70 C to 450 C.
28. The fiber network recited in claim 27 wherein the thermoplastic polymer is a co-polyetherester elastomer with long chain ether-ester units and short chain ester units joined head to tail through ester linkages.
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14

- 17 -

29. The fiber network recited in claim 27 wherein the thermoplastic polymer is a poly(ethylene terephthalate) or poly(trimethylene terephthalate).
30. The fiber network recited in claim 27 wherein the thermoplastic polymer is selected from nylon 6, nylon 6,6, polypropylene or polyethylene.
- 5 31. The fiber network recited in claim 27 wherein the thermoplastic fiber is homo-component, bicomponent, or multi-component.
32. The fiber network recited in claim 27 wherein the thermoplastic fiber used in the substrate is selected from the group consisting of: polyesters, polyamides, thermoplastic copolyetherester elastomers, polyoxefines, polyacrylates, and thermoplastic liquid crystalline polymers.
- 10 33. The fiber network recited in claim 25 wherein the substrate may further comprise tufted, stitchbonded and flocked substrates.
34. The fiber network recited in claim 25 wherein the fibrous network has projections or depressions measuring 0.1 mm to 5 cm in height.
- 15 35. The fiber network recited in claim 25 wherein the fibrous network comprises projections or depressions measuring between 0.1 mm and 100 mm in width.
36. The fiber network recited in claim 25 wherein the projections have a frusto-conical shape.
- 20 37. The fiber network recited in claim 25 wherein the fibrous network comprises partially oriented fibers and/or filaments.
38. The fiber network recited in claim 25 wherein the fibrous network also contains a thermoset resin.
39. The fiber network recited in claim 25 wherein the fibrous network is stiffened by nesting head-to-head or head-to-tail two or more layers of said network.
- 25 40. The fiber network recited in claim 25 wherein the fibrous network can be stiffened by laminating a planar nonwoven, woven or knitted or other planar structure such as a film or a polymeric or metallic sheet to the network.
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- 18 -

41. The fiber network recited in claim 25 wherein the fiber comprises a tipped trilobal cross-section wherein one component melts at a lower temperature.
- 5 42. The fiber network recited in claim 25 wherein the fiber comprises a sheath/core cross-section wherein the sheath melts at a lower temperature than the core.
43. The fiber network recited in claim 25 wherein the fiber comprises a side-by-side cross-section wherein one side melts at a lower temperature than the other.
- 10 44. The fiber network recited in claim 25 wherein the fiber is formed into a nonwoven web by carding, airlay, wetlay, spunbond or meltblown or any combinations thereof, or by knitting, weaving and braiding or any combination thereof.
- 15 45. The fiber network recited in claim 25 wherein the nonwoven has an Anisotropy Ratio between $-\frac{1}{2}$ to $\frac{1}{2}$.
46. A method to form the fiber network recited in claim 25, including forming the fiber network by thermo-forming, stamping, calendaring, deep-draw molding, pressing, or a combination thereof.
- 20 47. The method recited in claim 46 including adding additional functionality to the fiber network by including barrier layers, additional fibrous and non-fibrous layers, thermosetting resins, functional finishes such as waterproofing, mildew resistance, and/or permeability modification.

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WO 2004/098869

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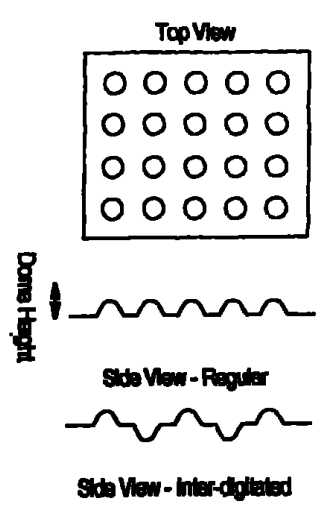


FIG. 1B

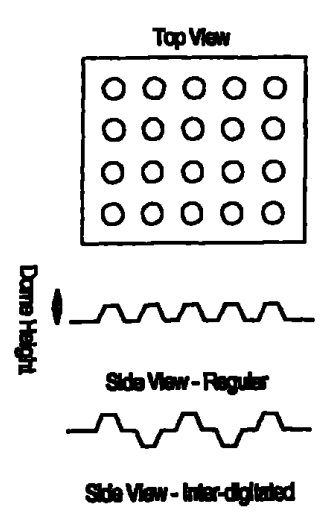


FIG. 1A

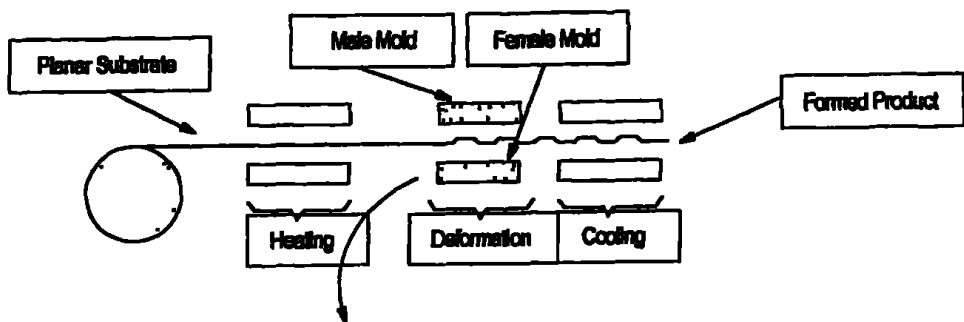


FIG. 2A

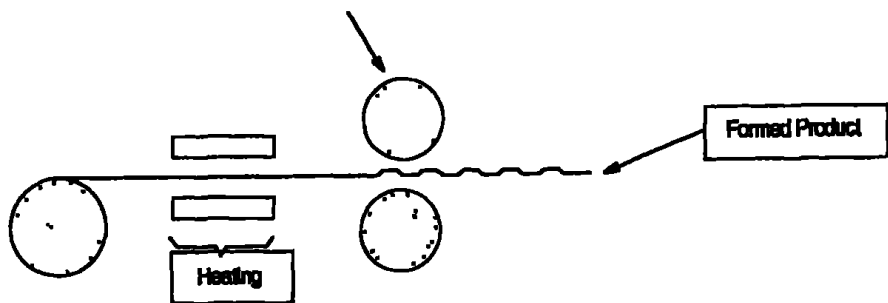


FIG. 2B

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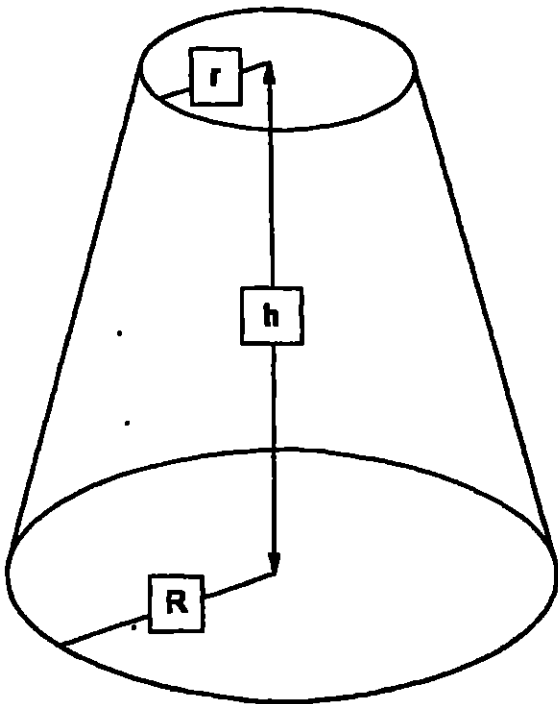
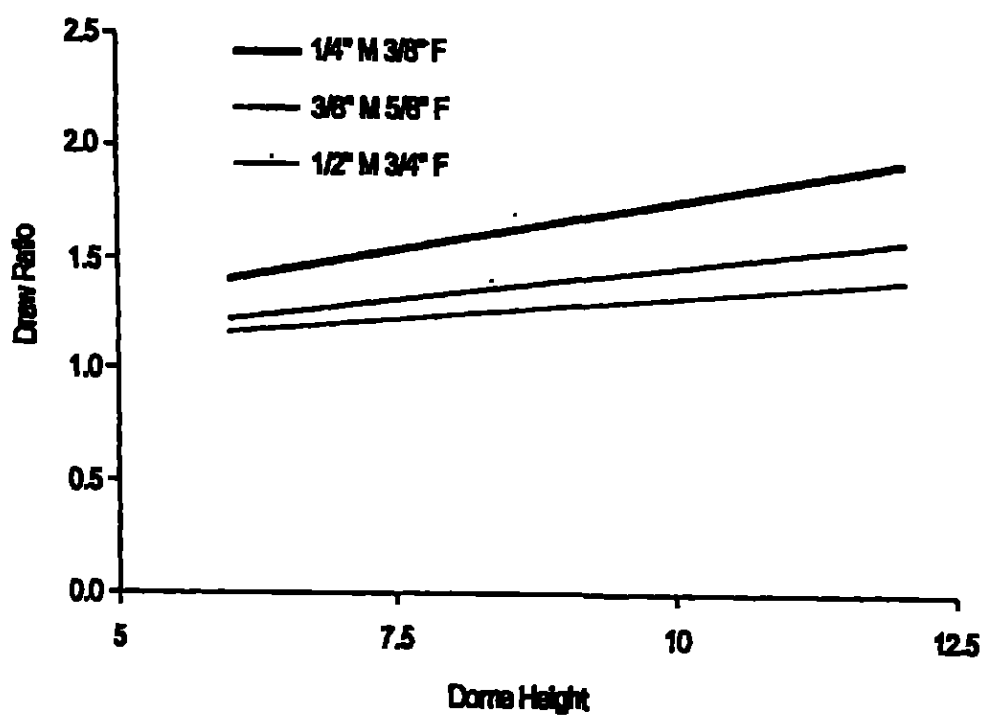


FIG. 3

4/9

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**FIG. 4****SUBSTITUTE SHEET (RULE 26)**

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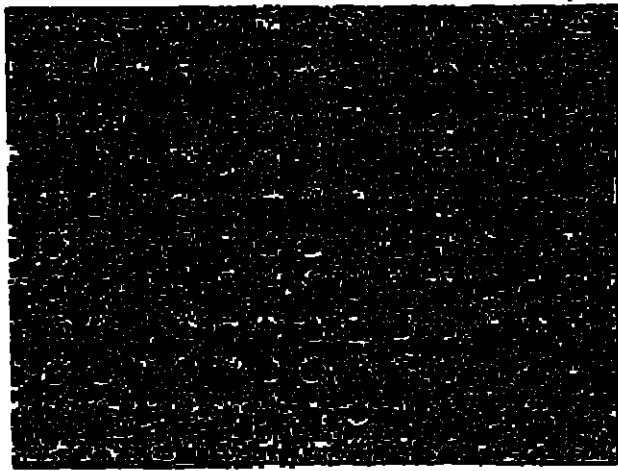


FIG. 5

SUBSTITUTE SHEET (RULE 26)

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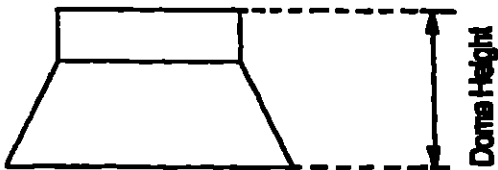


FIG. 6

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7/9

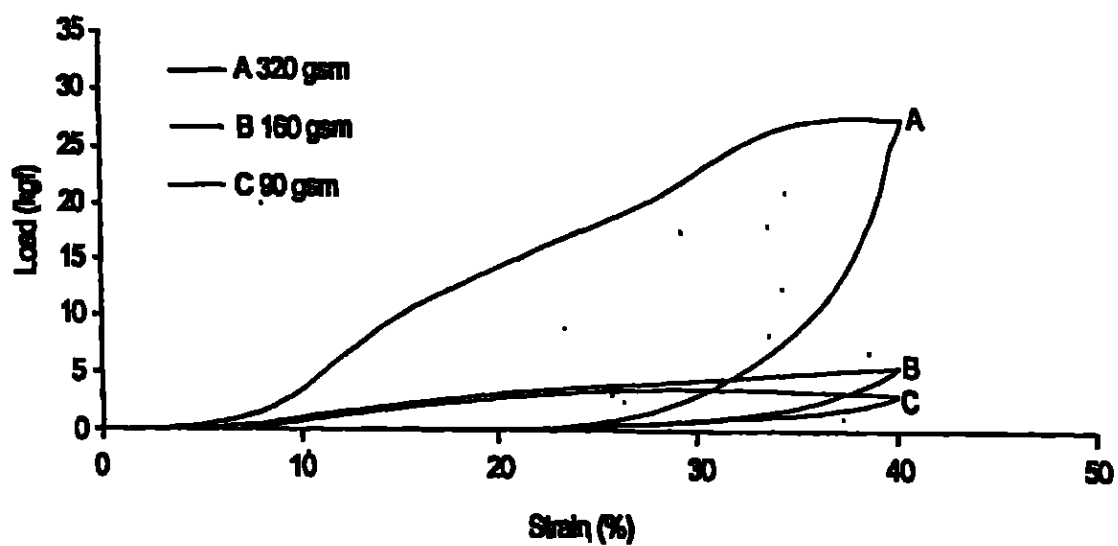


FIG. 7

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8/9

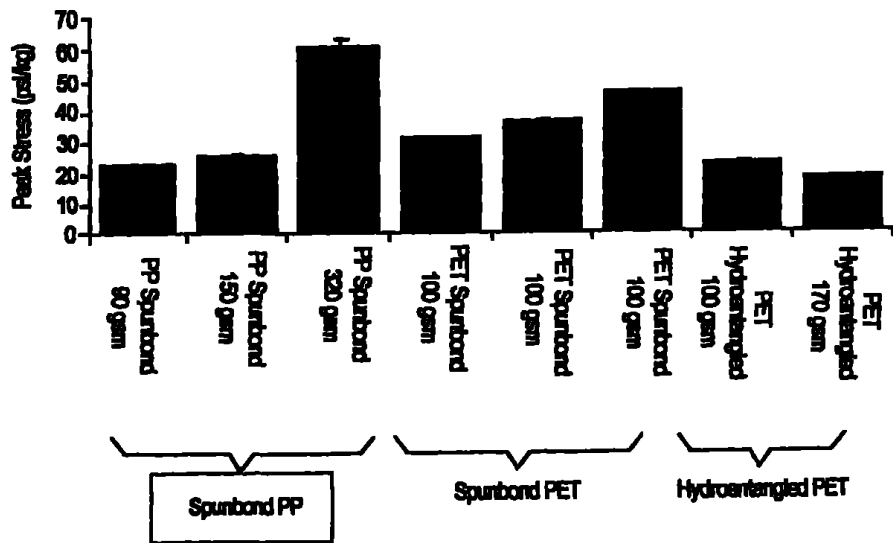


FIG. 8

9/9

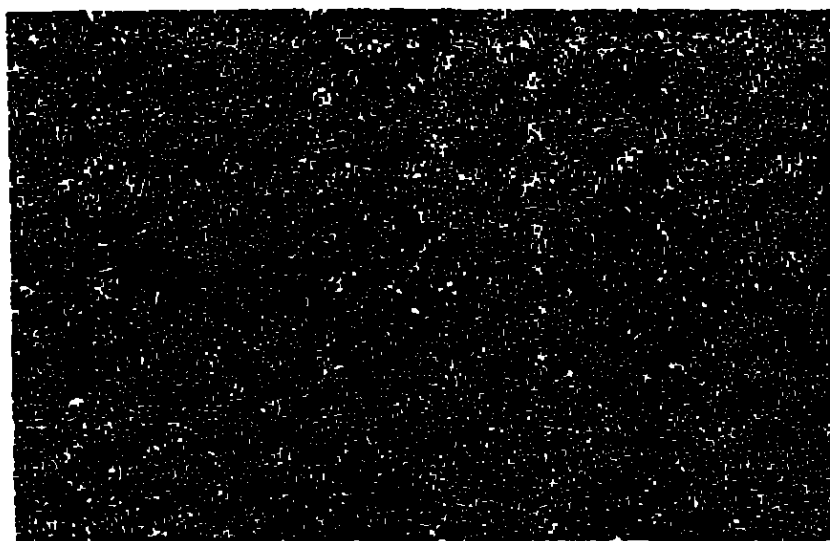


FIG. 9A



FIG. 9B

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SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/10685

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B32B 3/00, 1/00, 3/12, 7/02; D03D 3/08, 15/08, 17/00; D04H 1/00, 13/00, 3/00, 5/00
US CL : 428/156, 175, 178, 212; 442/328, 182

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 428/156, 175, 178, 212; 442/328, 182

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,165,979 A (WATKINS et al.) 24 November 1992, see col. 1, lines 51-64; col. 2, lines 26-50; col. 4, lines 36-38.	1-3, 6-8, 13, 21, 23
X	US 4,863,779 A (DAPONTE) 05 September 1989, see fig. 2a; col. 3, line 8 thru col. 4, line 61; col. 5, lines 48-60; col. 7, lines 42-65; col. 16, lines 29-42; col. 20, lines 58-66; col. 2, lines 63-65.	1-3, 6-8, 13, 17, 21, 23, 25-27, 30-32, 44, 46
Y		4-5, 9-12, 14-16, 18- 20, 22, 24, 28-29, 33- 43, 45, 47
Y	US 4,741,941 A (ENGLEBERT et al.) 03 May 1988, see figs. 3, 10; col. 2, lines 46-60; col. 4, line 62 thru col. 5, line 2; col. 6, lines 2-9, 40-44.	1-8, 10, 12-13, 21, 23- 24
X	US 5,731,062 A (KIM et al.) 24 March 1998, see col. 5, lines 41-66.	1-8, 12, 15, 21, 23
Y		4-5, 9-12, 14-16, 18- 20, 22, 24, 28-29, 33- 43, 45, 47

☐ Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"B" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another claim or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"A"

document member of the same patent family

Date of the actual completion of the international search

23 September 2004 (23.09.2004)

Date of mailing of the international search report

30 SEP 2004

Name and mailing address of the ISA/US

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Commissioner for Patents
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Descripción

25

**ESTRUCTURAS MOLDEADAS TRIDIMENSIONALES PROFUNDAS CON
PROPIEDADES MEJORADAS**Solicitudes Relacionadas

Esta solicitud reivindica el beneficio de la Solicitud de Patente Provisional U.S. Serie No. 60/467,943, presentada en Mayo 5, 2003, y la Solicitud de Patente U.S. Serie No. 10/761,924, presentada en Febrero 4, 2004, cuya descripción se cada una se incorpora aquí en su totalidad.

Campo de la Invención

La presente invención se relaciona con estructuras moldeadas tridimensionales preferiblemente que comprenden un sustrato no tejido formado de fibras y/o filamentos de diámetro pequeño.

Técnica Anterior

Las estructuras no tejidas moldeadas tridimensionales son utilizadas en una variedad de solicitudes. Más notoriamente, las partes automotrices se cuentan como la gran mayoría de

26

tales aplicaciones que incluyen recubrimiento de techos de carros, recubrimientos interiores de puertas, tapetes, y similares. Sin embargo la mayoría de estas estructuras son moldeadas para adecuarse a la forma del objeto que le circunda o sostiene. El grado en el cual están extendidas las fibras en la estructura es algo limitado. Adicionalmente, estas estructuras están moldeadas en una forma dada y la recuperación de la extensión o compresión no es una preocupación. Muchos no tejidos que son utilizados en estas aplicaciones están compuestos de fibras que tienen la capacidad de ser estiradas durante el proceso de moldeo para acomodarse a las formas requeridas sin ser roto. Por ejemplo, las estructuras unidas por hilado compuestas de fibras que no son completamente estiradas durante el proceso de elaboración de la tela son candidatos ideales para tales aplicaciones de moldeo. La mayoría de las otras estructuras sin embargo, no se prestan fácilmente para moldeare y a menudo se rompen durante el proceso de moldeo.

Otra área de moldeo se relaciona con las estructuras combadas que están destinadas a soportes de compresión en varias estructuras que incluyen asientos para automotores, zapatos deportivos y similares. Estos, sin embargo, utilizan estructuras tejidas y entretejidas elaboradas al intersectar

27

o entrelazar fibras de monofilamento pesadas para lograr las propiedades deseadas.

La técnica relacionada representativa de la tecnología de la invención incluye las siguientes referencias de patente:

Patente U.S. No. 2,029,376; Patente U.S. No. 2,627,644;
Patente U.S. No. 3,219,514; Patente U.S. No. 3,691,004;
Patente U.S. No. 4,104,430; Patente U.S. No. 4,128,684;
Patente U.S. No. 4,212,692; Patente U.S. No. 4,252,590;
Patente U.S. No. 4,584,228; Patente U.S. No. 5,731,062;
Patente U.S. No. 5,833,321; Patente U.S. No. 5,851,930;
Patente U.S. No. 5,882,322; Patente U.S. No. 5,893,680;
Patente U.S. No. 5,972,477; Patente U.S. No. 6,007,898; y
Patente U.S. No. 6,631,221. Las enseñanzas de estas referencias de la técnica anterior se incorporan aquí como referencia.

La presente invención está destinada a solucionar muchas de las deficiencias bien conocidas de las estructuras moldeadas profundas de la técnica anterior y a satisfacer una necesidad sentida durante largo tiempo de un material nuevo y mejorado que posee propiedades únicas.

28

Resumen de la Invención

Los solicitantes han descubierto estructuras tridimensionales moldeadas profundas fabricadas de sustratos no tejidos planos de varios tipos en una variedad de formas. La presente invención comprende una estructura moldeada profunda que es hecha de no tejidos que comprenden filamentos o fibras de hebra de cualquier tamaño para crear la estructura no tejida. Adicionalmente, la presente invención podría comprender una estructura moldeada profunda que es hecha de materiales entretejidos o tejidos que comprenden filamentos o fibras de hebra más pequeños de 100 micrómetros de diámetro. Las fibras en todas las estructuras pueden ser homocomponentes o multicomponentes como en núcleo de funda, lado a lado, a rayas, punteado de tres lóbulos, pastel segmentado, y otros.

La estructura puede ser alta en porosidad o puede ser muy densa. La clave de la invención para un amplio rango de productos es asegurar que durante el proceso de calentamiento, las fibras aproximen su arremetida de fundido y sean solo parcialmente fundidas. Esta invención también anticipa estructuras formadas del fundido completo de la estructura fibrosa que dará como resultado una estructura que no tenga mucha elasticidad y forme una estructura rígida utilizada como una tela espaciadora y similar. La estructura se basa en

29

componentes termoplásticos en la estructura para moldabilidad. Sin embargo, la estructura puede estar compuesta tanto de componentes termoplásticos como no termoplásticos también. Las características del dibujo de las fibras constituyentes son importantes porque es el proceso para moldear la estructura. Las estructuras están formadas por una combinación de calor y presión tal como aquellas comúnmente utilizadas en formación por presión de fase sólida, moldeo de placa que casa con balón de vacío, estampado, presionado o calandrado.

Es un objeto de la presente invención suministrar un material plano no tejido que comprende filamentos de diámetro pequeño o fibras de hebra para formar permanentemente una multiplicidad de proyecciones levantadas desde el plano del material no tejido.

Es otro objeto de la presente invención suministrar un material plano tejido o tejido de punto que comprende fibras o filamentos de hebra de diámetro pequeño moldeadas para formar permanentemente una multiplicidad de proyecciones levantadas desde el plano del material.

Es otro objeto de la presente invención suministrar una estructura moldeada profunda en donde la estructura local (de

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las porciones levantadas a las depresiones) requieren la naturaleza textil y permanecen funcionales.

Es otro objeto de la presente invención suministrar una estructura moldeada profunda en donde la estructura plana a ser moldeada se puede seleccionar de una variedad de no tejidos pero en donde un componente de la estructura debe ser termoplástico.

Es otro objeto de la presente invención suministrar rigidez adicional a la estructura moldeada profunda al laminar o unir otro sustrato plano a las estructuras moldeadas profundas.

Es aún otro objeto de la presente invención suministrar rigidez adicional a la estructura moldeada profunda al alojar dos o más estructuras moldeadas profundas cara a cara o cara con espalda.

Es otro objeto de la presente invención suministrar propiedades adicionales de la estructura moldeada profunda al agregar resinas termoendurecibles, y recubrimientos fibrosos y no fibrosos, y funcionalidad tal como electroactividad, resistencia al agua, resistencia al moho, materiales de barrera, vertimiento de capa, y similares.

31

Algunos de los objetos de la invención habiendo sido establecidos otros objetos serán evidentes con referencia a la descripción detallada y a los dibujos como se describen a continuación.

Descripción de los Dibujos

Las Figuras 1A, y 1B son vistas esquemáticas de dos estructuras moldeadas profundas representativas.

Las Figuras 2A, y 2B son vistas esquemáticas de dos procesos representativos que hacen uso de (1) moldeo de lámina plana y (2) moldeo por calandrado, respectivamente;

La Figura 3 es una vista esquemática de una forma de domo representativa conformada sobre un sustrato;

La Figura 4 es una gráfica de la proporción de estiramiento como una función del tamaño del domo;

La Figura 5 es una vista de planta superior de una estructura moldeada profunda de muestra con huecos en la estructura debido a la falla del sustrato;

32

La Figura 6 es una vista en elevación lateral de la deformación típica del domo a altos niveles de tensión;

La Figura 7 es una gráfica de carga y descarga para sustratos de material no tejido hilado en tres diferentes pesos base;

La Figura 8 es una gráfica de barras de valores de rigidez de compresión para varias estructuras moldeadas profundas conformadas de diferentes muestras no tejidas; y

Las Figuras 9A y 9B son fotografías de una estructura moldeada profunda de muestra después de veinticinco (25) lavadas.

Descripción Detallada de la Invención

La Invención es una estructura no tejida moldeada profunda que comprende filamentos o fibras que contienen un diámetro de cualquier tamaño adecuado. Los solicitantes también contemplan que la estructura novedosa puede ser conformada de telas tejidas y tejidas de punto que comprenden fibras y/o filamentos que miden menos de 100 micrómetros en el diámetro de la fibra o filamento de hebra. Esto proporciona una estructura moldeada profunda que retiene su mano similar a textil, pero tendrá textura significativamente diferente y

33

tridimensionalidad así como también elasticidad y recuperación de compresión. La estructura textil tridimensional tiene funcionalidad mejorada con respecto al manejo de calor lineal, manejo de partícula pequeño, detección y descontaminación de agentes riesgosos, manejo de fuerza e impacto, circulación de aire, protección personal, comodidad personal, en transporte y confinamiento.

Las fibras textiles naturales y sintéticas están disponibles en un amplio rango de formas de sección transversal que incluyen, circular, triangular, multilobuladas, de cinta, huecas, irregulares, y similares. Mientras que la medición del diámetro de la fibra es un medio común para describir las fibras con sección trasversal circular, es a menudo necesario medir las dimensiones de la fibra diferentes del diámetro. En el caso de secciones transversales trilobulares, la dimensión de fibra más larga estaría a lo largo de un borde que forma la sección transversal lobular o en el caso de fibras de cinta, la sección transversal tendría dos mediciones distintas (ancho y grueso). La invención pretendida puede utilizar fibras de cualquier forma de sección transversal y tiene un tamaño menor de 100 micrómetros de diámetro (por ejemplo una fibra de sección transversal redonda de 80 micrómetros de diámetro) o en donde al menos una de la

34

invención principal es menor de 100 micrómetros (por ejemplo, una fibra de cinta de 100 micrómetros x 10 micrómetros).

Las figuras 1A, 1B y 2A, 2B muestran productos típicos y procesos que se pueden utilizar para elaborar estas estructuras moldeadas profundas. La elaboración inicia con una tela plana específica. Estas telas son entonces estabilizadas y termoformadas para crear una estructura novedosa tridimensional de la invención. Las capas múltiples o compuestas pueden ser construidas después de la etapa de termoformación a elección. El proceso de termoformación puede utilizar equipo de termoformado de lámina convencional (Figura 2A) o equipo de moldeo por calandrado (Figura 2B), y se muestran procesos típicos en las Figuras 2A y 2B.

En un sustrato no tejido, un número de estructuras variables se puede controlar para formar la estructura deseada. En particular, la distribución y orientación de la fibra (ODF), encrespado de la fibra y diámetro de la fibra son importantes elementos de control. El ODF ψ es una función del ángulo θ . La integral de la función ψ de un ángulo θ_1 a θ_2 es igual a la probabilidad de que una fibra tenga una orientación entre los ángulos θ_1 a θ_2 . La función ψ debe satisfacer adicionalmente las siguientes condiciones:

35

$$\psi(\theta + \pi) = \psi(\theta)$$

$$\int_0^\pi \psi(\theta) d\theta = 1$$

Para describir la alineación de las fibras, los solicitantes utilizan una proporción conocida como la Proporción de Anisotropía, f_p definida como:

$$f_p = 2\langle \cos^2 \theta \rangle - 1$$

$$\langle \cos^2 \theta \rangle = \frac{\int_0^\pi \psi(\theta) \cos^2(\theta - \theta_1) d\theta}{\int_0^\pi \psi(\theta) d\theta}$$

El parámetro de anisotropía varía entre -1 y 1. Un valor para f_p de 1 indica una alineación perfecta de las fibras paralelas a una dirección de referencia y un valor de -1 indica una alineación perpendicular perfecta a esa dirección. f_p es 0 para un ensamble aleatorio. El grado de moldabilidad cambia con la anisotropía de la estructura. Las mejores estructuras para las actuales invenciones se obtienen cuando la estructura no tejida es aleatoria o cuando $f_p = 0$ o muy cercano a 0. Los sustratos no tejidos hilados adecuados para moldeo generalmente tienen un valor para f_p entre -1/2 a 1/2.

76

Nótese que un incremento en el encrespado de la fibra también resultará en moldabilidad mejorada. Esto ocurre debido a un incremento en el encrespado que incrementa el grado al que la estructura puede ser estirada. El diámetro de la fibra es importante al determinar y controlar la estructura debido a que esta afecta las propiedades de rigidez y porosidad.

La presente invención utiliza en forma más adecuada filamentos, y/o fibras que tienen un diámetro menor de 100 micrómetros, y preferiblemente cerca de 1-20 micrómetros, para formar el sustrato no tejido, tejido o sustrato de tejido de punto de éstos. Los solicitantes sorprendentemente descubrieron que el uso de un sustrato no tejido formado de tales fibras de diámetro pequeño resulta en una estructura tridimensional altamente resiliente sin afectar adversamente las propiedades de superficie del material base. Adicionalmente, estas estructuras se pueden recuperar bien de la compresión repetida y retener su forma y su tridimensionalidad. La presente invención también contempla el uso de filamentos, y/o fibras que tienen un diámetro mayor de 100 micrómetros para formar un no tejido significativamente más rígido. Los solicitantes descubrieron sorprendentemente que tales estructuras no tejidas rígidas

37

también son resistentes y tienen recuperación significativa de la compresión.

También se ha encontrado lo mismo para el caso de tejidos y tejidos de punto formados de acuerdo con la invención a partir de fibras de diámetro pequeño y/o filamentos.

El termoformado de sustratos no tejidos se acompaña a través de una combinación de dos fenómenos materiales: (1) deformación reológica y (2) deformación mecánica. La deformación reológica implica que una cierta cantidad de movimiento molecular se induce a través de la aplicación de calor al sustrato lo que suaviza la fibra al punto del movimiento laminar. Para mantener las características fibrosas sin cambio considerable a la orientación molecular y cristalinidad, la temperatura de formación se debe mantener por ser superior a la transición del vidrio e inferior a la temperatura de fusión (por ejemplo, fibras termoplásticos o polímeros que tienen una temperatura de fusión entre 70 -450° C). Las fibras utilizadas en los sustratos no tejidos de termoformado pueden incluir (elastómero copoliéster, poli(tereftalato de etileno), poli(tereftalato de trimetileno), nylon 6, nylon 6,6, polipropileno, polietileno, poliésteres, poliamidas, elastómeros de copoliéster termoplástico, poliolefinas, poliacrilonitrilos,

38

poliacrilatos, y polímeros cristalinos líquidos termoplásticos); ellos pueden ser homocomponentes, bicomponentes o multicomponentes; y ellos pueden ser punteados de tres lóbulos, lado a lado o núcleo de funda en donde un componente se funde a una temperatura inferior. En la termoformación que involucra estiramiento en profundidad, se observan cuatro formas fundamentales de deformación mecánica. Estas son tensión en plano, compresión transversal, rasgado en plano y unión fuera de plano. La complejidad en la deformación mecánica variará con la complejidad de los moldes utilizados durante el proceso de termoformado.

La presente invención difiere de otras estructuras moldeadas en que el estirado total del sustrato es importante localmente y en masa. Los solicitantes utilizan el término "capacidad de estiramiento" para expresar la proporción de estiramiento posible más grande o limitar la proporción de estiramiento obtenida antes de que ocurra falla. Para la presente invención, la proporción de estiramiento se define como el área de superficie del producto formado con respecto al sustrato. Específicamente, el área de superficie en la que ocurre falla se puede utilizar para determinar la proporción de estiramiento límite del sustrato con la siguiente ecuación:

$$DR = \frac{A_{sf}}{A_i}$$

39

En donde el área de superficie inicial (A_i) es el área de premoldeado y la superficie de área final (A_{sf}) es el incremento en área de superficie alcanzado después de moldeo. Para demostrar el alcance al que el sustrato se estira, los solicitantes utilizan la geometría de cono truncado mostrado en la Figura 3. Al determinar la proporción de estirado se hacen varias suposiciones. Se asume que una rejilla perfecta de "domos" de conos circulares rectos normales al plano del sustrato describen la forma geométrica producida que utiliza una geometría de molde macho/hembra.

Los solicitantes han descubierto que las fibras y/o filamentos utilizados para formar el sustrato normalmente alcanzan un mejor resultado durante el proceso de moldeo si las fibras y/o filamentos están parcialmente orientados. Se ha mostrado que alcanza orientación de fibra y/o filamento sustancialmente mejorada después de moldeo.

Con referencia a la figura 3, dentro de una célula unitaria, el área de superficie final (A_f) comprende un área de superficie lateral (L) del frustro, el área de la base superior (A_t), y la diferencia del área de superficie inicial (A_i) el área de la base inferior (A_b), y se da por:

40

$$A_{sf} = [a(L) + a(A_i)] + [(A_i) - a(A_b)]$$

En donde a, es el número total de domos en un área dada; en la célula unitaria a=1. El área de superficie lateral (ver Figura 3) se da por $L=\pi(r + R)s$ en donde $s=\sqrt{([R-r]^2 + h^2)}$ el área de la base superior (A_t) se da por $A_t = \pi r^2$ y el área de la base inferior (A_b) se da por $A_b = \pi R^2$. Así, el área de superficie final se da por $A_{sf} = [a(\pi(r + R)s) + a(\pi r^2)] + [(A_i) - a(\pi R^2)]$ en donde A_i = área de superficie inicial.

Considere una estructura tridimensional como se describe aquí con una longitud y ancho inicial de 101.6 mm. Se utiliza un diámetro de perno macho 9.525 mm (3/8") en conjunto con un agujero hembra de 15.875 mm (5/8"). Se aplican los siguientes parámetros:

Largo (L1), mm	101.6
Ancho (A1), mm	101.6
# de "Domos"	16
Radio a la Base del Domo, mm	7.9375
Radio a la Parte Superior del Domo, mm	4.7625
Altura del Domo (h), mm	12

4/1

En Consecuencia, $DR = \frac{A_{sw}}{A_i} = \frac{12639.849mm^2}{10322.56mm^2} = 1.222$

Para un sustrato dado, la proporción de estirado final es una función del tamaño del domo. La Figura 4 muestra que la proporción de estirado final puede ser tanto como 3 para varios diámetros de perno. Estas proporciones de estirado son significativamente mayores que la deformación hasta falla de los sustratos. Las propiedades estructura de ensayo utilizado para crear los datos mostrados en la figura 4 se establecen en la tabla 1 adelante.

Tabla 1

Muestra	Tipo de Fibra	Peso g/m ²	Espesor (mm)	Sección Cruzada de Fibra	Diámetro de Fibra (μ)
Material no tejido hilado	PP	160	0.46	R	40-50

Los solicitantes contemplan que las proyecciones o depresiones dentro del sustrato tendrán una altura entre 0.1-10.0 mm y ancho entre 0.1-100 mm.

42

Los solicitantes creen que la capacidad de formación de los sustratos descritos aquí para uso con la presente invención se afectan por la anisotropía de la estructura (distribución, orientación de la fibra, ODF en no tejidos) así como también el estiramiento de fibras o filamentos individuales. Y en el caso de los no tejidos el método de unión. La deformación hasta la falla del sustrato ensayado en el ambiente no es un indicador. La invención del solicitante permite el uso de sustratos con tan poco como 5.0% de deformación hasta la falla y deformaciones mayores del 100%. Las estructuras anisotrópicas con deformación hasta la falla menores de 5.0% no pueden ser moldeadas en profundidad y los agujeros son formados en unas alturas de domo moderado como se muestra en la Figura 5. Las propiedades de la estructura de ensayo mostradas en la Figura 5 se establecen adelante en la tabla 2.

Tabla 2

Muestra	Tipo de Fibra	Peso g/m ²	Espesor (mm)	Sección Cruzada de Fibra	Diámetro de Fibra (μ)
Hidroentramado	PET	100	1.0	R	20

En forma general, los solicitantes han descubierto que la proporción de estirado se incrementa como una función del

43

incremento del espesor del producto y reducción del diámetro del perno.

Para una estructura de capa sencilla, la rigidez de la estructura y resistencia son una función de las propiedades de las fibras constituyentes en la estructura así como también el peso por unidad de área de las muestras (peso base). Esto es especialmente cierto para estructuras no tejidas hiladas.

Mantener la forma de la estructura moldeada es de igual importancia. No existen métodos de ensayo estándar para determinar las propiedades compresivas de las estructuras moldeadas en profundidad. Los solicitantes han ensayado un método que utiliza una máquina de ensayo tensil (CRE) de extensión de proporción constante en el modo de compresión con las siguientes condiciones:

Separación de Plato:	10 mm
Velocidad de Cruceta:	1mm/min a 40% de deformación
Espesor del Espécimen:	Medido bajo .005 kgf
Tamaño de la Muestra:	10Cm ²

En una deformación de aproximadamente 40%, la proyección del domo cambia de una forma cilíndrica a una forma más

44

cilíndrica como se muestra en la figura 6. La habilidad para recuperar la forma original de este tipo de deformación se determinó mediante carga cíclica. La Figura 7 muestra un comportamiento de carga y descarga típico de muestras de material no tejido hilado en tres pesos base diferentes (por ejemplo, 320 gsm; 160 gsm; y 90 gsm). Nótese que la absorción de energía y rigidez de la estructura moldeada profundase incrementa rápidamente con base en el peso. También es evidente que no hay deformación permanente bajo carga de compresión. Las propiedades de las estructuras de ensayo utilizadas para crear los datos mostrados en la Figura 7 se establecen adelante en la tabla 3.

Tabla 3

Muestra	Tipo de Fibra	Peso g/m ²	Espesor (mm)	Sección Cruzada de Fibra	Diámetro de Fibra (μ)
Material no tejido hilado	PP	90	0.38	R	40-50
Material no tejido hilado	PP	160	0.46	R	40-50
Material no tejido hilado	PP	320	0.75	R	40-50

La Figura 8 muestra la rigidez compresiva de ocho estructuras moldeadas en profundidad normalizadas por el peso de los

45

especímenes. Es evidente que la rigidez incrementa con el peso base de los especímenes como se ve para las muestras PP. Nótese que estas estructuras están compuestas de fibras parcialmente orientadas (POF) y están mejor adecuadas para moldeo de profundidad. Estas estructuras tienden a formar proyecciones más uniformes y profundas. Adicionalmente, durante el proceso de moldeo las fibras pasan a través de cristalización de estado sólido lo cual mejora sus propiedades mecánicas. Nótese que las muestras de material no tejido hilado PET superan las muestras PP con los productos hidroentramados lo cual suministra los especímenes más suaves. Estas estaban compuestas de fibras completamente estiradas y no se espera que el proceso de moldeo resulte en mejoras de las propiedades de la fibra. Las propiedades de ocho sustratos de ensayo mostrados en la figura 8 se describen en la tabla 4 adelante.

Tabla 4

Muestra	Tipo de Fibra	Peso g/m ²	Espesor (mm)	Sección Cruzada de Fibra	Diámetro de Fibra (μ)
Material no tejido hilado	PP	90	0.38	R	40-50
Material no tejido	PP	160	0.46	R	40-50

46

hilado					
Material no tejido hilado	PP	320	0.75	R	40-50

Las figuras 9A & 9B muestran las fotografías antes y después de que un paño de punto formado de algodón y fibra de poliéster multilamelar 50/50 y lavado cincuenta veces (50). La forma y apariencia pueden ser vistas por ser bien retenidas. Las propiedades de la estructura de ensayo son como sigue: paño de punto de algodón poliéster 50/50.

En resumen, la invención hecha por los solicitantes es un producto moldeado profundo tridimensional hecho de telas no tejidas planas formadas de fibras de mechas de fichas o filamentos de cualquier tamaño. También, telas de material no tejido hilado y materiales no tejidos que comprenden fibras y/o filamentos más pequeños de 100 micrómetros de diámetro se contemplan por la invención. Preferiblemente, el diámetro de la fibra o filamento es de cerca de 1-20 micrómetros. Las mejores estructuras no tejidas son aquellas con una distribución de orientación de fibra aleatoria. Mientras las estructuras anisotrópicas comunes también pueden ser moldeadas, el grado al que ellas pueden ser estiradas llega a ser más limitado con el incremento de la anisotropía. También

47

se pueden utilizar telas aflocadas, telas unidas por puntadas, y telas tejidas en rama para hacer el producto moldeado profundo.

La rigidez de la estructura puede ser controlada al emplear fibras de diámetros más grandes y/o un peso base mayor. La porosidad mayor se puede alcanzar al utilizar fibras más gruesas. Sin embargo, la flexibilidad general de la estructura también se reduce haciéndolo más difícil al corte. Estos atributos se pueden balancear para alcanzar mayor resiliencia, mayor porosidad, y mayor flexibilidad.

El proceso de formación de tela no tejida (por ejemplo, cardado, colocación de fibras por aire, paneles compuestos, material no tejido hilado y extrusión por fusión y soplado) típicamente conducen a una estructura orientada en donde la mayoría de las fibras son paralelas a la dirección en la que la tela se está formando y recolectado (dirección de la máquina). La Introducción de encrespadores en las fibras tiende a aleatorizar la distribución de orientación localmente que conduce a la moldabilidad mejorada.

Se entenderá que varios detalles de la invención pueden ser cambiados sin apartarse del alcance la invención. Adicionalmente, la anterior descripción es solo para

48

propósito de ilustración, y no para propósito de limitar la invención que se define por las reivindicaciones.

49

REIVINDICACIONES

Lo que se reivindica es:

1. Una red fibrosa flexible tridimensional que comprende un sustrato textil flexible que tiene una multiplicidad de proyecciones compresibles que regresan a su forma después de ser sustancialmente comprimidas, en donde el sustrato se selecciona a partir del grupo que consiste de no tejidos, tejidos de punto y trenzas fabricados a partir de fibras y/o filamentos con un diámetro menor de 10 micrómetros o al menos una dimensión de sección transversal principal de menos de 100 micrómetros.
2. La red de fibra mencionada en la reivindicación 1 en donde el sustrato es una capa sencilla o compuesto multicapa.
3. La red de fibra mencionada en la reivindicación 1 en donde el sustrato es completamente o parcialmente hecho de una fibra o polímero termoplástico con temperatura de fusión en el rango de 70° C a 450° C.

50

4. La red de fibra mencionada en la reivindicación 3 en donde el polímero termoplástico es un elastómero copolieteréster con unidades de éster-éter de cadena larga y unidades de éster de cadena corta unidas cabeza con cola a través de las uniones de éster.
5. La red de fibra mencionada en la reivindicación 3 en donde el polímero termoplástico es un poli(tereftalato de etileno) o poli(tereftalato de trimetileno).
6. La red de fibra mencionada en la reivindicación 3 en donde el polímero termoplástico se selecciona a partir de nylon 6, nylon 6,6, polipropileno o polietileno.
7. La red de fibra mencionada en la reivindicación 3 en donde la fibra termoplástica es un homocomponente, bicomponente o multicomponente.
8. La red de fibra mencionada en la reivindicación 3 en donde la fibra termoplástica utilizada en el sustrato se selecciona a partir del grupo que consiste de poliésteres, poliamidas, elastómeros de copolieteréster termoplástico, poliolefinas,

51

poliacrilatos, y polímeros cristalinos líquidos termoplásticos.

9. Las redes de fibra mencionadas en la reivindicación 1 en donde el sustrato puede comprender adicionalmente, tejido en rama, tejido unido por puntadas, y tela aflocada.
10. La red de fibra mencionada en la reivindicación 1 en donde la red de fibra tiene proyecciones o depresiones que miden 0,1 mm a 5 cm de altura.
11. La red de fibra mencionada en la reivindicación 1 en donde la red de fibra comprende proyecciones o depresiones que miden entre 0,1 mm y 100 mm de ancho.
12. La red de fibra mencionada en la reivindicación 1 en donde las proyecciones tienen una forma de cono truncado.
13. La red de fibra mencionada en la reivindicación 1 en donde la red de fibra comprende más adecuadamente fibras y/o filamentos con diámetros de cerca de 1-20 micrómetros para estructuras suaves y 20-100 micrómetros para estructuras rígidas.

52

14. La red de fibra mencionada en la reivindicación 1 en donde la red de fibra comprende fibras y/o filamentos orientados parcialmente.
15. La red de fibra mencionada en la reivindicación 1 en donde la red de fibra también contiene una resina termoendurecible.
16. La red de fibra mencionada en la reivindicación 1 en donde la red de fibra es rígida al anidar cabeza con cabeza o cabeza con cola dos o más capas de dicha red.
17. La red de fibra mencionada en la reivindicación 1 en donde la red de fibra puede ser rígida al laminar una estructura plana no tejida, tejida o tejida por punto u otra estructura plana tal como una película o una hoja metálica o polimérica a la red.
18. La red de fibra mencionada en la reivindicación 1 en donde la fibra comprende una sección transversal punteada de tres lóbulos en donde un componente se funde a una temperatura inferior.

53

19. La red de fibra mencionada en la reivindicación 1 en donde la fibra comprende una sección transversal del núcleo de funda en donde la funda se funde a una temperatura inferior a la del núcleo.

20. La red de fibra mencionada en la reivindicación 1 en donde la fibra comprende una sección transversal lado a lado en donde una funda se funde a una temperatura inferior a la otra.

21. La red de fibra mencionada en la reivindicación 1 en donde la fibra se forma dentro de una tela no tejida mediante cardado, colocación de fibras por aire, paneles compuestos, material no tejido hilado o extrusión por fusión y soplado o cualquier combinación de estos o mediante tejido de punto, ondulado y trenzado o cualquier combinación de éstos.

22. La red de fibra mencionada en la reivindicación 1 en donde el no tejido tiene una proporción de anisotropía entre $-1/2$ a $1/2$.

23. Un método para formar la red de fibra mencionada en la reivindicación 1, que incluye formar la red de fibra al termoformar, estampar, calandrar, moldear en

54

profundidad, formar por presión, o cualquier combinación de éstos.

24.El método mencionado en la reivindicación 23 que incluye agregar funcionabilidad adicional a la red de fibra al incluir capas de barrera, fibra adicional y capas no fibrosas, resinas termoendurecibles, terminados funcionales tales como impermeabilidad, resistente al moho, y/o modificación de permeabilidad.

25.Una red de fibra flexible tridimensional que comprende un sustrato textil flexible moldeado que tiene una multiplicidad de proyecciones compresibles que regresan a su forma después de ser sustancialmente comprimidos en donde el sustrato se selecciona a partir del grupo que consiste de tejidos, tejidos de punto y trenzados fabricados a partir de filamentos y/o fibras con un diámetro de menos de 100 micrómetros o al menos una dimensión de sección transversal principal de menos de 100 micrómetros y no tejidos fabricados a partir de fibras y/o filamentos con un diámetro mayor de 100 micrómetros en donde las intersecciones de cruce de fibra a fibra son parcialmente o completamente fundidas durante el

55

proceso de moldeo para suministrar rigidez sustancial al sustrato textil flexible.

26. La red de fibra mencionada en la reivindicación 25 en donde el sustrato es una capa sencilla o un compuesto multicapa.

27. La red de fibra mencionada en la reivindicación 25 en donde el sustrato es completamente o parcialmente hecho de una fibra o polímero termoplástico con temperatura de fusión en el rango de 70° C a 450° C.

28. La red de fibra mencionada en la reivindicación 27 en donde el o polímero termoplástico es un elastómero copolietiléster con unidades etiléster de cadena larga y unidades éster de cadena corta unidas cabeza a cola a través de los enlaces éster.

29. La red de fibra mencionada en la reivindicación 27 en donde el polímero termoplástico es un poli(tereftalato de etileno) o poli(tereftalato de trimetileno).

30. La red de fibra mencionada en la reivindicación 27 en donde el polímero termoplástico se selecciona a

56

partir de nylon 6, nylon 6,6, polipropileno o polietileno.

31. La red de fibra mencionada en la reivindicación 27 en donde la fibra termoplástico es un homocomponente, bicomponente, o multicomponente.

32. La red de fibra mencionada en la reivindicación 27 en donde la fibra termoplástico utilizada en el sustrato se selecciona a partir del grupo que consiste de: poliésteres, poliamidas, elastómeros de copoliésteréter termoplástico, poliolefinas, poliacrilatos, y polímeros cristalinos líquidos termoplásticos.

33. La red de fibra mencionada en la reivindicación 25 en donde el sustrato puede comprender adicionalmente, tejido en rama, tejido unido por puntadas, y tela aflocada.

34. La red de fibra mencionada en la reivindicación 25 en donde la red de fibra tiene proyecciones o depresiones que miden 0.1 mm a 5 cm de altura.

57

35. La red de fibra mencionada en la reivindicación 25 en donde la red de fibra comprende proyecciones o depresiones que miden entre 0.1 mm y 100 mm de ancho.
36. La red de fibra mencionada en la reivindicación 25 en donde las proyecciones tienen una forma de cono truncado.
37. La red de fibra mencionada en la reivindicación 25 en donde la red de fibra comprende fibras y/o filamentos orientados parcialmente.
38. La red de fibra mencionada en la reivindicación 25 en donde la red de fibra también contiene una resina termoendurecible.
39. La red de fibra mencionada en la reivindicación 25 en donde la red de fibra es rígida al anidar cabeza a cabeza o cabeza a cola dos o más capas de dicha red.
40. La red de fibra mencionada en la reivindicación 25 en donde la red de fibra puede ser rígida al laminar una estructura plana no tejida, tejida, o tejido de punto u otra estructura plana tal como una película o una hoja metálica o polimérica a la red.

58

41. La red de fibra mencionada en la reivindicación 25 en donde la fibra comprende una sección transversal de punteado de tres lóbulos en donde un componente se funde a una temperatura inferior.

42. La red de fibra mencionada en la reivindicación 25 en donde la fibra comprende una sección transversal de núcleo de funda en donde la funda se funde a una temperatura inferior a la del núcleo.

43. La red de fibra mencionada en la reivindicación 25 en donde la fibra comprende una sección transversal lado a lado en donde un lado se funde a una temperatura inferior a la del otro lado.

44. La red de fibra mencionada en la reivindicación 25 en donde la fibra se forma dentro de una tela no tejida mediante cardado, colocación de fibras por aire, paneles compuestos, material no tejido hilado o extrusión por fusión y soplado o cualquier combinación de estos o mediante tejido de punto, ondulado y trenzado o cualquier combinación de éstos.

59

45. La red de fibra mencionada en la reivindicación 25 en donde el no tejido tiene una proporción de anisotropía entre $-1/2$ a $1/2$.

46. Un método para formar la red de fibra mencionada en la reivindicación 25, que incluye formar la red de fibra mediante termoformado, estampado, calandrado, moldeo de profundidad, por presión o una combinación de éstos.

47. El método mencionado en la reivindicación 46 que incluye agregar funcionalidad adicional a la red de fibra al incluir capas de barrera, fibras adicionales y capas no fibrosas, resinas termoendurecibles, acabados funcionales tales como impermeabilidad, resistencia al moho, y/o modificación de permeabilidad.

60

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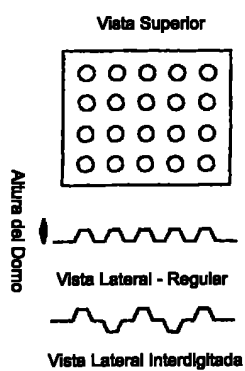


FIG. 1A

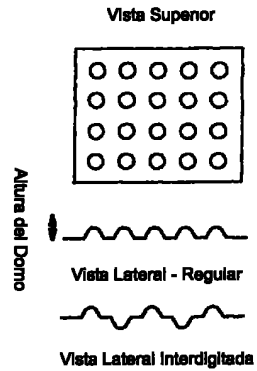


FIG. 1B

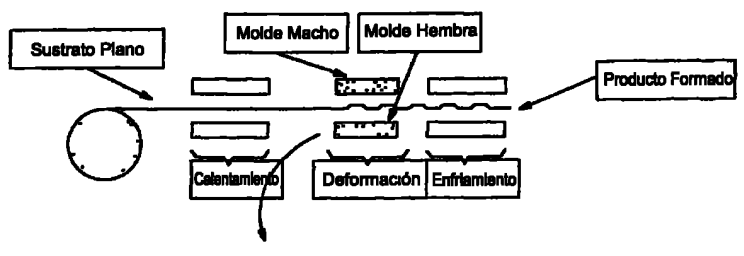


FIG. 2A

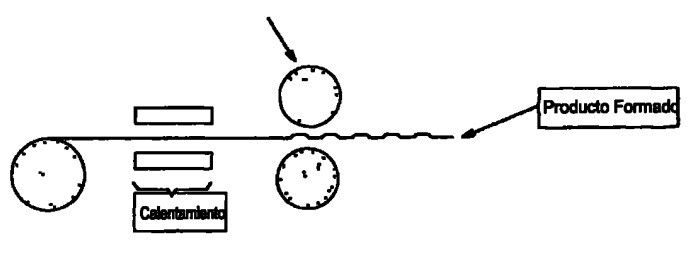


FIG. 2B

HOJA SUSTITUTA (REGLA 26)

62

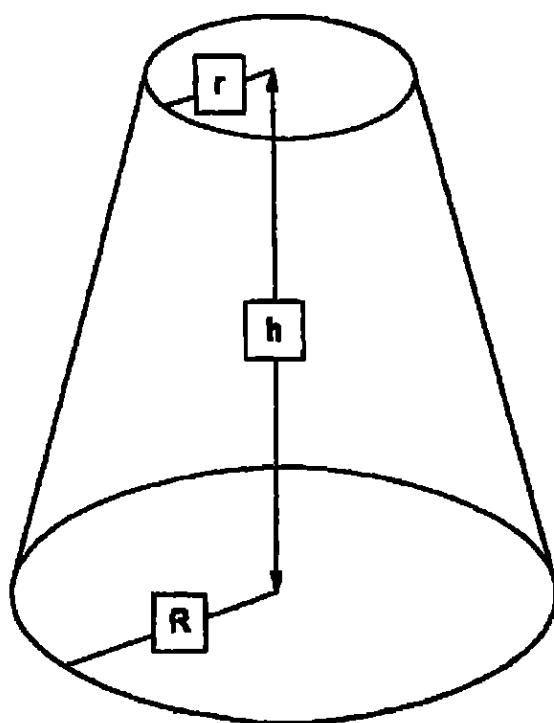


FIG. 3

63

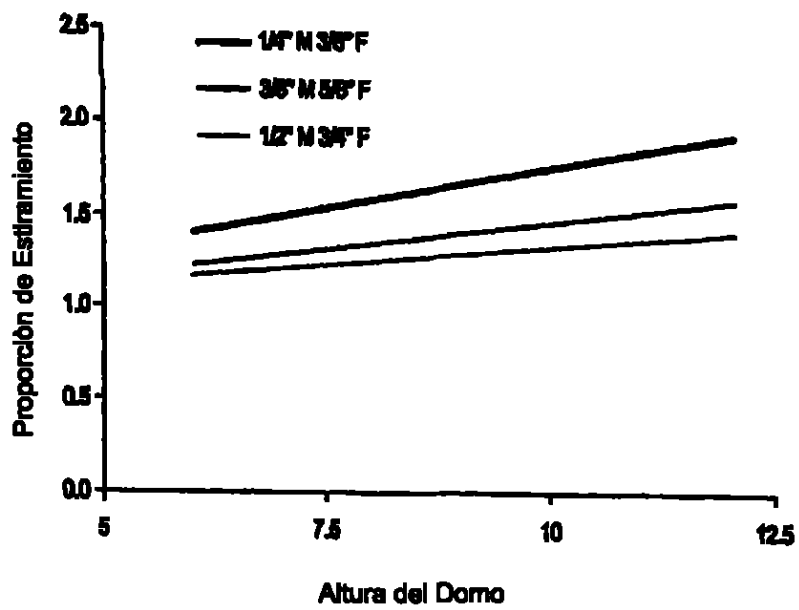


FIG. 4

64

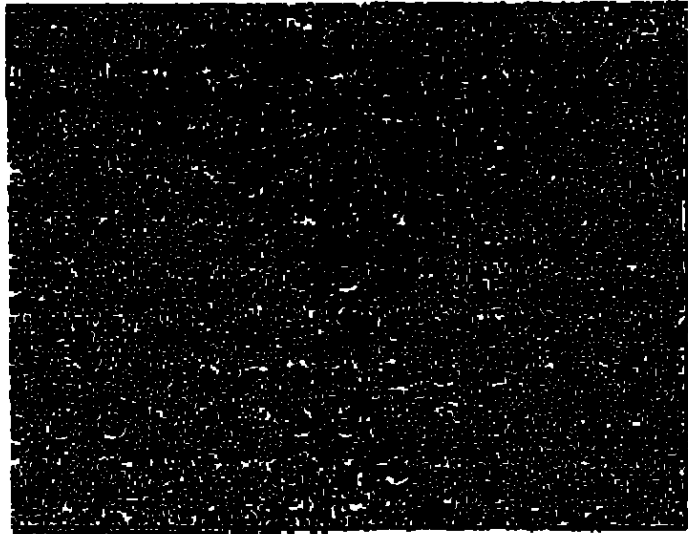


FIG. 5

65

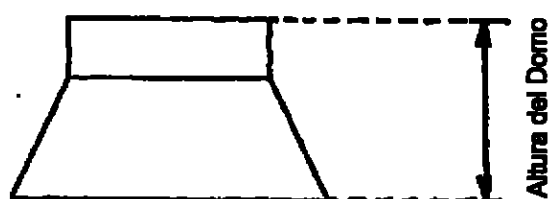


FIG. 6

66

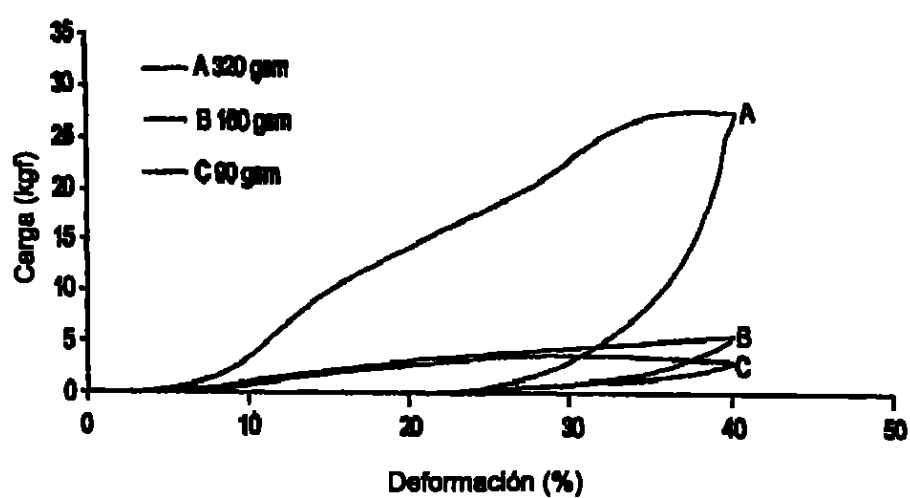


FIG. 7

64

7

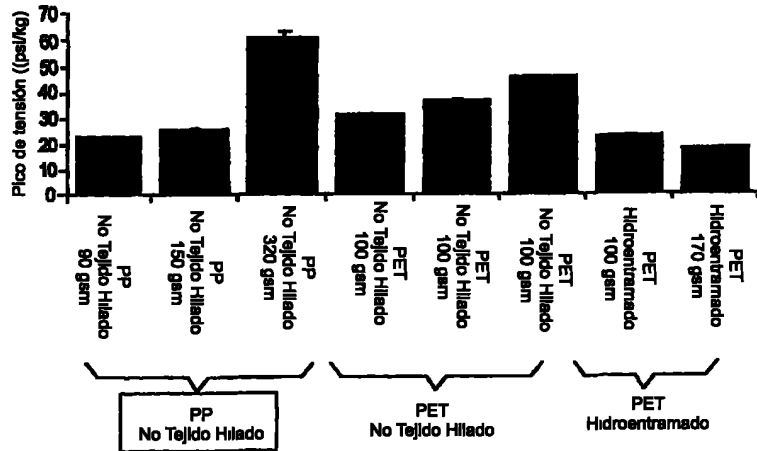


FIG. 8

HOJA SUSTITUTA (REGLA 26)



FIG. 9A

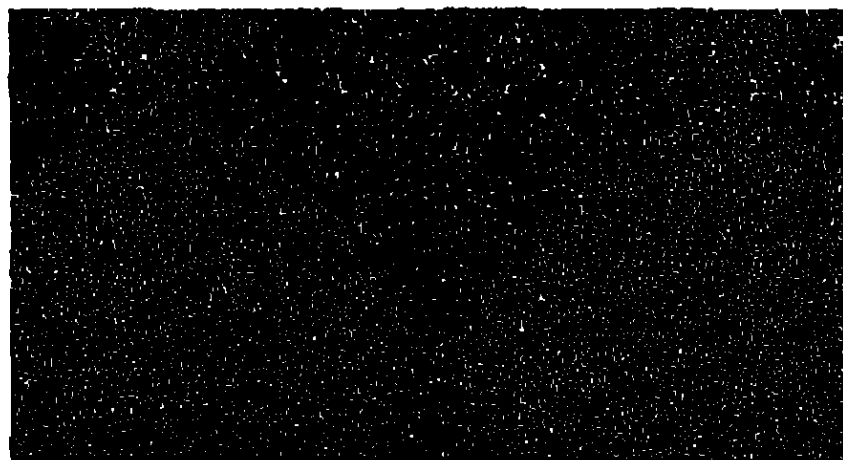


FIG. 9B

HOJA SUSTITUTA (REGLA 28)

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY



69

To:
RICHARD E. JENKINS
JENKINS, WILSON & TAYLOR, PA.
SUITE 1400 UNIVERSITY TOWER
3100 TOWER BOULEVARD
DURHAM, NC 27707

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Date of mailing
(day/month/year) 30 SEP 2004

Applicant's or agent's file reference
297/168PCT

FOR FURTHER ACTION See paragraphs 1 and 4 below

International application No.
PCT/US04/10685

International filing date
(day/month/year) 07 April 2004 (07.04.2004)

Applicant
NORTH CAROLINA STATE UNIVERSITY

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes
1211 Geneva 20, Switzerland, Facsimile No.: +41 22 740 14 35

For more detailed instructions, see the notes on the accompanying sheet.
2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.
3. ☐ With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.
4. Reminders

Shortly after the expiration of 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. These comments would also be made available to the public but not before the expiration of 30 months from the priority date.

Within 19 months from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later); otherwise, the applicant must, within 20 months from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

In respect of other designated Offices, the time limit of 30 months (or later) will apply even if no demand is filed within 19 months.

See the Annex to Form PCT/IB/301 and, for details about the applicable time limits, Office by Office, see the PCT Applicant's Guide, Volume II, National Chapters and the WIPO Internet site.

Name and mailing address of the ISA/ US
Mail Stop PCT, Attn: ISA/US
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
Facsimile No. (703) 305-3230

Authorized officer

MARIAN KNODE
Telephone No. 571-272-1700

Form PCT/ISA/220 (January 2004)

DOCKET DATES: 10/30, 11/23, 11/30/04 (See notes on accompanying sheet)

ASSIGNED ATTY: RED

FILE NO. 297/168 PCT

DOCKETED BY: HMD

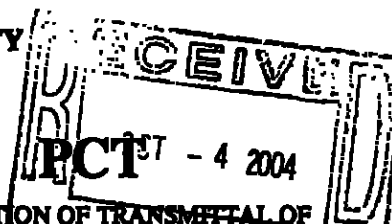
DATE: 10.7.04

* 12/30/04 = Del to file IDS in US ✓

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:
RICHARD E. JENKINS
JENKINS, WILSON & TAYLOR, PA.
SUITE 1400 UNIVERSITY TOWER
3100 TOWER BOULEVARD
DURHAM, NC 27707



70

**NOTIFICATION OF TRANSMITTAL OF
 THE INTERNATIONAL SEARCH REPORT AND
 THE WRITTEN OPINION OF THE INTERNATIONAL
 SEARCHING AUTHORITY, OR THE DECLARATION**

(PCT Rule 44.1)

Applicant's or agent's file reference 297/168PCT	Date of mailing (day/month/year)
International application No. PCT/US04/10685	International filing date (day/month/year) 07 April 2004 (07.04.2004)
Applicant NORTH CAROLINA STATE UNIVERSITY	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.
 Filing of amendments and statement under Article 19:
 The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):
 When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.
 Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes
 1211 Geneva 20, Switzerland. Facsimile No.: +41 22 740 14 35
 For more detailed instructions, see the notes on the accompanying sheet.
2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.
3. ☐ With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:
 - ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.
 - ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.
4. **Reminders**
 Shortly after the expiration of 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.
 The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. These comments would also be made available to the public but not before the expiration of 30 months from the priority date.
 Within 19 months from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later); otherwise, the applicant must, within 20 months from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.
 In respect of other designated Offices, the time limit of 30 months (or later) will apply even if no demand is filed within 19 months.
 See the Annex to Form PCT/IB/301 and, for details about the applicable time limits, Office by Office, see the *PCT Applicant's Guide*, Volume II, National Chapters and the WIPO Internet site.

Name and mailing address of the ISA/ US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1490 Alexandria, Virginia 22313-1490 Facsimile No. (703) 305-3230	Authorized officer MARIAN KNODE Telephone No. 571-272-1700
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PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 297/168PCT	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US04/10685	International filing date (day/month/year) 07 April 2004 (07.04.2004)	(Earliest) Priority Date (day/month/year) 05 May 2003 (05.05.2003)
Applicant NORTH CAROLINA STATE UNIVERSITY		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.



It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the Report

- a. With regard to the language, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.



The international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).



- b. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, see Box No. I.

2. ☐ Certain claims were found unsearchable (See Box No. II)

3. ☐ Unity of invention is lacking (See Box No. III)

4. With regard to the title,



the text is approved as submitted by the applicant.



the text has been established by this Authority to read as follows:

5. With regard to the abstract,



the text is approved as submitted by the applicant.



the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the drawings,

- a. the figure of the drawings to be published with the abstract is Figure No. 1



as suggested by the applicant.



as selected by this Authority, because the applicant failed to suggest a figure.



as selected by this Authority, because this figure better characterizes the invention.

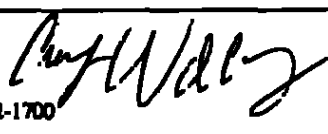
- b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/10685

72

A. CLASSIFICATION OF SUBJECT MATTER		
IPC(7) : B32B 3/00, 1/00, 3/12, 7/02; D03D 3/08, 15/08, 17/00; D04H 1/00, 13/00, 3/00, 5/00 US CL : 428/156, 175, 178, 212; 442/328, 182 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) U.S. : 428/156, 175, 178, 212; 442/328, 182		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) NONE		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,163,979 A (WATKINS et al.) 24 November 1992, see col. 1, lines 51-64; col. 2, lines 26-50; col. 4, lines 36-38.	1-3, 6-8, 13, 21, 23
X	US 4,863,779 A (DAPONTE) 05 September 1989, see fig. 2a; col. 3, line 8 thru col. 4, line 61; col. 5, lines 48-60; col. 7, lines 42-65; col. 16, lines 29-42; col. 20, lines 58-66; col. 2, lines 63-65.	1-3, 6-8, 13, 17, 21, 23, 25-27, 30-32, 44, 46
—		4-5, 9-12, 14-16, 18-20, 22, 24, 28-29, 33-43, 45, 47
Y	US 4,741,941 A (ENGLEBERT et al.) 03 May 1988, see figs. 3, 10; col. 2, lines 46-60; col. 4, line 62 thru col. 5, line 2; col. 6, lines 2-9, 40-44.	1-8, 10, 12-13, 21, 23-24
X	US 5,731,062 A (KIM et al.) 24 March 1998, see col. 5, lines 41-66.	1-8, 12, 15, 21, 23
—		4-5, 9-12, 14-16, 18-20, 22, 24, 28-29, 33-43, 45, 47
Y		
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	
"E" earlier application or patent published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another claim or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is considered with one or more other such documents, such combination being obvious to a person skilled in the art	
"O" document referring to an oral disclosure, use, exhibition or other means	"A" document member of the same patent family	
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 23 September 2004 (23.09.2004)		Date of mailing of the international search report 30 SEP 2004
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703) 305-3230		Authorized officer MARIAN KNODE Telephone No. 571-272-1700 

PATENT COOPERATION TREATY

73

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
RICHARD E. JENKINS
JENKINS, WILSON & TAYLOR, PA.
SUITE 1400 UNIVERSITY TOWER
3100 TOWER BOULEVARD
DURHAM, NC 27707

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing
(day/month/year) **30 SEP 2004**

Applicant's or agent's file reference

FOR FURTHER ACTION
See paragraph 2 below

297/168PCT

International application No.

International filing date (day/month/year)

Priority date (day/month/year)

PCT/US04/10685

07 April 2004 (07.04.2004)

05 May 2003 (05.05.2003)

International Patent Classification (IPC) or both national classification and IPC

IPC(7): B32B 3/00, 1/00, 3/12, 7/02; D03D 3/08, 15/08, 17/00; D04H 1/00, 13/00, 3/00, 5/00 and US Cl.: 428/156, 175, 178, 212; 442/328, 182

Applicant

NORTH CAROLINA STATE UNIVERSITY

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/ US

Mail Stop PCT, Attn: ISA/US
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Facsimile No. (703) 305-3230

Authorized officer

MARIAN KNODE

Telephone No. 571-272-1700

Form PCT/ISA/237 (cover sheet) (January 2004)

DOCKET DATES: 12/5/04

ASSIGNED ATTY: KEJ

FILE NO. 297/168 PCT

DOCKETED BY: HMD

x 12/30/04 = Ddl to file in US

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.

PCT/US04/10685

74

Box No. 1 Basis of this opinion

1. With regard to the language, this opinion has been established on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ This opinion has been established on the basis of a translation from the original language into the following language _____, which is the language of a translation furnished for the purposes of international search (under Rules 12.3 and 23.1(b)).

2. With regard to any nucleotide and/or amino acid sequence disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

a. type of material

☐ a sequence listing

☐ table(s) related to the sequence listing

b. format of material

☐ in written format

☐ in computer readable form

c. time of filing/furnishing

☐ contained in international application as filed.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US04/10683

75

Box No. V Reasoned statement under Rule 43 bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)

Claims Please See Continuation Sheet YES

Claims Please See Continuation Sheet NO

Inventive step (IS)

Claims Please See Continuation Sheet YES

Claims Please See Continuation Sheet NO

Industrial applicability (IA)

Claims Please See Continuation Sheet YES

Claims Please See Continuation Sheet NO

2. Citations and explanations:

Please See Continuation Sheet

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US04/10685

76

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

V.1. Reasoned Statements:

The opinion as to Novelty was positive (Yes) with respect to claims 9, 11, 14, 16, 18-20, 22, 28-29, 33-43, 45, 47
The opinion as to Novelty was negative (No) with respect to claims 1-8, 10, 12-13, 15, 17, 21, 23-27, 30-32, 44, 46
The opinion as to Inventive Step was positive (Yes) with respect to claims NONE
The opinion as to Inventive Step was negative (NO) with respect to claims 1-47
The opinion as to Industrial Applicability was positive (YES) with respect to claims 1-47
The opinion as to Industrial Applicability was negative (NO) with respect to claims NONE

V. 2. Citations and Explanations:

Claims 1-3, 6-8, 13, 21 and 23 lacks novelty under PCT Article 33(2) as being anticipated by Watkins et al. (5,163,979).

Watkins teaches a three dimensional (i.e. containing projections) non-woven wherein polypropylene fibers of 1 micron to 100 microns are disclosed. Refer to col. 1, lines 51-64; col. 2, lines 26-50 and col. 4, lines 36-38.

Claims 1-3, 6-8, 13, 17, 21, 23, 25-27, 30-32, 44 and 46 lacks novelty under PCT Article 33(2) as being anticipated by Daponte (4,863,779).

Daponte teaches a three dimensional (i.e. containing projections) non-woven wherein polypropylene fibers having a diameter of less than 200 microns, preferably .5 to 50 microns are used. The non woven can be attached to another woven layer as recited in instant claim 25. Claim 25 is interpreted by the examiner as being a composite formed of two networks, one being wovens, knits or braids as in lines 4 and 5 and a second one being of non wovens as recited in line 7, both networks being formed of fibers of less than 100 microns. Refer to figure 2A showing projections 16a and 20a along with col. 3, line 8 thru col. 4, line 61; col. 5, lines 48-60 (for the other woven layer in claim 25 as specified above), col. 7, lines 42-65; col. 16, lines 29-42 and col. 20, lines 58-66.

Claims 1-8, 10, 12-13, 21, 23 and 24 lacks novelty under PCT Article 33(2) as being anticipated by Englebert et al. (4,741,941).

Englebert et al. Teaches a fibrous network formed of the recited fibers having a size of 1 to 100 microns. The three dimensional network can have truncated cones (figs. 3 and 10) of height .3mm to 25mm. Refer to col. 2, lines 46-60; col. 4, line 62 thru col. 5, line 2 and col. 6, lines 2-9 and 40-44.

Claims 1-8, 12, 15, 21 and 23 lacks novelty and inventive step under PCT Article 33(2-3) as being anticipated by Kim et al. (5,731,062).

Kim et al. Discloses a fiber network formed of poly ethylene terephthalate (PET) fibers of a diameter of at least about .1mm (100 microns). The examiner deems this appears to overlap the applicant's range of less than one 100 microns with sufficient specificity. Aprima facie case of obviousness also exists if the ranges overlap and it would have been obvious to use smaller sized fibers in order to form a softer three dimensional network. See col. 2, lines 63-65 in Daponte (4,863,779), as teaching reference to the fact that it is known to use the smaller fibers in order to form a softer, cloth like material therefrom.

Claims 4-5, 9-12, 14-16, 18-20, 22, 24, 28-29, 33-43, 45 and 47 lack an inventive step under PCT Article 33(3) as being obvious over Daponte in view of Kim et al.

Daponte teaches the invention substantially as recited except for the use of PET for the fibers and the size of the projections.

Kim et al. Teaches to use PET fibers and that the size of the fibers and projections can be chosen to give the desired

**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/US04/10685

77

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

cushioning properties for a specific application. Refer to col. 5, lines 41-66.

Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to the primary reference to use PET fibers of the size recited and to form the projections of whatever shape and/or size is desired in order to conform the article to its desired application motivated by the fact the Kim et al. teaches that these features can be chosen to give desired cushioning properties to the article.

Claims 1-47 meet the criteria set out in PCT Article 33(4), and thus having industrial applicability because the subject matter claimed can be made or used in industry.

78

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under Article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the *PCT Applicant's Guide*, a publication of WIPO.

In these Notes, "Article," "Rule" and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions, respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended ?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Preliminary Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When ? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments ?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How ? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments ?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

United States Patent [19]
Watkins et al.



US005165979A

[11] Patent Number: **5,165,979**
[45] Date of Patent: **Nov. 24, 1992**

79

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[54] **THREE-DIMENSIONAL POLYMER WEBS
WITH IMPROVED PHYSICAL PROPERTIES**

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[73] Assignee: **Kimberly-Clark Corporation,
Nenah, Wn.**

[21] Appl. No.: **626,817**

[22] Filed: **Dec. 13, 1990**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 518,904, May 4, 1990.

[51] Int. Cl.³ **B32B 3/26; B32B 5/08;
B32B 33/00; D04H 1/74**

[52] U.S. Cl. **428/113; 15/209.1;
15/229.11; 19/301; 156/62.4; 156/62.8;
156/176; 156/178; 156/181; 156/308.2;
264/123; 264/210.1; 264/211.12; 428/135;
428/138; 428/141; 428/158; 428/172; 428/179;
428/286**

[58] Field of Search **428/286, 288, 296, 71,
428/113, 135, 138, 141, 158, 172, 179, 311.5,
316.6; 156/62.4, 62.8, 176, 178, 181, 308.2;
15/209 R, 209 B; 19/301; 264/123, 210.1,
211.12**

[56] **References Cited**

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4,211,819 7/1990 Kuhlmann et al. 428/374

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4,830,907 5/1989 Sawyer et al. 428/225
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FOREIGN PATENT DOCUMENTS

394334 10/1990 European Pat. Off.

Primary Examiner—James C. Cannon

Attorney, Agent, or Firm—William D. Harrick

[57] **ABSTRACT**

There is disclosed a three dimensional nonwoven web consisting of drawn and unoriented thermoplastic fibers formed from a blend of polypropylene and polybutylene, wherein the blend by weight is from 90% to 70% polypropylene and from 10% to 30% polybutylene. The blend can be a blend of a homopolymer of polypropylene and a homopolymer of polybutylene; a homopolymer of polypropylene and a copolymer of polybutylene; a copolymer of polypropylene and a homopolymer of polybutylene; and a copolymer of polypropylene and a copolymer of polybutylene. In addition, ternary blends comprising polypropylene, polybutylene, and terpolymer (propylene, ethylene, and 1-butene) are useful. The resulting nonwoven webs have enhanced strength, toughness, and tear resistance.

67 Claims, 1 Drawing Sheet

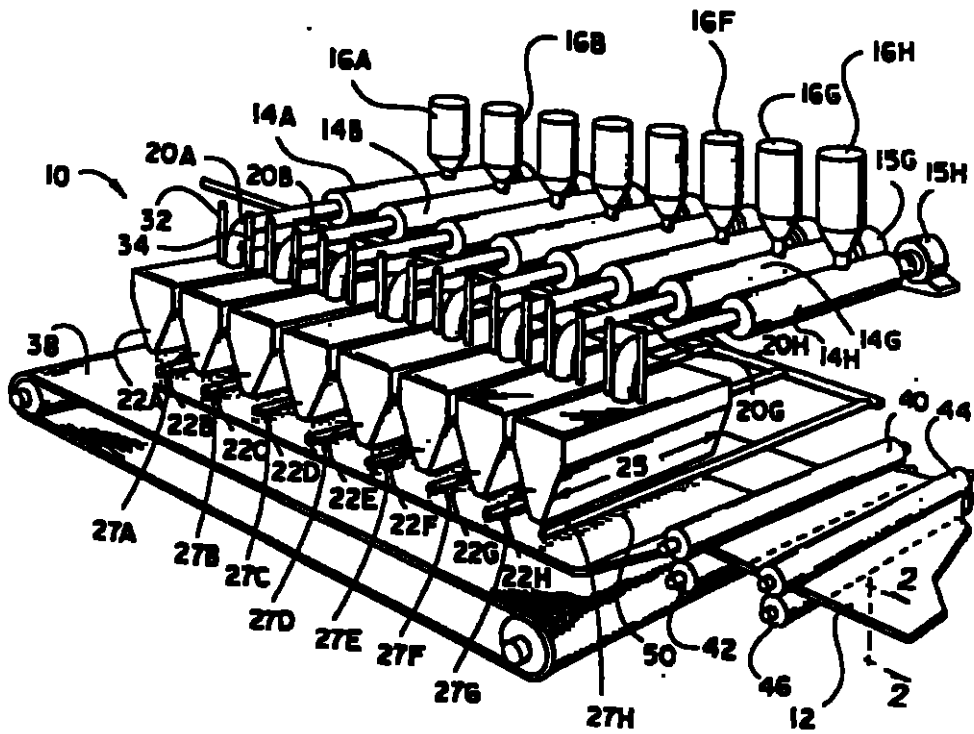


FIG. 1

THREE-DIMENSIONAL POLYMER WEBS WITH IMPROVED PHYSICAL PROPERTIES

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of Ser. No. 07/518,904, filed May 4, 1990 is now pending.

BACKGROUND OF THE INVENTION

This invention relates generally to three dimensional nonwoven webs consisting of thermoplastic fibers, and more particularly concerns such webs which are formed from blends of polypropylene and polybutylene.

Nonwoven webs formed of thermoplastic fibers are well-known in the art and have found uses in a variety of applications. In one application, such nonwoven webs are formed by melt-blowing and are used as disposable industrial wipers. Such industrial wipers find application in numerous manufacture and maintenance facilities where personnel find it necessary to wipe up oil, grease, and water from a variety of surfaces. One such wiper made of melt-blown polypropylene fibers is manufactured and sold by Kimberly-Clark Corporation, the assignee of the present invention, under the trademark Kuxtex®.

Melt-blown nonwoven wipers of polypropylene thermoplastic fibers have advantage over cloth wipers in being cost effectively disposable with similar wiping characteristics as compared to cloth. Particularly, industrial wipers must be able to quickly pick up spilled liquids, both oil based and water based, and leave a clean, streak free surface. In addition, the wipers must have sufficient capacity to hold such liquids within the wiper structure until it is desired to remove the liquid by pressure such as by wringing.

Nonwoven melt-blown industrial wipers formed from polypropylene in the past have performed adequately in terms of their wiping characteristics, particularly with respect to oil and, when treated with a surfactant, with respect to water. Moreover, nonwoven industrial wipers made of polypropylene fibers have exhibited resistance to most commercially available solvents.

A superior three dimensional nonwoven melt-blown wiper, however, could be achieved by increasing strength, increasing toughness, and increasing tear resistance. A three dimensional nonwoven web is described in U.S. Pat. No. 4,741,941, to Englebert et al, which is incorporated herein by reference.

As described therein a three dimensional fabric is defined by a pattern of hollow projections extending out of the base plane of the web wherein the fibers or filaments are more aligned than in the land areas between the projections. The projections average in the range generally of from about 1 per square centimeter to about 80 per square centimeter, and they have an average height measured from the base plane to the most extended fibers within the range generally of from about 0.3 millimeters to 25 millimeters. The web is further characterized by an average bulk density in the range generally of from about 0.001 g/cc to about 0.11 g/cc. The fiber diameter may vary generally from about 1 micron to about 100 microns. Other important parameters include the variation in fiber alignment between the web land and projection areas. The projections include fibers or filaments with an average alignment of at least 5° greater than the average alignment of

the fibers or filaments in the land areas. Also the webs may be characterized by a volume ratio of volume of the projections to volume contained between the projections in both cases measured between planes at the base and the tops of the projections, in the range of from about 1 to 250. However, the web described in Englebert et al does not teach the increased strength which characterizes a superior three dimensional nonwoven melt-blown wiper.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a three dimensional nonwoven web consisting of thermoplastic fibers, which web will display improved strength, toughness, and tear resistance over three dimensional melt-blown webs formed of polypropylene and polyethylene fibers.

It is likewise an object of the present invention to provide an industrial wiper comprising a three dimensional nonwoven melt-blown web consisting of thermoplastic fibers which will provide improved strength, toughness, and tear resistance over three dimensional melt-blown wipers formed of polypropylene and polyethylene fibers.

It is also an object of the present invention to provide a laminate material comprising at least one three dimensional layer consisting of thermoplastic fibers which will provide improved strength, toughness, and tear resistance over laminate materials which contain at least one three dimensional layer formed of polypropylene and polyethylene fibers.

It is a further object of the present invention to provide an industrial wiper formed from a laminate material comprising at least one three dimensional layer consisting of thermoplastic fibers which will provide improved strength, toughness, and tear resistance over industrial wipers formed from laminate materials which contain at least one three dimensional layer formed of polypropylene and polyethylene fibers.

The foregoing objectives are obtained by nonwoven webs consisting of drawn and unoriented thermoplastic fibers formed from blends of polypropylene and polybutylene including blends of homopolymers of polypropylene and homopolymers of polybutylene; from blends of homopolymers of polypropylene and copolymers of polybutylene; from blends of copolymers of polypropylene and homopolymers of polybutylene; and from blends of copolymers of polypropylene and copolymers of polybutylene.

In addition, the foregoing objects can be obtained by nonwoven webs consisting of drawn and unoriented thermoplastic fibers formed from a ternary blend comprising polypropylene, polybutylene and a terpolymer comprising propylene, ethylene, and 1-butene.

In connection with the present invention, "drawn thermoplastic fibers" refers to fibers that are drawn to a ratio of greater than 14 to 1 (often greater than 30 to 1) in the forming process. Also in connection with the present invention, "unoriented thermoplastic fibers" refers to fibers which solidify in a relaxed condition (not under tension). Such drawn and unoriented fibers are characteristically formed by melt-blowing techniques as well as other fiber forming techniques such as melt-spraying.

More particularly, the foregoing objectives are realized by a three dimensional nonwoven melt-blown web consisting of drawn and unoriented thermoplastic fibers

81

formed by melt-blowing a blend comprising polypropylene and polybutylene. Particularly, the three dimensional blend of polypropylene and polybutylene is from 90-70% by weight of polypropylene and from 10-30% by weight of polybutylene. More particularly, in the case of a nonwoven wiper, the three dimensional blend is preferred to be from 85% to 75% by weight of polypropylene and from 15% to 25% by weight of polybutylene.

In connection with the present invention, the prior art European Patent Application No. 89303407.4 of Don & Low Ltd. has disclosed the usefulness of blending polypropylene and polybutylene to form fibers, tapes, and films where the thermoplastic fibers, tapes, and films are drawn to a ratio of at least 2:1 to produce an oriented molecular structure. Particularly, the Don & Low reference discloses thermoplastic fibers, tapes, and films that have improved strength as measured by tenacity which is the maximum stress they can resist without rupture. Such thermoplastic fibers, tapes, and films result from blending up to 10% by weight of polybutylene with polypropylene with from 2% to 4% by weight of polybutylene being preferred. The Don & Low reference, however, teaches that "it has been found that if the polybutylene proportion is increased beyond ten percent there is little if any increase in strength [tenacity]". Also the Don & Low reference does not teach improved elongation. As will be demonstrated hereinafter the nonwoven melt-blown and melt-spray webs of the present invention result from a blend of polypropylene and polybutylene with the polybutylene in excess of 10%. Moreover, the thermoplastic fibers of the present invention are drawn to a ratio of substantially greater than 14 to 1 and are not oriented as a result of the melt-blowing or melt-spraying process.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram showing machinery for producing a three dimensional nonwoven melt-blown web in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

While the invention will be described in connection with a preferred embodiment and procedure, it will be understood that we do not intend to limit the invention to that embodiment or procedure. On the contrary, we intend to cover all alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

Turning to FIG. 1 there is shown a web forming machine 10 for forming a melt-blown web 12 made up of a number of layers of melt-blown fibers 30. The machine 10 includes eight identical extruders 14A-H with corresponding hoppers 16A-H for receiving thermoplastic resin pellets. The extruders 14A-H include internal screw conveyors which are driven by motors 18A-H. The extruders 14A-H are heated along their lengths to the melting temperature of the thermoplastic resin pellets to form a melt. The screw conveyors driven by motors 18A-H force the thermoplastic material through the extruders into attached delivery pipes 32A-H which are connected to die heads 22A-H, each having a die width 28.

Die head 22A, for example, comprises a die tip 24 which has a die opening or orifice (not shown). The die tip may be retracted, flush, or stick out. Hot fluid, usu-

ally air, is supplied to the die tip via pipes 32 and 34 (FIG. 1) which terminate in chambers adjacent to the orifice of the die tip.

As the thermoplastic polymer exits the die tip for each die head, the high pressure air attenuates and breaks up the polymer stream to form fibers at each die head. The fibers are then in accordance with the present invention quenched with a mist of water from spray nozzles 27A-H. The spray nozzles are located just below the orifice of the die tip and spray the fibers 30 with water at room temperature or slightly above at a flow rate of at least 0.02 liter/min/inch width of die tip. Fiber quenching is conventional as demonstrated by U. S. Pat. No. 3,999,421. If desired, a surfactant can be added to the fibers by adding the surfactant to the quenching water. It should also be noted that significantly improved toughness and tear resistance result only if the fibers are subjected to quenching.

Once the fibers have been quenched, they are deposited on a forming surface 36 to form the layered web. In the preferred embodiment of the present invention, the forming surface 36 is an open mesh wire surface into which the fibers are pulled in order to form the three dimensional layer. However, a number of alternative types of forming surfaces 36 may be utilized in order to produce the desired three dimensional layer. A variety of such forming surfaces are described in the Englebert et al patent and are well-known in the art.

A vacuum is drawn behind the forming surface 36 to draw the fibers onto the forming surface 36 during the process of melt-blowing. Separate vacuum chambers behind the forming surface 36 may be provided for each die head 22A-H. Once the fiber layers have been deposited on the forming surface 36 by the multiple die heads 22A-H, the web 12 is drawn from the forming surface 36 by withdrawal rolls 40 and 42. Embossing rolls 44 and 46 engage the web 12 after the withdrawal rolls to emboss the web with a pattern.

The foregoing description of the melt-blowing machine 10 is generally conventional and well-known in the art as demonstrated by NRL Report 4364, "Manufacture of Super-Fine Organic Fibers", by V. A. Wendt, E. L. Boon, and C. D. Flaherty; NRL Report 5265, "An Improved Device for the Formation of Super-Fine Thermoplastic Fibers", by E. D. Lawrence, R. T. Lukas, and J. A. Young; and U.S. Pat. No. 3,849,241, issued Nov. 19, 1974, to Douth, et al. It also will be appreciated by one of ordinary skill in the art that a single head melt-blowing machine can be used instead of the multiple bank machine illustrated. It should also be appreciated that the web 12 may be comprised of a single layer, multiple layers which are all identical in composition, or multiple layers some of which layers are made in accordance with the present invention and some of which layers are conventional. Moreover, one of ordinary skill in the art will appreciate that fine adjustment of the equipment and process may be required to optimize performance and efficiency. Such fine adjustment can be accomplished by one of ordinary skill without undue experimentation.

In addition, the fibers and the resulting web can be formed by other fiber forming techniques including, for example, melt-spray techniques. Melt-spraying is a process for forming fibers from a fiber forming resin using compact spray head designs usually including one to four spray heads in a cluster. The equipment includes a die housing with a hydraulic chamber and a retractable piston assembly for releasing molten resin. As the mol-

82

ten resin is released, it is contacted and drawn by a primary air supply which completely surrounds the molten resin and contacts it at a predetermined angle. If additional drawing and attenuation of the newly formed fibers is desired, secondary fiberization air also may be utilized. The secondary fiberization air will most typically include at least two fluid streams which each impinge upon the resin/fibers at a second angle.

In more refined embodiments the fiberization air can also be angled such that it will spiral around the forming fibers. Additionally, the piston within the hydraulic chamber may be cycled on and off to interrupt the flow of the fiber forming resin thereby creating discrete plinkies of fibers.

Both melt-blowing and melt-spraying techniques produce fibers that are drawn and unoriented.

In accordance with the present invention, it has been found that an improved three dimensional nonwoven web of drawn and unoriented thermoplastic fibers can be formed by melt-blowing a blend of polypropylene and polybutylene to enhance certain properties in the melt-blown web 12, as compared with 100% three dimensional melt-blown polypropylene and polyethylene. Specifically, the melt-blown web 12 formed from melt-blowing a blend of polypropylene and polybutylene improves the strength, toughness (the elongation and absorbed energy), and tear resistance. Particularly, we have found that blends of from 90% to 70% polypropylene and from 10% to 30% polybutylene produce three dimensional nonwoven melt-blown webs with these improved characteristics. The advantages of the present invention can be realized by blending homopolymers of polypropylene and polybutylene; by blending copolymers of polypropylene and homopolymers of polybutylene; by blending homopolymers of polypropylene and copolymers of polybutylene; and by blending copolymers of polypropylene and copolymers of polybutylene. The copolymers of polypropylene may have ethylene in amounts ranging up to about 3% by weight. The copolymers of polybutylene may have ethylene in amounts ranging up to about 6% by weight.

In addition, the invention may be carried out by using ternary blends comprising polypropylene, polybutylene, and a terpolymer (propylene, ethylene, and 1-butene). The resulting three dimensional nonwoven webs have enhanced strength, toughness, and tear resistance.

Webs in accordance with the present invention can be formed at polymer throughputs of from 1 to 15 pounds per inch of die head width per hour (plh). Once the melt-blown web has been formed, the material may be bonded or unbonded. The bond pattern may be a line pattern, a weave pattern, or a point pattern, but the point pattern, with bonding occurring within certain discrete areas on the material, is preferred. The bonding may be accomplished by ultrasonic heating, by use of an adhesive, or by embossing with heated rolls. In connection with the present invention, most webs described in the following examples were heat embossed with a weave pattern, such as that shown in U.S. Pat. No. Des. 264,512, or with a dot pattern. The resulting bonded webs had a bonded area of about 18% of the total area

when embossed with the weave pattern and of 5%-18% when embossed with the dot pattern.

In carrying out the present invention, the blends and ternary blends were formed by simply mixing the thermoplastic pellets in the proper weight proportions before being added to the hoppers 16A-H. The terpolymers were polymerized in the desired proportions during manufacture.

Three dimensional nonwoven webs formed from blends, ternary blends, terpolymers, and terpolymer blends utilizing the present invention were made and tested in accordance with the following examples which illustrate the invention.

EXAMPLE 1

A melt-blowing machine similar to that shown in FIG. 1 was used to form a control web, Sample 59, from 100% polypropylene and four additional webs, Samples 61, 62, 64, and 66, from blends of 90% polypropylene and 10% polybutylene, 85% polypropylene and 15% polybutylene, 80% polypropylene and 20% polybutylene, and 70% polypropylene and 30% polybutylene, respectively. The polypropylene used for the control web, Sample 59, was a homopolymer with a melt flow of 800 g/10 min (ASTM D1238, Condition L, (230° C., 2160 g weight)) and a narrow molecular weight distribution. Such a polypropylene homopolymer is manufactured by Hincot U.S.A., Inc of Wilmington, Del. and designated Valtac HH442H. The polypropylene used for the inventive melt-webs, Samples 61, 62, 64, and 66, was also Valtac HH442H. The polybutylene used for Samples 61, 62, 64, and 66 was Dureflex DF-8910, which is an ethylene copolymer (6% ethylene) and is manufactured by Shell Chemical Company of Houston, Tex. The melt-blowing machine was set up in accordance with the following process conditions for Samples 59, 61, 62, 64, and 66:

Machine Configuration

- A. nose die tip
- B. single bank
- C. water quench with surfactant

		Sample 59	Samples 61-66
Set Points			
Rotator Barrel Pressure	psi	300	300
Primary Air Pressure	psi	2.4	2.2
Primary Air Temperature	°F.	383	383
Forming Distance	in	6.5	6.8
Measured Variables			
Die Tip Pressure	psi	21	15
Die Tip (Melt) Temperature	°F.	497	499

In order to provide an accurate comparison between conventional Sample 59 and inventive Samples 61, 62, 64, and 66, the actual data for the conventional web, Sample 59, and the inventive webs, Samples 61, 62, 64, and 66, has been normalized to a basis weight of 1 gm. Both the actual data and the normalized data which show the characteristics of Samples 59, 61, 62, 64, and 66 are set out in Table 1 below.

TABLE 1

COMPARISON WITH 100% POLYPROPYLENE G) POLYMER BLENDS FOR IMPROVED STRENGTHS AND TOUGHNESS IN THREE DIMENSIONAL MELT-BLOWN														
Sample Number	Composition	GRAB TENSILE						TRAP TEAR		NORMALIZED GRAB TENSILE		NORMALIZED TRAP TEAR		
		Bulk Weight g/m	Load MD g	Load CD g	Energy MD kg-mm	Energy CD kg-mm	Elong MD mm	Elong CD mm	Load MD g	Load CD g	Load MD g/gm	Load CD g/gm	Load MD g/gm	Load CD g/gm
59	100% PP	42	1344	1453	26	46	30	30	245	227	32	33	6	5
61	95:5 PP:PB	25	1544	1444	73	62	75	72	454	368	68	39	18	15
62	85:15 PP:PB	41	1839	1362	87	70	76	73	528	327	45	38	14	8
64	92:8 PP:PB	25	1889	1775	53	69	46	55	545	381	76	72	22	15
66	70:30 PP:PB	26	2393	1325	32	41	30	42	849	420	91	58	32	16

In connection with the characteristics reported in Table 1, the bulk weight was measured in accordance with Federal Test Method 191A-5 and expressed in grams per square meter (g/m). The bulk was measured in accordance with the Ames Method and expressed in millimeters (mm). The grab tensile strength was measured in accordance with Method 5100, Federal Test Method 191A and expressed in grams (g), kilogram-millimeters (kg-mm), and millimeters (mm). The trapezoid tear was measured in accordance with Method 5135, Federal Test Method 191 and expressed in grams (g).

In order to measure strength and toughness, the various samples were subjected to tensile testing in the machine direction and the cross-machine direction. Toughness is determined by the amount of energy that the material will absorb prior to failure. The peak energy is the amount of energy the material will absorb until the peak load is achieved. The fail energy is the amount of total energy the material will absorb until it finally fails by separating. Particularly as the stress to which the web is subjected is increased, the web begins stretching or elongating. At some point, the web reaches a peak loading at which failure begins and additional stressing does not increase the loading on the web. As the material begins failing, further elongation results under decreasing loading. The amount of peak energy the material experiences is the integral of the load v. elongation curve for the web from 0 load to the peak of the load. The amount of failed energy is the integral of the load v. elongation curve for the web from the initial 0 load until rupture occurs and the load again returns to 0. Both peak energy and fail energy give a good indication of the toughness of a web. Peak strength is determined by measuring the maximum load achieved before the web begins to fail.

Consequently, it can be seen from Table 1 that Samples 61, 62, 64 and 66, made in accordance with the present invention, all demonstrate a substantial increase in the peak load and energy over those of the prior art 100% three dimensional polypropylene melt-blown web of Sample 59. Particularly, Samples 61, 62, 64 and 66 have an increase in peak load in the cross-machine direction of between 15% and 78% over the control Sample 59. Additionally, Samples 61, 62, 64 and 66 have an increase in peak energy in the machine direction of

between 100% and 215% over the control Sample 59. Accordingly, the inventive webs, Samples 61, 62, 64 and 66, all demonstrate the increased strength and toughness of the three dimensional nonwovens webs prepared in accordance with the present invention.

While toughness measures a web's resistance to initial tearing, trapezoid tear measures the web's resistance to the propagation of a tear after an initial tear. As can be seen again from Table 1, Samples 61, 62, 64 and 66 show between a 85% and 247% increase in their tear resistance over that of the control Sample 59.

EXAMPLE 2

Inventive webs, Samples 61, 62, 64 and 66, were next compared to a control web, Sample 2, formed from 100% polyethylene. The polyethylene used for the control web, Sample 2, was a copolymer (with 1-octene) with a melt index of 135 (ASTM D1238, Condition E, (190° C., 2160 g weight)) and a narrow molecular weight distribution. Such a polyethylene homopolymer is manufactured by Dow Chemical, Inc. of Wilmington, Del. and designated ASPUN® 6814A. The melt-blowing machine was set up in accordance with the following process conditions for Sample 2:

Machine Configuration:		
A. round die tip		
B. single bank		
C. water quench with surfactant		
Set Points:		
Extruder Barrel Pressure	psi	504
Primary Air Pressure	psi	4.2
Primary Air Temperature	°F.	307
Forming Distance	in	7.5
Measured Variables:		
Die Tip Pressure	psi	139
Die Tip (Melt) Temperature	°F.	307

As with Example 1, the actual data for the conventional web, Sample 2, and the inventive webs, Samples 61, 62, 64, and 66, have been normalized to a basis weight of 1 g/m. Both the actual data and the normalized data which show the characteristics of Samples 2, 61, 62, 64, and 66 are set out in Table 2 below.

TABLE 2

COMPARISON WITH 100% POLYETHYLENE POLYMER BLENDS FOR IMPROVED STRENGTHS AND TOUGHNESS IN THREE DIMENSIONAL MELT-BLOWN														
Sample Number	Composition	GRAB TENSILE						TRAP TEAR		NORMALIZED GRAB TENSILE		NORMALIZED TRAP TEAR		
		Bulk Weight g/m	Load MD g	Load CD g	Energy MD kg-mm	Energy CD kg-mm	Elong MD mm	Elong CD mm	Load MD g	Load CD g	Load MD g/gm	Load CD g/gm	Load MD g/gm	Load CD g/gm
2	PE	40	985	908	44	55	67	57	25	23	25	23		

85

TABLE 2-continued

COMPARISON WITH 100% POLYETHYLENE POLYMER BLENDS FOR IMPROVED STRENGTH AND TOUGHNESS IN THREE DIMENSIONAL MELTLOWN													
Sample Number	Composition	GRAB TENSILE						TRAP TEAR		NORMALIZED GRAB TENSILE		NORMALIZED TRAP TEAR	
		Peak Weight gms	Load MD g	Load CD g	Energy MD kg-mm	Energy CD kg-mm	Elong MD mm	Elong CD mm	Load MD g	Load CD g	g/gms	g/gms	g/gms
61	90:10 PP:PB	25	1544	1444	73	61	75	72	454	366	63	39	18
62	85:15 PP:PB	41	1839	1562	87	70	76	73	538	327	45	34	14
64	80:20 PP:PB	25	1880	1775	53	60	46	33	343	381	76	72	22
66	70:30 PP:PB	26	2385	1525	52	41	30	42	849	429	91	38	22

It can be seen from Table 2 that Samples 61-66, made in accordance with the present invention, all demonstrate a substantial increase in the peak load and energy over those of the prior art 100% three dimensional polyethylene melt-blown web of Sample 2. Particularly, Samples 61-66 have an increase in peak load in the machine direction of between 57% and 143% over the control Sample 2. Additionally, Samples 61-66 have an increase in peak energy in the machine direction of between 18% and 98% over the control Sample 2. Accordingly, the inventive webs, Samples 61-66, all demonstrate the increased strength and toughness of the three dimensional nonwoven webs prepared in accordance with the present invention.

EXAMPLE 3

In order to determine the effectiveness of the ternary blends of the present invention, Samples 4, 6, 7 and 8 were prepared in accordance with the present invention for comparison with control Samples 2 and 59. Samples

-continued

A. room die tip
B. single bank
C. water quench with surfactant

		Sample 4/6	Samples 7/8
<u>Set Points</u>			
Primary Air Pressure	psi	3	2.5
Primary Air Temperature	T.	623	633
Parading Distance	in	7	7
<u>Measured Variables</u>			
Die Tip Pressure	psi	125	128
Die Tip (Melt) Temperature	T.	579	597

As with the previous examples, the actual data for the inventive webs, Samples 4, 6, 7, and 8, have been normalized to a basis weight of 1 gsm. Both the actual data and the normalized data which show the characteristics of Samples 2, 4, 6, 7, 8, and 59 are set out in Table 3 below.

TABLE 3

COMPARISON WITH TRI-LEND PP/PB/TERPOLYMER
POLYMER BLENDS FOR IMPROVED STRENGTHS AND TOUGHNESS
IN THREE DIMENSIONAL MELTLOWN

Sample Number	Composition	GRAB TENSILE						NORMALIZED GRAB TENSILE	
		Peak Weight gms	Load MD g	Load CD g	Energy MD kg-mm	Energy CD kg-mm	Elong MD mm	Elong CD mm	Load MD g/gms
7 & 8	45:45:10 PP/TERP/PB	41	1871	1738	85	98	63	85	46
4 & 6	50:50 PP/TERP	41	2393	1841	53	67	28	51	39
59	100% PP	41	1344	1433	26	46	30	30	22
2	100% PE	40	925	908	44	33	67	97	23

4 and 6 were formed from a blend of 50% polypropylene (homopolymer; Himont HH442R) and 50% terpolymer (formed from three monomers, namely propylene, ethylene, and 1-butene), which was an experimental polymer manufactured by Himont U.S.A., Inc. of Wilmington, Del., identified by the designation EP-5, having a melt flow rate of 45 g/10 min. Samples 7 and 8 are examples of a ternary blend of polymers in accordance with the present invention. Particularly, Samples 7 and 8 were formed from a blend of 45% polypropylene (homopolymer; Himont HH442R), 45% terpolymer (same terpolymer as present in Samples 4 and 6), and 10% polybutylene (Shell DP8910).

Samples 4, 6, 7, and 8 were formed by melt-blowing in accordance with the following parameters:

Machine Configuration

It can be seen from Table 3 that although Samples 4 and 6, made in accordance with the present invention, demonstrate a substantial increase in the peak load and energy over those of the prior art three dimensional melt-blown webs of Samples 2 and 59, the polypropylene/terpolymer blend has a decreased elongation, which is an important characteristic of toughness. To the contrary, Samples 7 and 8 demonstrate increased strength, toughness, and elongation. Particularly, Samples 7 and 8 have an increase in peak load in the machine direction of between 39% and 90% over the control Samples 2 and 59. Additionally, Samples 7 and 8 have an increase in peak energy in the machine direction of between 93% and 227% over the control Samples 2 and 59, an increase in elongation of between 70% and 110% compared with control Sample 59, and a comparable elongation with that of control Sample 2. Accordingly, the inventive ternary blend webs, Samples 7 and 8,

demonstrate the increased strength and toughness of the three dimensional nonwoven webs prepared in accordance with the present invention.

EXAMPLE 4

In order to test the effectiveness of the three dimensional web of the present invention as a laminate material, Samples 53, 56, 213, C, D were prepared in accordance with the present invention. Each of these samples was bonded to an intermediate layer of material which was not the three dimensional web of the present invention.

Samples 55 and 207 were also prepared to show the effectiveness of the three dimensional web of the present invention as a laminate material in situations where the three dimensional web will be directly bonded to another three dimensional web, without any intermediate layer.

Sample 53 was formed from a blend of 60% polyethylene (Dow 6814) and 40% polypropylene. The polypropylene used for Sample 53 was a homopolymer with a melt flow of 400 g/10 min (ASTM D1258, Condition L, (230° C., 2160 g weight)) and a narrow molecular weight distribution. Such a polypropylene homopolymer is manufactured by Himont U.S.A., Inc. of Wilmington, Del. and designated HH441. Sample 56 was formed from a blend of 75% polyethylene (Dow 6814) and 25% polypropylene (Himont HH441). As an intermediate material to which the laminate materials of Samples 53 and 56 were bonded, Intermediate Layer X was formed from a blend of 60% pulp (IPSS) and 40% ethylene vinyl acetate copolymer (Exxon "Escorene").

Sample 213 was formed from a blend of 25% polybutylene (Shell DP8910) and 75% polypropylene (Himont HH442H) and was bonded to an intermediate material "X," formed from a blend of 70% pulp (IPSS) and 30% ethylene vinyl acetate copolymer (Exxon "Escorene").

Sample C was formed from a blend of 80% polypropylene (Himont HH442H) and 20% polybutylene (Shell DP8910) which was bonded to an intermediate material "X," formed from a blend of 30% pulp (Weyerhaeuser NF105) and 70% polymer blend (comprised of 85% polypropylene (Himont HH442H) and 15% polybutylene (Shell DP8910)).

Sample D was formed from a blend of 80% polypropylene (Himont HH442H) and 20% polybutylene (Shell DP8910) which was bonded to an intermediate material "X," formed from a blend of 30% pulp (Weyerhaeuser NF105) and 30% polymer blend (comprised of 85% polypropylene (Himont HH442H) and 15% polybutylene (Shell DP8910)).

Sample 55 was formed from a blend of 75% polyethylene (Dow 6814) and 25% polypropylene (Himont HH442H). Sample 207 was formed from a blend of 80% polypropylene (Himont HH442H) and 20% polybutylene (Shell DP8910).

All the webs were heat embossed with a conventional bonding pattern.

Samples 53, 56, 213, C, D, 55, and 207 were formed by melt-blowing in accordance with the following parameters:

Machine Configuration

- A. seven die tip
- B. single bank
- C. water quench with surfactant

Intermediate

-continued

		3D Layer Sample 53		Layer X
5	Primary Air Pressure	psi	15	4.6
	Primary Air Temperature	°F.	313	404
	Forming Distance	in	6.5	9
	Primary Air Flow	scfm	168	
	Measured Variables			
10	Die Tip Pressure	psi	133	
	Die Tip (Melt) Temperature	°F.	309	381
	Reading			
	Pattern Roll Temperature			
	Set Point	°F.	180	
15	Actual Surface	°F.	160	
	Actual Roll Temperature			
	Set Point	°F.	180	
	Actual Surface	°F.	170	
	Pressure (Average)	psi	19	
20	Line Speed	fpm	14	
				Intermediate Layer X
25	Primary Air Pressure	psi	543	4.6
	Primary Air Temperature	°F.	313	404
	Forming Distance	in	4.0	9
	Primary Air Flow	scfm	408	
	Measured Variables			
30	Die Tip Pressure	psi	174	
	Die Tip (Melt) Temperature	°F.	318	381
	Reading			
	Pattern Roll Temperature			
	Set Point	°F.	180	
35	Actual Surface	°F.	160	
	Actual Roll Temperature			
	Set Point	°F.	180	
	Actual Surface	°F.	170	
	Pressure (Average)	psi	19	
40	Line Speed	fpm	14	
				Intermediate Layer X
45	Primary Air Pressure	psi	2.3	5.0
	Primary Air Temperature	°F.	311	380
	Forming Distance	in	7.5	
	Primary Air Flow	scfm	85	
	Measured Variables			
50	Die Tip Pressure	psi		220
	Die Tip (Melt) Temperature	°F.	304	378
	(and Triton X-102 surfactant spray)			
	Reading			
	Pattern Roll Temperature			
55	Set Point	°F.	185	
	Actual Surface	°F.	160	
	Actual Roll Temperature			
	Set Point	°F.	190	
	Actual Surface	°F.	175	
60	Pressure (Average)	psi	12.5	
	Line Speed	fpm	21	
				Intermediate Layer X
65	Primary Air Pressure	psi	1.6	6.3
	Primary Air Temperature	°F.	317	334
	Forming Distance	in	7	18
	Primary Air Flow	scfm		
	Measured Variables			
70	Die Tip Pressure	psi	79	117
	Die Tip (Melt) Temperature	°F.	485	314
	(and Triton X-102 surfactant spray)			
	Reading			
	Pattern Roll Temperature			
75	Set Point	°F.	220	
	Actual Surface	°F.		
	Actual Roll Temperature			
	Set Point	°F.	230	
	Actual Surface	°F.		

87

-continued

Pressure (Average)	psi	16
Line Speed	fpm	22
		3D Layer
		Intermediate Layer

As with the previous examples, the data for these inventive samples were all normalized to a basis weight of 1 gm. Both the actual data and the normalized data which show the characteristics of these inventive samples are set out in Table 4 below.

TABLE 4

COMPARISON OF COMPOSITES WITH 3D OUTER LAYERS															
63 POLYMER BLENDS FOR IMPROVED STRENGTHS AND TOUGHNESS IN THREE DIMENSIONAL MELTLOWN															
Sample Number	Composition	GRAB TENSILE								TRAP TEAR		NORMALIZED GRAB TENSILE		NORMALIZED TRAP TEAR	
		Basis Weight gsm	Load MD S	Load CD S	Energy MD kg-mm	Energy CD kg-mm	Elong MD mm	Elong CD mm	Load MD S	Load CD S	Load MD S/gsm	Load CD S/gsm	Load MD S/gsm	Load CD S/gsm	
<u>3D + 1 + 3D</u>															
53	3D = 60:40 PE:PP 1 = 60:40 PUL:PEVA	80	1895	1940	85	98	89	80	539	647	24	25	7	8	
56	3D = 75:25 PE:PP 1 = 60:40 PUL:PEVA	103	1651	1678	39	77	26	40	522	270	16	18	5	3	
213	3D = 75:25 PE:PB 1 = 70:30 PUL:PEVA	88	2301	2117	145	161	85	97	628	816	26	24	9	9	
C	3D = 80:20 PP:PB 1 = 30:70 PUL: (85:15 PP:PB)	111	5269	4272	175	182	44	63	1221	635	47	38	11	6	
D	3D = 80:20 PP:PB 1 = 30:70 PUL: (85:15 PP:PB)	112	4217	2014	117	108	38	46	980	648	38	30	9	6	
<u>3D + 3D (no intermediate layer)</u>															
55	3D = 75:25 PE:PP	76	2118	1689	63	32	31	28	575	226	28	22	8	3	
207	3D = 80:20 PE:PB	50	2234	1856	111	108	71	89	882	661	47	37	18	13	

		D		X	
		psi	°F.	psi	°F.
Primary Air Pressure	psi	16		63	
Primary Air Temperature	°F.	517		514	
Forming Distance	in	7		18	
Primary Air Flow	scfm				
Measured Variables					
Die Tip Pressure	psi	79		117	
Die Tip (Melt) Temperature	°F.	493		514	
(and Teflon X-102 surface quench)					
Resin					
Pattern Roll Temperature					
Set Point	°F.	220			
Actual Surface	°F.				
Aerial Roll Temperature					
Set Point	°F.	230			
Actual Surface	°F.				
Pressure (Average)	psi	16			
Line Speed	fpm	22			
		3D Layer		Intermediate Layer	
		53		207	
Primary Air Pressure	psi			15	
Primary Air Temperature	°F.	245		522	
Forming Distance	in			7	
Primary Air Flow	scfm	400		195	
Measured Variables					
Die Tip Pressure	psi	174		36	
Die Tip (Melt) Temperature	°F.	538		502	
(and Teflon X-102 surface quench)					
Resin					
Pattern Roll Temperature					
Set Point	°F.	180		237	
Actual Surface	°F.	180		207	
Aerial Roll Temperature					
Set Point	°F.	180		234	
Actual Surface	°F.	170		202	
Pressure (Average)	psi	10		22	
Line Speed	fpm	14		39	

35 It can be seen from Table 4 that the laminate material formed from polyethylene, namely samples 53 and 56, do not exhibit the same strength, toughness, and tear resistance as those formed from polybutylene, namely Samples 213, C, and D. In particular, the polybutylene laminate materials bonded to an intermediate layer have an increase in peak load in the machine direction of 121% on average over the polyethylene laminate materials. Additionally, these polybutylene laminate materials have an increase in peak energy in the machine direction of 135% on average over the polyethylene laminate materials. Accordingly, the inventive laminate materials containing polybutylene, Samples 213, C, and D demonstrate the increased strength and toughness of the three dimensional nonwoven webs prepared in accordance with the present invention.

As can also be seen from Table 4, Samples 213, C, and D formed with polybutylene, show much greater tear resistance than the samples formed with polyethylene.

It can also be seen from Table 4 that the three dimensional layer formed with polybutylene, Sample 207, had a 10% greater peak load than the three dimensional layer formed with polyethylene, Sample 55. As for peak energy, Sample 207 was 76% greater than Sample 55. Additionally, Sample 207's tear resistance was 56% greater than the tear resistance of Sample 55. It should be noted that there was no intermediate layer bonded between the two three dimensional layers of Samples 207 and 55.

We claim:
63 1. A three dimensional nonwoven web comprising at least one layer consisting of drawn and unoriented thermoplastic fibers formed from a blend comprising polypropylene and polybutylene, wherein the blend by

weight is from 90% to 70% polypropylene and from 10% to 30% polybutylene.

2. The three dimensional nonwoven web of claim 1, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

3. The three dimensional nonwoven web of claim 2, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

4. A three dimensional nonwoven web comprising at least one layer consisting of drawn thermoplastic fibers formed from a ternary blend comprising polypropylene, polybutylene, and a terpolymer, wherein the ternary blend by weight is from 10% to 30% polybutylene.

5. The three dimensional nonwoven web of claim 4, wherein the terpolymer comprises propylene, ethylene, and 1-butene.

6. The three dimensional nonwoven web of claim 4, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

7. The three dimensional nonwoven web of claim 4, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

8. A method for forming a layer of three dimensional nonwoven web consisting of thermoplastic fibers, comprising the steps of:

- a. mixing polypropylene and polybutylene to form a blend, wherein the blend by weight is from 90% to 70% polypropylene and from 10% to 30% polybutylene;
- b. heating the blend to form a melt;
- c. extruding the melt through an orifice to form thermoplastic fibers;
- d. initially drawing the fibers to a ratio of greater than 14 to 1; and
- e. depositing the fibers onto a forming surface to form a first layer.

9. The method of claim 8, wherein the fibers are quenched prior to being deposited on the forming surface.

10. The method of claim 8 or 9, wherein after the fibers are deposited, the layer is bonded.

11. The method of claim 8 or 9, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

12. The method of claim 11, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

13. A method for forming a layer of three dimensional nonwoven web consisting of thermoplastic fibers, comprising the steps of:

- a. mixing polypropylene, polybutylene, and a terpolymer to form a ternary blend, wherein the ternary blend by weight is from 10% to 30% polybutylene;
- b. heating the ternary blend to form a melt;
- c. extruding the melt through an orifice to form thermoplastic fibers;
- d. initially drawing the fibers to a ratio of greater than 14 to 1; and

e. depositing the fibers onto a forming surface to form a first layer.

14. The method of claim 13, wherein the terpolymer comprises propylene, ethylene, and 1-butene.

15. The method of claim 13, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

16. The method of claim 15, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

17. The method of claim 13 or 14, wherein the fibers are quenched prior to being deposited on the forming surface.

18. The method of claim 17, wherein after the fibers are deposited, the layer is bonded.

19. A three dimensional nonwoven wiper comprising a web consisting of drawn thermoplastic fibers, wherein the fibers are formed from a blend comprising polypropylene and polybutylene to form thermoplastic fibers wherein the blend by weight is from 90% to 70% polypropylene and from 10% to 30% polybutylene.

20. The three dimensional nonwoven wiper of claim 19, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

21. The three dimensional nonwoven wiper of claim 20, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

22. A three dimensional nonwoven wiper consisting of drawn thermoplastic fibers formed from a ternary blend comprising polypropylene, polybutylene, and a terpolymer wherein the ternary blend by weight is from 10% to 30% polybutylene.

23. The three dimensional nonwoven wiper of claim 22, wherein the terpolymer comprises propylene, ethylene, and 1-butene.

24. The three dimensional nonwoven wiper of claim 22, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

25. The three dimensional nonwoven wiper of claim 24, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

26. A method for forming a three dimensional nonwoven wiper consisting of thermoplastic fibers comprising the steps of:

- a. mixing polypropylene and polybutylene to form a blend, wherein the blend by weight is from 90% to 70% polypropylene and from 10% to 30% polybutylene;
- b. heating the blend to form a melt;
- c. extruding the melt through an orifice to form thermoplastic fibers;
- d. initially drawing the fibers to a ratio of greater than 14 to 1; and
- e. depositing the fibers onto a forming surface to form a first layer.

27. The method of claim 26, wherein the fibers are quenched prior to being deposited on the forming surface.

28. The method of claim 26 or 27, wherein after the fibers are deposited, the wiper is bonded.

29. The method of claim 26 or 27, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

30. The three dimensional nonwoven web of claim 29, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

31. A method for forming a three dimensional nonwoven wiper consisting of thermoplastic fibers comprising the steps of:

a. mixing polypropylene, polybutylene, and a terpolymer to form a ternary blend, wherein the ternary blend by weight is from 10% to 30% polybutylene;

b. heating the ternary blend to form a melt;

c. extruding the melt through an orifice to form thermoplastic fibers;

d. initially drawing the fibers to a ratio of greater than 14 to 1; and

e. depositing the fibers onto a forming surface to form a first layer.

32. The method of claim 31, wherein the terpolymer comprises propylene, ethylene, and 1-butene.

33. The method of claim 31, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

34. The method of claim 33, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

35. The method of claim 31 or 32, wherein the fibers are quenched prior to being deposited on the forming surface.

36. The method of claim 35, wherein after the fibers are deposited, the wiper is bonded.

37. A laminate material comprising at least one three dimensional layer consisting of drawn and unoriented thermoplastic fibers formed from a blend comprising polypropylene and polybutylene, wherein the blend by weight is from 90% to 70% polypropylene and from 10% to 30% polybutylene.

38. The laminate material of claim 37, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

39. The laminate material of claim 38, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

40. A laminate material comprising at least one three dimensional layer consisting of drawn thermoplastic fibers formed from a ternary blend comprising polypropylene, polybutylene, and a terpolymer, wherein the ternary blend by weight is from 10% to 30% polybutylene.

41. The laminate material of claim 40, wherein the terpolymer comprises propylene, ethylene, and 1-butene.

42. The laminate material of claim 40, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene co-

polymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

43. The laminate material of claim 42, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

44. A method for forming a laminate material comprising at least one three dimensional layer consisting of thermoplastic fibers, comprising the steps of:

a. mixing polypropylene and polybutylene to form a blend, wherein the blend by weight is from 90% to 70% polypropylene and from 10% to 30% polybutylene;

b. heating the blend to form a melt;

c. extruding the melt through an orifice to form thermoplastic fibers;

d. initially drawing the fibers to a ratio of greater than 14 to 1; and

e. depositing the fibers onto a forming surface to form a first layer.

45. The method of claim 44, wherein the fibers are quenched prior to being deposited on the forming surface.

46. The method of claim 44 or 45, wherein after the fibers are deposited, the first layer is bonded.

47. The method of claim 44 or 45, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

48. The method of claim 47, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

49. The method of claim 48, wherein the first layer is bonded to a second layer selected from the group of materials consisting of foam, meltblown, coform, spunbond, scrim, and three dimensional meltblown.

50. The method of claim 49, wherein the second layer is bonded to a third layer.

51. The method of claim 50, wherein the second layer is bonded to a third layer selected from the group of materials consisting of foam, meltblown, coform, spunbond, scrim, and three dimensional meltblown.

52. A method for forming a laminate material comprising at least one three dimensional layer consisting of thermoplastic fibers, comprising the steps of:

a. mixing polypropylene, polybutylene, and a terpolymer to form a ternary blend, wherein the ternary blend by weight is from 10% to 30% polybutylene;

b. heating the ternary blend to form a melt;

c. extruding the melt through an orifice to form thermoplastic fibers;

d. initially drawing the fibers to a ratio of greater than 14 to 1; and

e. depositing the fibers onto a forming surface to form a first layer.

53. The method of claim 52, wherein the terpolymer comprises propylene, ethylene, and 1-butene.

54. The method of claim 52, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

55. The laminate material of claim 54, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

56. The method of claim 52 or 53, wherein the fibers are quenched prior to being deposited on the forming surface.

57. The method of claim 56, wherein after the fibers are deposited, the first layer is bonded.

58. The method of claim 57, wherein the first layer is bonded to a second layer selected from the group of materials consisting of foam, meltblown, coform, spunbond, scrim, and three dimensional meltblown.

59. The method of claim 58, wherein the second layer is bonded to a third layer.

60. The method of claim 59, wherein the second layer is bonded to a third layer selected from the group of materials consisting of foam, meltblown, coform, spunbond, scrim, and three dimensional meltblown.

61. A three dimensional nonwoven wiper comprising a laminate material comprising at least one three dimensional layer consisting of drawn and unoriented thermoplastic fibers formed from a blend comprising polypropylene and polybutylene, wherein the blend by weight is from 90% to 70% polypropylene and from 10% to 30% polybutylene.

62. The three dimensional nonwoven wiper of claim 61, wherein the polypropylene is selected from the

group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

63. The three dimensional nonwoven wiper of claim 62, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

64. A three dimensional nonwoven wiper comprising a laminate material comprising at least one three dimensional layer consisting of drawn thermoplastic fibers formed from a ternary blend comprising polypropylene, polybutylene, and a terpolymer, wherein the ternary blend by weight is from 10% to 30% polybutylene.

65. The three dimensional nonwoven wiper of claim 64, wherein the terpolymer comprises propylene, ethylene, and 1-butene.

66. The three dimensional nonwoven wiper of claim 64, wherein the polypropylene is selected from the group consisting of polypropylene homopolymers and polypropylene copolymers and the polybutylene is selected from the group consisting of polybutylene homopolymers and polybutylene copolymers.

67. The three dimensional nonwoven wiper of claim 66, wherein the polypropylene copolymer and the polybutylene copolymer are copolymers of ethylene.

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**UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION**

PATENT NO. : 5,165,979

Page 1 of 2

DATED : November 24, 1992

INVENTOR(S) : S. L. Watkins and H. P. Watts

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

Column 1, line 9, after "May 4, 1990" —is now pending— should be deleted.

Column 4, line 23, "to form the the three" should read --to form the three--.

Column 6, lines 48-49, "Samples 59 and 61-65" should be under and to the right of "Set Points".

Column 7, Table I, "63 Polymer Blends" should read --Polymer Blends--.

Column 7, line 21, "kilogram.millimeters" should read --kilogram-millimeters--.

Columns 7/8, Table 2, please line up "Grab Tensile, Trap Tear, Normalized Grab Tensile";

Columns 9/10, Table 2, please line up "Grab Tensile, Trap Tear, Normalized Grab Tensile".

Columns 9/10, Table 3, should not split paragraph in Column 9.

Column 9, lines 67-68, please remove "Machine Configuration:" so that this does not split from table.

92

**UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION**

PATENT NO. : 5,165,979

Page 2 of 2

DATED : November 24, 1992

INVENTOR(S) : S. L. Watkins and H. P. Watts

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

Column 10, Table 3, please line up "Grab Tensile and Normalized Grab Tensile".

Column 11, line 69, please move "Intermediate" up to column 12 so it does not split from table.

Columns 13/14, Table 4, "Table 4 should not break up, other table in Column 13";

"63 Polymer Blends For" should read --Polymer Blends For--;

"213 3D-75:25 PE:PB" should read --213 3D-75:25 PP:PB--;

"In sample C please move the 3D that comes after PB under the 80";

"In sample D please move the 3D so that it comes after PB under the 80";

"207 3D-80:20 PE:PB" should read --207 3D-80:20 PP:PB--.

Signed and Sealed this

First Day of November, 1994

Attest:



BRUCE LEHMAN

Attending Officer

Commissioner of Patents and Trademarks

United States Patent [19]

Daponte

[11] Patent Number: 4,863,779

[45] Date of Patent: Sep. 5, 1989

[54] COMPOSITE ELASTOMERIC MATERIAL
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Related U.S. Application Data

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1986, abandoned.
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428/340; 428/903
[58] Field of Search 428/152, 198, 284, 286,
428/287, 297, 298, 340, 903

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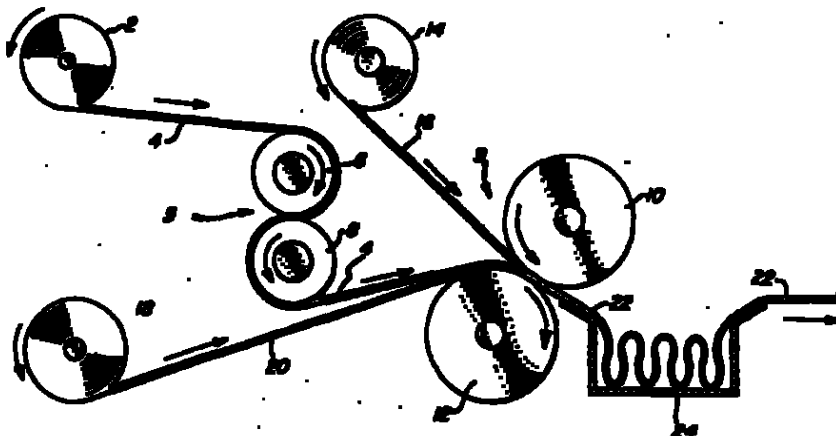
Primary Examiner—James J. Bell

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[57] ABSTRACT

Describes improved composite material comprising an elastic web preferably formed of collected, entangled, nonwoven fibers comprising a copolymer made of ethylene and at least one other vinyl monomer selected from the group including vinyl ester monomers and unsaturated aliphatic monocarboxylic acids and alkyl esters of these monocarboxylic acids, where the amount of monomer other than the ethylene in the copolymer is sufficient to impart elasticity to a cohesive nonwoven web formed from melt-blown fibers of the material. This elastic web is bonded to at least one other web, and preferably is interrelated between two other nonwoven webs of spun-bonded or melt-blown fibers. Discloses processes of making these composite materials. The composites are useful for protective covers and wraps, outerwear, undergarments, menstrual and incontinence control articles, and garments such as disposable diapers and the like.

74 Claims, 2 Drawing Sheets



94

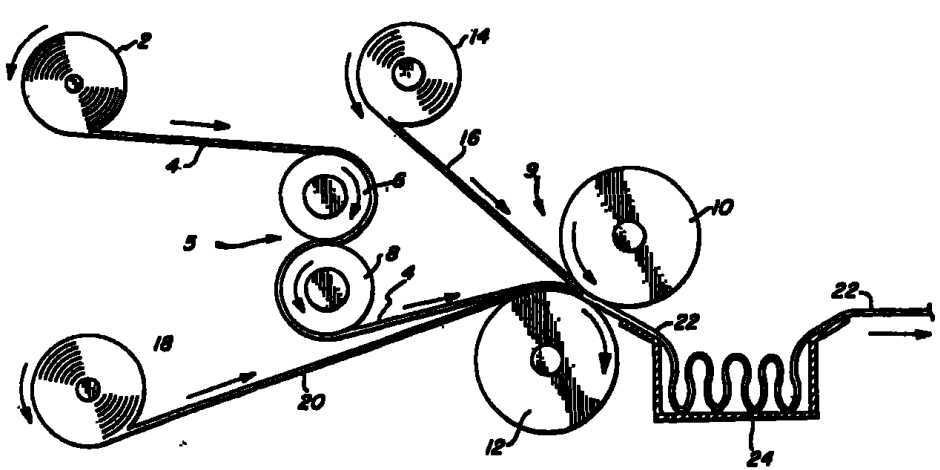


FIG. 1

95

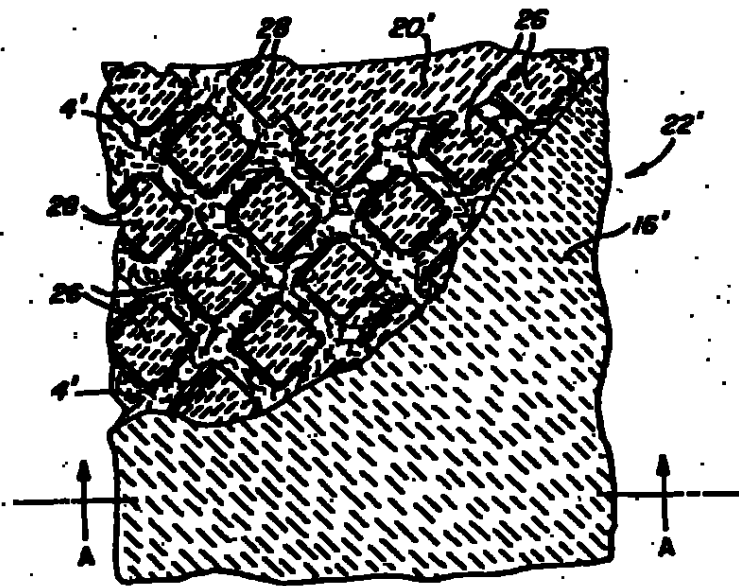


FIG. 2

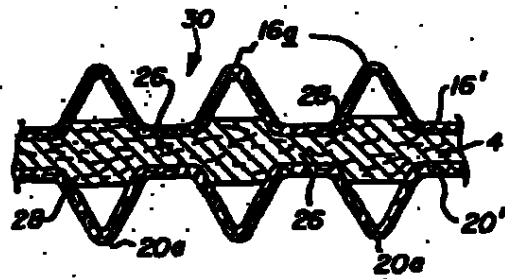


FIG. 2A

COMPOSITE ELASTOMERIC MATERIAL

This application is a continuation in part of Ser. No. 06/843,428, now abandoned.

FIELD OF THE INVENTION

The present invention is concerned with a cloth-like material that is formed from a particular kind of laminate, methods of making it, and articles that can be made from it. In one embodiment, this laminate is a composite comprising at least one elastic web, such as a nonwoven cohesive web of elastomeric fibers, bonded to one or more webs of a nonwoven, nonelastic cohesive material. The composite of the invention may be made in the form of soft, cloth-like materials that may be superior to prior art materials with respect to drape, strength, and stretch.

BACKGROUND OF THE INVENTION

A suggestion for using a nonwoven web in a laminate is found in the British U.S. Pat. No. 3,849,241. The nonwoven web was formed of a melt-blown thermoplastic polymer such as polypropylene.

Composite fabrics comprising at least one layer of nonwoven textile fabric secured to an elastic layer are known. For example, the presently pending, commonly assigned U.S. patent application Ser. No. 760,437, filed July 30, 1985, of J. D. Taylor and M. J. Vander Wisen, for "Composite Elastomeric Material and Process for Making the Same", discloses composite elastomeric material in which at least one elastic web is bonded to at least one gatherable web. The gatherable web must be extensible and contractible with the elastic web upon stretching and relaxing of the composite material. The composite is made by tensioning the elastic web to elongate it, bonding the elongated elastic web to at least one gatherable web under conditions that soften one or both webs so that they bond to each other, and then relaxing the composite web immediately after the bonding step. Relaxation is accompanied by contraction of the elastic web, and since the gatherable web and elastic web are bonded together, the gatherable web is gathered.

Composites made in accordance with the Taylor and Vander Wisen disclosure have great utility for a number of consumer and industrial applications. For example, a disposable cover for the head of a mop may be fabricated from the composite. Such a cover may be made up so that it must be stretched to place it over a mop head, but when relaxed, will be self-retaining on the mop head because of its relaxation to a size that holds it in place over the headed mop head. These composites are also useful in fabricating stretchable protective covers and wraps, outerwear, undergarments, and menstrual and incontinence control articles and garments, such as disposable diapers and the like. The mop head cover is disclosed in the copending, commonly assigned application of L. L. Gibbs and C. J. Morell.

The applications of Taylor and Vander Wisen, and of Gibbs and Morell, are incorporated herein by reference.

While the Taylor and Vander Wisen composites are self-bonded nonwoven webs that are bonded to each other by the partial melting and subsequent cooling of at least one of the webs while in contact with the other, composite fabrics comprising at least one layer of non-

woven textile fabric secured to an elastic layer by mechanical means are also known.

U.S. Pat. No. 4,209,563 discloses a method of making an elastic material which includes continuously forwarding relatively elastomeric fibers and elongatable but relatively nonelastic fibers onto a forming surface and bonding at least some of the fiber crossings to form a coherent cloth which is subsequently mechanically worked, as by stretching, following which it is allowed to relax. As described by the patentee at column 8, lines 19 et seq., the elastic modulus of the cloth is substantially reduced after the stretching, resulting in the permanently stretched nonelastic filaments relaxing and looping to increase the bulk and improve the feel of the fabric (column 9, lines 9-14 and FIG. 3). Forwarding of the filaments to the forming surface is positively controlled, which the patentee (column 7, lines 19 et seq.) contrasts to the use of air streams to convey the fibers as used in melt-blowing operations. Bonding of the filaments to form the coherent cloth may utilize embossing patterns or smooth, heated roll nips, as set forth at column 9, lines 44 et seq.

U.S. Pat. No. 3,316,136 discloses a composite fabric comprising a layer of an elastic or resilient material and an overlying layer of fabric, for example, a woven fabric. The elastic fabric may be a polyurethane foam or a nylon woven to impart stretchability or the like and, as is disclosed in the paragraph bridging columns 1 and 2 of the patent, an adhesive may be applied in a predetermined pattern to the elastic material which is then stretched, and while in a stretched or elongated state, the overlying fabric is contacted therewith and held in pressure engagement for a time sufficient to ensure adhesion of the two layers. When the applied adhesive is dry, tension on the backing material is released, causing the overlying nonelastic fabric to gather in the areas outlined by the adhesive.

U.S. Pat. No. 2,957,512 concerns a method of producing elastic composite sheet materials and discloses that a reticulated, fibrous web formed of an elastomeric material such as rubber, including butadiene-styrene copolymer, may be utilized as the elastic ply of a composite material as disclosed at column 3, lines 18-24. At column 3, lines 39-48, the patent discloses, with reference to FIG. 7 of the drawings, that a relaxed sheet material ply may have a fibrous web of elastomeric material of smaller area than the sheet material stretched so as to conform it in area to the area of the sheet material and the plies bonded together at spaced points or areas. Upon allowing the fibrous elastomeric ply to relax, the composite body is stated to assume the structure shown in FIG. 7, which is described at column 3, lines 15 et seq., as showing a fibrous web of elastomeric material 50 bonded at spaced areas or lines 56 to a ply 55 of a creped or corrugated flexible sheet material, which may be paper or a synthetic resin material. The structures of the patented invention are stated to be particularly well-suited for the manufacture of foundation garments, bathing garments, elastic stocking, ankle braces, belts, garters, gallsies and the like.

SUMMARY OF THE INVENTION

This invention is concerned with a soft, cloth-like material that is suitable as a bodyside cover for diapers, health care garments and materials, tissues, and a variety of industrial products. This material is a composite or laminate of a pair of webs, and preferably both of these webs are nonwoven. To develop the desirable charac-

4/6

teristics of the laminate of the invention, one of these nonwoven webs is formed from melt-blown microfibers of an ethylene-vinyl acetate copolymer, as hereinafter described in greater detail. The other layer is formed from either spun-bonded or melt-blown fibers, preferably of polypropylene, polyethylene, or a random copolymer of ethylene and propylene.

For some purposes, a trilaminate is preferred. In the trilaminate embodiment of the invention, the nonwoven web that is formed from poly(ethylene-vinyl acetate) microfibers is the intercalary layer. The outer layers are both formed of nonwoven webs and may be the same or different. For example, one of the outer layers may be formed of a nonwoven web of spun-bonded or melt-blown polypropylene fibers, and the other may be formed from spun-bonded or melt-blown polyethylene fibers. Such a product represents one preferred embodiment of the invention, and offers different properties on each of its faces. Thus, the cover layer that is formed from spun-bonded or melt-blown polyethylene fibers generally provides greater softness, and thus might be more attractive and useful as a surface intended for body contact.

In both the dilaminate and trilaminate embodiments, the laminae are heat-bonded together. This is ordinarily accomplished simply by passing the laminae between rolls, either one or both of which are heated sufficiently to soften at least one of the laminae sufficiently to become adhesive in nature. The pressure applied by the rolls is then sufficient to press them together to permit the laminae to become bonded to each other.

The intercalary layer may be formed from fibers consisting entirely of poly(ethylene-vinyl acetate). Nonwoven webs of this type have superior elasticity and are preferred for many applications. Where a less elastic intercalary layer is desired, it may be formed from a nonwoven web made from a blend of a poly(ethylene-vinyl acetate) with a modifying polymer such as, for example, a polyolefin or a mixture of polyolefins, or a similar polymer formed from one or more monomers having olefinic unsaturation.

Composites made in accordance with the invention can be formed to be very cloth-like, and to be superior in terms of drape, softness, strength, and stretch, to currently known composites made from other nonwoven materials such as, for example, polyethylene or polypropylene webs formed from spun-bonded or melt-blown fibers.

While the preferred intercalary layer is formed from microfibers of melt-blown poly(ethylene-vinyl acetate) having a melt index in the range from 31 to 500 at 190° C. and comprising from 10% by weight to about 50% by weight of vinyl acetate, the invention also encompasses laminates made from nonwoven webs formed from melt-blown fibers where the copolymer is made of ethylene and at least one other vinyl monomer that is selected from the group including vinyl ester monomers and unsaturated aliphatic monocarboxylic acids and alkyl esters of these monocarboxylic acids, wherein the amount of monomer other than ethylene in the copolymer is sufficient to impart elasticity to a cohesive nonwoven web formed from these melt-blown fibers.

In accordance with one particular embodiment of the present invention, there is provided a method of producing a composite elastic material comprising at least one gatherable web bonded to at least one elastic web, that is, a nonwoven web formed from melt-blown fibers comprising a copolymer made of ethylene and at least

one other vinyl monomer selected from the group including vinyl ester monomers and unsaturated aliphatic monocarboxylic acids and alkyl esters of these monocarboxylic acids, wherein the amount of monomer other than ethylene in the copolymer is sufficient to impart elasticity to a cohesive nonwoven web formed from said melt-blown fibers. The method of uniting these webs is that disclosed in the Taylor and Vander Wiele patent application, although other materials were disclosed as useful in that patent application.

The method of uniting these webs comprises (a) tensioning the elastic web, such as a nonwoven cohesive web of elastomeric fibers, to elongate it; (b) bonding the elongated elastic web to at least one gatherable web under conditions which soften at least portions of the elastic web to form a bonded composite web; and (c) relaxing the composite web immediately after the bonding step, so that the gatherable web is gathered to form a composite elastic material having gathered web material on at least one surface thereof.

Generally, the bonding step involves overlaying the stretched elastic web and the gatherable web or webs, and applying heat and pressure. For example, bonding may often be effected by heating bonding sites on the elastic web to temperatures in the range from at least about 65° C. to about 120° C., and preferably from at least about 70° C. to about 90° C.

Preferably, the elastic web is bonded to the gatherable web or webs at a plurality of spaced-apart locations in a repeating pattern, so that the gatherable web is gathered between these locations.

In another aspect, the present invention provides an improved composite material comprising an elastic web of the materials previously described, bonded to at least one gatherable web in such fashion that the gatherable web is extensible and contractable with the elastic web upon stretching and relaxing of the composite material, the composite being made in the fashion described above.

Other aspects of the invention provide that the elastic web may comprise a nonwoven web of elastomeric fibers of the composition already described, preferably elastomeric microfibers such as, for example, an elastomeric nonwoven web of melt-blown elastomeric fibers or an elastomeric film.

In a preferred embodiment of the invention, the elastic web is formed from fibers of a copolymer of ethylene and vinyl acetate having a melt index in the range from 32 to 500, or preferably 32 to 300, at 190° C. and comprising from 10% by weight to about 50% by weight of vinyl acetate, preferably 18% by weight to 36% by weight. Particularly if this material is melt-blown to form microfibers that in turn are formed into a cohesive nonwoven web, the web that is formed has very good characteristics in terms of drape, elasticity, and cloth-like appearance.

One important characteristic of nonwoven webs formed from microfibers of poly(ethylene-vinyl acetate) is their ability to be heat-bonded to other webs. Since poly(ethylene-vinyl acetate) has a melting point in the range from about 45° C. to about 115° C., depending upon its particular composition, it has the ability to become tacky when heated to temperatures within this range, which are readily obtainable simply by passing the nonwoven web, together with one or more webs to which it is to become bonded, through a heated calendar roll-uvul roll pair. This characteristic of the nonwoven web of poly(ethylene-vinyl acetate) is important

97

whether the laminate being formed is a simple dilaminate or trilaminate, or whether the laminate being formed is a composite where the intercalary layer is stretched before being bonded to the cover sheet or sheets.

In order to develop particular properties in the intercalary layer, it is possible to add to the poly(ethylene-vinyl acetate) a modifying polymer prior to melt-blowing. This is done simply by mixing pellets of the two or more resins together to form a uniform blend of pellets. The modifying polymer must be one which, when blended with the poly(ethylene-vinyl acetate), and subjected to an effective combination of elevated temperature and elevated pressure conditions, is adapted to be extruded in blended form to form staple, homogeneous fiber or microfibers of the blend.

Suitable modifying polymers may be selected from the group consisting of polyethylene, polypropylene, polybutene, polystyrene, copolymers and mixtures of these, and an A-B-A' block copolymer, where A and A' are each a thermoplastic polymer endblock that includes a styrenic moiety and where B is an elastomeric poly(ethylene-butene) midblock.

The elastomeric fibers that form the elastomeric nonwoven web, preferably melt-blown microfibers, are composed of at least 10% by weight, preferably at least 20% by weight, and even more preferably at least 30% by weight, up to 100% by weight of the copolymer made of ethylene and vinyl acetate. When used, the modifying polymer or polymers may be present in an extrudable blend of resins in an amount greater than 0% by weight and up to a maximum of about 90% by weight of the modifying polymer, based on the weight of the elastic web.

To make the gathered composite of the invention, the fibrous elastic web is bonded to the gatherable web at a plurality of spaced-apart locations in a repeating pattern, and the gatherable web is gathered, in the composite, between these bonded locations.

The elastic web preferably has a low basis weight of from about 15 to about 300 grams per square meter, preferably from about 15 to about 200 grams per square meter, and even more preferably from about 15 to about 100 grams per square meter. The basis weight can be much higher, depending upon the intended application.

The cover web or webs, whether gatherable or not, may be nonwoven, nonelastic material. Preferably, each cover web is composed of fibers formed from materials selected from the group consisting of polyester fibers such as poly(ethylene terephthalate) fibers, polyolefin fibers, and polyamide fibers such as nylon fibers, cellulosic fibers, cotton fibers, and mixtures thereof. Alternatively, the cover web may be any suitable woven fabric. Preferably, however, the cover webs are formed from spun-bonded or melt-blown fibers of polyethylene, polypropylene, or a random copolymer of ethylene and propylene.

In addition, the conforming process may be used to incorporate a secondary fiber in the melt-blown microfibers of the elastic web and of the fibers of each cover sheet, if desired. Thus, wood pulp fibers may be incorporated in the melt-blown fibers of poly(ethylene-vinyl acetate), to create fibers of high absorbency value.

Other aspects of the invention are described in the description of the preferred embodiments.

DEFINITIONS

The term "copolymer" without any preceding modifying term, is used herein as a form of abbreviation. It refers to a copolymer made of ethylene and at least one other vinyl monomer selected from the group consisting of vinyl ester monomers, and unsaturated aliphatic monocarboxylic acids and alkyl esters of said monocarboxylic acids. For the practice of the present invention, the preferred copolymer is a copolymer of ethylene and vinyl acetate having a melt index in the range from 32 to 300, or preferably 32 to about 300, at 190° C. and comprising from 10% by weight to about 50% by weight of vinyl acetate, preferably 18% by weight to 36% by weight, and more preferably 26% by weight to 30% by weight. Other copolymer materials that have been proposed as suitable for use in the practice of the invention include ethylene-acrylic acid copolymer, ethylene-methacrylic acid copolymer, ethylene-ethyl acrylic acid copolymer, ethylene-ethyl acrylate copolymer, ethylene-methyl acrylate copolymer, ethylene-ethyl methacrylate copolymer, ethylene-methyl methacrylate copolymer, and similar copolymer materials. In any of these materials, the amount of monomer contained besides ethylene is generally from about 10% to about 50% by weight of the copolymer. Copolymer materials of this type contribute pendent groups to the low density polyethylene backbone, and it has been observed that about 10% by weight of the component other than ethylene, if vinyl acetate, is needed to impart desired elastomeric properties to the products produced, and of course the amount would be expected to be higher for larger comonomer molecules.

The term "melt flow" as used herein is the amount (usually in grams per 10 minutes or decigrams per minute) of a material which can be forced through a given orifice under a specified pressure and at a given temperature. The value should be determined in accordance with ASTM D 1238. The term "melt index" refers to the value obtained in accordance with condition E of ASTM D 1238 (190° C. and 2,160 gram load) and modified as follows:

(1) If the melt index (MI) at condition E is less than 100 grams per 10 minutes the melt flow rate (MFR) in accordance with ASTM D 1238 at 125° C. and 2,160 gram load is determined and the reported melt index is determined by the following equation:

$$MI = 0.7 \times (MFR)^{0.917}$$

(2) If the melt index (MI) at condition E is greater than 100 grams per 10 minutes the melt flow rate (MFR) in accordance with ASTM D 1238 at 125° C. and 325 gram weight is determined and the reported melt index is determined by the following equation:

$$MI = 0.15 \times (MFR)^{0.25}$$

The term "modifying polymer" is employed to refer to a material that is added to the copolymer to modify the properties of the product. Preferred types of modifying polymer are those formed from monomers having olefinic unsaturation.

The term "compatible" is used to refer to the relationship of one polymeric material to another with respect to the extrusion process and extrudate. To be compatible, two different polymeric materials must have similar rheological behavior, they must form a homogeneous

melt, and after being blown into fibers and solidifying, meet form a homogeneous solid product.

The term "coforming" is well understood in the art. It is used to refer to the application of at least one secondary fibrous material to microfibers, to form a web of both types of fibers, in a coherent, integrated structure. U.S. Pat. No. 4,100,324 illustrates one kind of coforming process, and it is incorporated herein by reference.

The terms "elastic" and "elastomeric" are used interchangeably herein to mean that property of any material that, upon application of a biasing force, permits that material to be stretchable to a stretched, biased length which is at least about 125 percent, that is about one and one-quarter times, its relaxed, unbiased length, and that will cause the material to recover at least 40 percent of its elongation upon release of the stretching, elongating force. A hypothetical example which would satisfy this definition of an elastomeric material would be a one (1) inch sample of a material which is elongatable to at least 1.25 inches and which, upon being elongated to 1.25 inches and released, will recover to a length of not more than 1.15 inches. Many elastic materials may be stretched by much more than 25 percent of their relaxed length and many of these will recover to substantially their original relaxed length upon release of the stretching, elongating force. This latter class of materials is generally preferred for purposes of the present invention.

As used herein, the term "recover" relates to a contraction of a stretched material upon termination of a biasing force following stretching of the material by application of the biasing force. For example, if a material having a relaxed, unbiased length of one (1) inch were elongated 50% by stretching to a length of one and one-half (1.5) inches, the material would have been elongated 50% and would have a stretched length that is 150% of its relaxed length. If this exemplary stretched material contracted, that is, recovered to a length of one and one-tenth (1.1) inches after release of the biasing and stretching force, the material would have recovered 80 percent (0.4 inch) of its elongation.

The term "microfibers" is used herein to refer to small diameter fibers having an average diameter not greater than about 200 microns, preferably having diameters in the range from about 0.5 micron to about 50 microns, more preferably having an average diameter of from about 4 microns to about 40 microns. Microfibers may be melt-blown by extruding a molten thermoplastic material through a plurality of small diameter, usually circular die capillaries as molten threads and attenuating the molten threads by application of a high velocity gas, usually air, stream to reduce their diameter to be within the range stated above.

As used herein, the term "spun-bonded microfibers" refers to small diameter fibers having a diameter not greater than about 100 microns, preferably having a diameter of from about 10 microns to about 50 microns, more preferably having a diameter of from about 12 microns to about 30 microns, and which are made by extruding a molten thermoplastic material as filaments through a plurality of fine usually circular capillaries of a spinnerette with the diameter of the extruded filaments then being rapidly reduced as by, for example, eductive drawing or other well-known spun-bonding mechanisms. The product of spun-bonded nonwoven webs is illustrated in U.S. Pat. No. 4,340,563 to Appel, and the disclosure of this patent is hereby incorporated by reference.

As used herein, the term "nonwoven web" means a web of material which has been formed without the use of a weaving process. A nonwoven web has a structure of individual fibers or threads which are interlaid, but not in an identifiable, repeating manner. Nonwoven webs in the past have been formed by a variety of processes such as, for example, melt-blowing processes, spun-bonding processes, film aperturing processes, and staple fiber carding processes. These nonwoven webs generally have an average basis weight of not more than about 300 grams per square meter. Preferably, the nonwoven webs have an average basis weight of from about 15 grams per square meter to about 100 grams per square meter. More preferably, for many applications, the nonwoven webs have an average basis weight of from about 15 grams per square meter to about 75 grams per square meter.

Unless specifically set forth and defined or otherwise limited, the terms "polymer" or "polymer resin" as used herein generally include, but are not limited to, homopolymers, copolymers, such as, for example, block, graft, random and alternating copolymers, terpolymers, etc., and blends and modifications thereof. Furthermore, unless otherwise specifically limited, the terms "polymer" or "polymer resin" shall include all possible geometrical, i.e., stereo, configurations of the material. These configurations include, but are not limited to, isotactic, syndiotactic and random symmetries.

As used herein, the term "consisting essentially of" does not exclude the presence of additional materials which do not significantly affect the elastic properties and characteristics of a given polymeric composition. Exemplary materials of this sort would include, without limitation, pigments, antioxidants, stabilizers, surfactants, waxes, flow promoters, solid solvents, particulates and materials added to enhance processability of the composition.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view in elevation illustrating one mode of carrying out the laminating process of the present invention, for that embodiment of the invention that is concerned with the production of a trilaminar composite where both face or cover webs are gathered in the composite product;

FIG. 2 is a schematic plan view with parts broken away of one embodiment of a composite elastic material in accordance with the present invention, shown in a stretched condition; and

FIG. 2A is a section view along line A—A of FIG. 2, but with the composite elastic material in a relaxed condition relative to its condition in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The composite elastic materials of the invention generally comprise at least one layer or web of elastic material comprising a copolymer, bonded to one or more other facing or cover layers of nonwoven material.

Elastic webs suitable for use in the invention include both elastic nonwoven fibrous webs such as, for example, melt-blown elastomeric fibrous webs. Such fibrous webs usually comprise microfibers. In fact, nonwoven webs of melt-blown microfibers constitute a preferred embodiment. The fibrous elastic web may also comprise a composite material in that it may be comprised of two or more individual coherent, self-bonded webs or it may comprise one or more webs that individually are elastic.

The conforming technique is one that is well-known in the trade. Conforming involves the incorporation of a secondary fiber into a primary fiber and the formation of a nonwoven web in which both fibers are substantially uniformly distributed. The secondary fiber may be incorporated in the web simply through mechanical entanglement, or the process may have been such that the secondary fibers were applied to the primary fibers while the primary fibers were tacky and adherent. In the latter case, the secondary fibers are bonded in place. In many cases, the secondary fibers will be held in place in the nonwoven web by a combination of adhesive bonding and mechanical entanglement.

One conforming technique is disclosed in U.S. Pat. No. 4,100,324 issued July 11, 1978 to Richard A. Anderson et al., and assigned to the assignee of this application. That patent discloses a nonwoven material comprised of a mixture of melt-blown thermoplastic and other fibers which are combined in the gas stream, in which the melt-blown fibers are borne so that an intimate, entangled co-mingling of thermoplastic melt-blown fibers and other fibers, e.g., wood pulp or staple natural or staple artificial fibers, occurs prior to collection of the fibers upon a collecting device to form a coherent web of randomly dispersed fibers. The disclosure of U.S. Pat. No. 4,100,324 is also incorporated by reference herein.

Broadly, the kind of resin that is useful and preferred for making melt-blown elastomeric fibers in accordance with the present invention that, upon collection as an entangled mass, form an elastomeric fibrous nonwoven web useful as the elastic web, is a copolymer of ethylene and at least one other vinyl monomer that is selected from the group consisting of vinyl ester monomers, unsaturated aliphatic monocarboxylic acids, and alkyl esters of such monocarboxylic acids, where the amount of monomer in the copolymer, other than the ethylene, is sufficient to impart elasticity to a cohesive nonwoven web formed from these melt-blown fibers.

Examples of such copolymer resins include copolymers of the following materials with ethylene, that can be melt-blown by being subjected to an effective combination of elevated temperature and elevated pressure conditions, and extruded to form microfibers that can be collected to form elastomeric nonwoven coherent webs. Among these are the copolymers of ethylene with acrylic acid, vinyl acetate, ethyl acrylic acid, ethyl ethacrylate, methacrylic acid, methyl acrylate, ethyl acrylate, ethyl methacrylate, methyl methacrylate, and the like. The amount of the secondary monomer present should be, in percentages by weight based on the copolymer, at least 10% by weight, up to about 50% by weight of the secondary monomer. It is theorized that one of the functions of the secondary monomer is to provide side groups that are pendant from the polyethylene backbone, and that impart elasticity, perhaps by disrupting the otherwise crystalline nature of the polymer.

Other characterizing features of the secondary monomer and copolymer are also important, as will be illustrated with reference to the preferred embodiment, which is a copolymer of ethylene and vinyl acetate.

The preferred copolymer embodiment, that of ethylene and vinyl acetate, has a melt index in the range from 32 to 300, preferably 32 to 300, at 190° C., and comprises from 10% by weight to about 50%, preferably 18% by weight to 36% by weight, and more preferably 26% by weight to 30% by weight of vinyl acetate. Generally, as

the content of vinyl acetate in the copolymer increases, the following characteristics of a nonwoven coherent web formed from copolymer microfibers increase: flexibility, toughness, adhesion, and what can be referred to as bondability or sealability, meaning the readiness with which the web can be heat-sealed to an adjacent web, as by calendering. As the melt index decreases, the viscosity during the melt-blowing process (which takes place at an elevated temperature) increases. Many other characteristics of the web can be expected to improve, however, as the melt index of the copolymer at 190° C. decreases, such as toughness, tear strength, and seal strength, referring again to the strength of a heat bond to an adjacent web or to itself.

Preferred elastic webs for use in the practice of the invention are generally those formed from melt-blown microfibers made from an extrudate consisting essentially of ethylene-vinyl acetate copolymer characterized by a melt index at 190° C. in the range from about 32 to about 300 and containing from about 18% by weight to about 30% by weight of vinyl acetate. However, for some applications where properties other than those exhibited by webs consisting essentially of ethylene-vinyl acetate microfibers are desired, a modifying polymer may be added to the copolymer resin to form a blend that is mixed to make it uniform, and then passed into the extruder during the melt-blowing process. Satisfactory blends are ordinarily achieved by simply mixing pellets of the copolymer with pellets of the modifying polymer, until a uniform mixture of pellets has been attained. Suitable modifying polymers include polyethylene, polypropylene, polybutene, polystyrene, copolymers and mixtures of these, and an A-B-A' block copolymer, where A and A' are each a thermoplastic polymer endblock that includes a styrenic moiety and where B is an elastomeric poly(ethylene-butene) mid-block.

The preferred modifying polymers are the polyolefins, particularly polyethylene, polypropylene, random copolymers of ethylene and of propylene, and mixtures of polyethylene and polypropylene. However, the preferred polyolefin materials also include polybutene, and as well, ethylene copolymers, propylene copolymers, and butene copolymers. Blends of two or more of the polyolefins may be utilized.

A particularly preferred polyethylene for use as a modifying polymer is a linear low density (LLD) polyethylene sold by Exxon Chemical Company under the designation LPK 61. It has a density of about 0.930 gram per cubic centimeter measured in accordance with ASTM D 1505, a number average molecular weight (M_n) of about 10,500, a weight average molecular weight (M_w) of about 30,500, a Z average molecular weight (M_z) of about 62,000, and a polydispersity (M_w/M_n) of about 2.9.

Another commercial polyethylene resin that is expected to be suitable for use as the modifying polymer is obtainable from U.S.I. Chemical Company under the trade designation Petrothene Na601, also referred to as PE Na601 or Na601. Information obtained from U.S.I. Chemical Company states that the Na601 is a low molecular weight, low density polyethylene for application in the areas of hot-melt adhesives and coatings. U.S.I. has also stated that the Na601 has the following nominal values: (1) a Brookfield Viscosity, cP at 150° C. of 8,500 and at 190° C. of 3,300 when measured in accordance with ASTM D 3236; (2) a density of 0.903 gram per cubic centimeter when measured in accordance

100

with ASTM D 1505; (3) an equivalent melt index of 2,000 grams per 10 minutes when measured in accordance with ASTM D 1238; (4) a ring and ball softening point of 102° C. when measured in accordance with ASTM E 28; (5) a tensile of 850 pounds per square inch when measured in accordance with ASTM D 638; (6) an elongation of 90% when measured in accordance with ASTM D 638; (7) a modulus of rigidity, T_r (45,000) of -34° C., and (8) a penetration hardness (tenths of mm) at 77° F. of 3.6.

Na601 polyethylene is believed to have a number average molecular weight (M_n) of about 4,600; a weight average molecular weight (M_w) of about 22,400 and a Z average molecular weight (M_z) of about 83,300. The polydispersity (M_w/M_n) of the Na601 is about 4.87.

A preferred polypropylene for use as the modifying polymer is a product of Exxon Chemical Company that is sold under the designation, Polypropylene 3143. It has a density of about 0.910 gram per cubic centimeter when measured in accordance with ASTM D 792. It has a melt flow rate, obtained in accordance with ASTM D 1238, Condition L, of about 300 grams per 10 minutes. It has a number average molecular weight (M_n) of about 43,580, a weight average molecular weight (M_w) of about 124,400, a Z average molecular weight (M_z) of about 255,600, and a polydispersity (M_w/M_n) of about 2.85.

Another commercially available polypropylene that is expected to be suitable for use as the modifying polymer is available from The Himont Corporation under the trade designation PC-973.

Typical characteristics of the Himont PC-973 polypropylene, as stated by Himont, include a density of about 0.900 gram per cubic centimeter measured in accordance with ASTM D 792 and a melt flow rate obtained in accordance with ASTM D 1238, Condition L, of about 35 grams per 10 minutes. Other characteristics of the PC-973 are a tensile strength of about 4,300 pounds per square inch (psi) measured in accordance with ASTM D 638; a flex modulus of about 182,000 psi measured in accordance with ASTM D 790B and a Rockwell hardness, R scale, of about 93 measured in accordance with ASTM D 785A. The PC-973 is believed to have a number average molecular weight (M_n) of about 40,100, a weight average molecular weight (M_w) of about 172,000 and a Z average weight (M_z) of about 674,000. The polydispersity (M_w/M_n) of the PC-973 is about 4.29.

Another group of modifying polymeric materials that may be used are the KRATON block copolymers developed by Shell Chemical Company. These are generally ABA' type block polymers. They are generally typified by relatively high viscosity, and for that reason may be useful in connection with copolymers made of ethylene and vinyl acetate having high melt index numbers and correspondingly low viscosities at the die head in the melt-blowing process.

A representative KRATON block copolymer might well be one of the S-EB-S type, standing for polystyrene/poly(ethylene-butylene)/polystyrene. Such block copolymers are available under the trademark KRATON G, for example KRATON G 1650, KRATON G 1652, and KRATON GX 1657, from Shell Chemical Company. KRATON rubber materials are described in detail in a number of Shell Chemical Company publications including one designated SC: 198-83, 7/83 5M. KRATON G 1650 rubber has a weight ratio of polystyrene A and A' endblocks to poly(ethylene-

butylene) B midblocks of 28:72; for KRATON G 1652 rubber the weight ratio is 29:71, and for KRATON GX 1657 the weight ratio is 14:86. For example, with respect to the KRATON GX 1657 the sum of the molecular weight of A with the molecular weight of A' is 14% of the molecular weight of the A-B-A' block copolymer.

These block copolymers are not believed to contain plasticizer oils, although they are commercially available in compounded form. The G 1650 and G 1652 block copolymers are available in crumb form and have a specific gravity of 0.91 and a Shore A hardness of 73. The GX 1657 block copolymer is available in pellet form, has a specific gravity of 0.90 and a Shore A hardness of 65. KRATON G materials are considered to be satisfactory as modifying polymers.

Other elastomeric resins which may be suitable as modifying polymers in forming the elastomeric webs of the present invention are A-B-A' block copolymers where A and A' are polystyrene endblocks, as defined above, and B is a polybutadiene midblock.

This material is sometimes referred to as an S-B-S block copolymer and is also available from Shell Chemical Company, under the trade designation KRATON D; for example, KRATON D 1101; KRATON D 1102, and KRATON D 1116. According to the Shell Chemical Company publications noted above, KRATON D 1101 rubber has a weight ratio of polystyrene A and A' endblocks to the polybutadiene B midblock of 31:69; for KRATON D 1102 rubber the weight ratio is 28:72; for KRATON D 1116 rubber it is 21:79. For example, with respect to the KRATON D 1116 material the sum of the molecular weight of A with the molecular weight of A' is 21% of the molecular weight of the A-B-A' block copolymer. These block copolymers are available as porous pellets, have a specific gravity of 0.94 and a Shore A hardness of 71 for the D 1101 and D 1102 block copolymers and 65 for the D 1116 block copolymer.

Another S-B-S block copolymer material is commercially available under the trade designation Solprene 418 from the Phillips Petroleum Company.

Yet other elastomeric resins which are considered to be useful as modifying polymers for the copolymers used in forming the elastomeric web of the present invention are A-B-A' block copolymers where A and A' are polystyrene endblocks, as defined above, and B is a polyisoprene midblock.

These block copolymers are sometimes referred to as S-I-S block copolymers and are also available from the Shell Chemical Company under the trade designation KRATON D, for example, KRATON D 1107, KRATON D 1111, KRATON D 1112, and KRATON D 1117. The KRATON D 2207, D 1111, D 1112 and D 1117 block copolymers have respective weight ratios of polystyrene A and A' endblocks to the B midblock of 14:86 (D 1107); 21:79 (D 1111); 14:86 (D 1112), and 17:83 (D 1117). For example, with respect to the KRATON D 1117, the sum of the molecular weight of A with the molecular weight of A' is 17% of the molecular weight of the A-B-A' block copolymer. The D 1111 grade is available as a porous pellet having a specific gravity of 0.93 and a Shore A hardness of 52.

Further, the S-EB-S block copolymers, when used as modifying polymers, may be blended with polyolefins, e.g., polyethylene and/or polypropylene. The polyolefin which is utilized in blending the S-EB-S block copolymers must be one which, when blended with the S-EB-S block copolymer, and the copoly-

101

mer made of ethylene with vinyl acetate, and subjected to an appropriate combination of elevated pressure and elevated temperature conditions, is extrudable in blended form with the block copolymer.

Whether the elastic web comprises a fibrous elastic web, such as, for example, a nonwoven web of melt-blown fibers, or a web of melt-blown primary fibers containing other secondary fibers or particulates which were incorporated into the web during its formation by, for example, utilization of the teachings disclosed in U.S. Pat. No. 4,100,324, it should have sufficient elasticity and be bondable to the facing web or webs of the composite structure of the invention with sufficient strength to form a composite material which may be stretched slightly. The composite should thus provide a desired degree of elasticity.

Although some of the elastomeric EVA microfibers may be somewhat tacky, they do not generally exhibit a high degree of adhesion to many materials, unless heated to the softening point. Accordingly, heat or other types of conventional bonding techniques should preferably be utilized when such webs are to be utilized in forming composites in accordance with the present invention.

It will be appreciated that a degree of elasticity is one important consideration in forming composite fabrics such as those of the present invention, particularly when such composites are to be utilized in garments which are designed to conform to the body of the wearer. For example, in the manufacture of disposable diapers a degree of elasticity of the fabric will assist in conforming it to the body contours of the wearer. Further, it is often desired that the composite material should have a soft hand and feel so it is therefore desirable that the bonding of the elastic web to the other web or webs of the laminate be done without the provision of an adhesive which would tend to make the resultant composite stiff.

Because the elastic web may be bonded to a nonelastic material, by which is meant generally any suitable material which lacks the characteristics of an elastic as defined above, the nonelastic material tends to have a limiting effect on the degree of stretch of the elastic web. In the case of the embodiment of the invention where the elastic web is bonded, while in stretched condition, to two gatherable facing webs, one on each side of the elastic web, the gatherable webs may have some limiting effect on both the extent of stretch and on the degree of recovery of the elastic web in its composite form.

For example, if the elastic web is stretched to an elongation of 100 percent, i.e., to twice its relaxed length, and then bonded to a gatherable nonelastic web such as a nonwoven polyolefin fiber web, upon release of the stretching force action on the composite web, the nonelastic web tends to prevent the elastic web from retracting fully to its original length. This requires that the elastic limit of the elastic web be greater than the desired minimum elastic limit of the composite material.

For example, if it is desired to prepare a composite material stretchable to 100% elongation, a 100 cm length of elastic web may be stretched to a length of, for example, 220 cm (120% elongation) and bonded at spaced-apart locations to a 220 cm length of nonelastic material. The bonded composite elastic material is then allowed to relax and even if the elastic web is capable of recovering to its original 100 cm length, the nonelastic web bonded thereto will inhibit full recovery and the

composite may relax to a length of, say, 100 cm. Pickers or gathers will form in the gatherable web between the bond points. The resulting 100 cm length of composite material is stretchable to its 220 cm length to provide a 120% elongatable composite material. The original length of the nonelastic web limits, in this hypothetical example, the attainable elongation of the composite material because the nonelastic web would act as a "stop" to prevent further or excessive stretching of the elastic web under the effect of stretching forces which are less than the failure strength of the nonelastic gathered web.

The elastic web may be bonded to the facing web, which may be a gatherable web, by any suitable means, such as, for example, thermal bonding or ultrasonic welding, which will so join at least portions of at least one of the webs, usually the elastic web, because the elastomeric materials used for forming the elastic web have lower softening points than many of the materials commonly employed to form the facing webs. Of course, in the case where the facing web is formed from a woven material such as, for example, cotton or a polyester-cotton blend, the woven fabric may have no softening point at all, or none within a practical range, so that for either thermal bonding or ultrasonic welding the bonding process must depend upon the characteristics of the elastic web. Thus, effectuating the bonding by applying heat and pressure to the overlaid elastic and facing webs will soften at least portions of the elastic web by heating these portions (or the entire elastic web) to at least its softening temperature and applying sufficient pressure to form a reasonably strong and permanent bond between the resolidified softened portions of the elastic web and the gatherable web.

One difficulty with such bonding of nonwoven elastomeric webs is that the low basis weight of such webs renders them susceptible to losing their ability to contract to their pretensioned, that is, prestretched, dimension if they are subjected, even briefly, to being heated while stretched and allowed to cool in the stretched condition. For example, the elastic nonwoven webs of the present invention may have a basis weight ranging from about 15 grams per square meter to about 300 grams per square meter, preferably from about 15 grams per square meter to about 200 grams per square meter, for example from about 15 grams per square meter to about 100 grams per square meter. Although low basis weight elastic webs are preferred largely for economic reasons, particularly for use in disposable articles, the elastic webs may have basis weights considerably higher than 300 gm/m², for example, up to about 750 gm/m² or even higher.

A distinct advantage of the present invention is the ability to attain the elastic characteristics in the composite web by bonding a low basis weight, highly elastic web to a facing web, which may be a gatherable nonelastic material that may be of greater tensile strength than the elastic web. In the case of a laminate or a trilaminate made by passing the elastic web and either one or two facing layers of spun-bonded or melt-blown fibers formed into a nonwoven, essentially nonelastic web, bonding can be accomplished simply by passing the laminae together through a pair of rolls, at least one of which may be heated. In the case where the elastic web is stretched and then spot-bonded at spaced locations to the elastic web, immediate relaxation of the composite and then of the elastic web after the bonding step allows the elastic web to contract and then cool

while relaxed, enabling it to gather the gatherable web so that the composite web possesses elastic properties without rupturing the gatherable webs because the gatherable webs are able to extend and retract with the elastic web as a result of the presence of the gathers.

The tensile strength of the finished composite web is in most cases largely determined by the usually stronger nonelastic facing web or webs. Naturally, in the case where the facing web or webs are gathered, the elastic web must be sufficiently strong to enable it to gather the gatherable web or webs to which it is bonded and, generally, the stiffer the gatherable web or webs are, the stronger must be the recovering force of the elastic web or webs.

As used herein and in the claims, a "gatherable" web is one which can be gathered into pleats, loops or the like by contraction of the elastic web or webs bonded to it.

One or more elastic webs may be heat-bonded to one or more gatherable webs, for example, essentially nonelastic nonwoven webs, by the application of heat and pressure by passing the overlaid webs, with the elastic web being in a stretched, flat or elongated condition, through the nip of a bonder arrangement. At least one of the rolls of the bonder arrangement should be heated to impart the requisite bonding temperature to at least the bond sites of one or more of the webs to be bonded. In many cases, the elastic web or webs have softening temperatures which are lower than those of the gatherable web or webs to which the elastic web(s) are to be bonded and, consequently, the elastic web(s) may be the only web(s) which are significantly softened in the bonding step. In other cases, the gatherable web(s) may similarly be softened. Accordingly, the elastic web(s), or the gatherable web(s), or both, are thus heated to above the softening temperature of the elastic web, at least at the bond sites therebetween.

The heat for bonding the laminate in making a composite may be applied by the rolls of the bonder arrangement or by another heat source such as a heat source positioned just ahead of the bonder arrangement. However, excellent bonding and an attractive pattern and texture of the composite elastic material are attained by utilizing pattern bonding in which the overlaid elastic and facing web or webs are passed through the nip of a bonder arrangement comprising an anvil roll and a calendar roll having a repeating embossing pattern formed thereon. The anvil roll may be smooth or may contain a pattern such as one which is the complementary negative of a positive pattern on the calendar roll and one or both of the calendar and anvil rolls may be heated. One skilled in the art will appreciate that the temperature to which the webs or at least the bond sites are heated will depend not only on the temperature of the heated roll(s) or other heat source but on the residence time of the webs on the heated roll(s) or adjacent the other heat source, the contact pressure, the bulk weights of the webs and their specific heats and thermal conductivities. For a given combination of webs, the processing conditions necessary to effectuate satisfactory bonding can readily be determined by one skilled in the art.

As to the bonding pressure utilized in cases where the bonding is effectuated by passing the overlaid webs through the pressure nip of a bonder arrangement having a pair of rolls which form a nip, specification of the overall pressure loading along the nip does not, in itself, take into account complicating factors such as the ef-

fects of pressure roll construction, e.g., roll diameters, materials, and embossing patterns, if any, on the nip width and pressure distribution through the nip. Nonetheless, one skilled in the art, taking into account the overall pressure loading along the nip, the materials of construction of the pressure rolls, the pressure roll diameters and the geometry of embossing patterns, if any, on the rolls, will readily be able to select an effective bonding pressure.

Generally, in the case where two nonwoven facing webs are bonded on each side of an elastic web, the bonding will take place over the complete surface area of each of the two surfaces of the elastic web, that is, no embossing pattern will be used. However, for some purposes, especially, for example, for garments where warmth is a consideration and trapped air between layers is useful, an embossing pattern of bonding may be desirable.

The facing webs preferably are formed from spun-bonded or melt-blown polymeric materials. Among the preferred polymeric materials are spun-bonded or melt-blown nonwoven webs made of LLD polyethylene, high density polyethylene, polypropylene, or a random copolymer of ethylene and propylene. Generally, spun-bonded fibers will be used where greater strength is needed, and melt-blown fibers are often used where strength is not as important as some other characteristic, such as softness.

When the facing web or webs of the composite are a gatherable web or webs to which one or more of the elastic webs are bonded, each gatherable web may be elastic or, more usually, may comprise one or more nonelastic webs. Generally, elastic fibrous webs have a rubbery feel and in applications where the feel of the composite material is of importance, a nonelastic web such as a bonded carded nonelastic polyester fiber web, or nonelastic spun-bonded polypropylene fiber nonwoven web, a spun-bonded nonelastic polyester or polyethylene nonelastic fiber web, nonelastic cellulosic fiber webs, e.g., cotton fiber webs, polyamide fiber webs, e.g., nylon 6-6 webs sold under the trademark Cerec by Monsanto, and blends of two or more of the foregoing, may be utilized.

The production of spun-bonded nonwoven webs is illustrated in U.S. Pat. No. 4,340,563, issued July 20, 1982 to David W. Appel et al., the disclosure of which has been incorporated by reference herein. Generally, in the spun-bonding process a thermoplastic material is extruded through a spinnerette and extrusion-drawn into filaments to form a coherent web of randomly deposited filaments on a collecting or forming surface.

Generally, woven and nonwoven webs of any textile or other material may be used in forming the facing web or webs.

Relatively inexpensive and attractive composite fabrics with good hand and feel have been attained by bonding to one or both sides of an elastic web made from microfibers of ethylene-vinyl acetate copolymer, a spun-bonded polypropylene fiber web, and single- and multi-layer combinations thereof. Satisfactory results have been attained by pattern-bonding the webs together under heat and pressure to provide a composite material with excellent characteristics and uniform and attractive appearance.

Referring now to FIG. 1 of the drawings, there is schematically illustrated a continuous manufacturing process for heat-bonding gatherable webs, which may be nonelastic webs, to each of the two opposite sides of

a stretched elastic web. An elastic web which may comprise a fibrous nonwoven elastic web or elastic film 4 is unwound from a supply roll 2 of such fibrous elastic material and, traveling in the direction indicated by the arrows associated therewith, passes through the nip of an S roll arrangement 5, comprised of stacked rollers 6 and 8, in the reverse-S path indicated by the rotation direction arrows associated with the stacked rollers 6 and 8. From the S roll arrangement, the web 4 passes into the pressure nip of a bonder roll arrangement 9, which is comprised of a patterned calendar roll 10 and a smooth anvil roll 12.

A first gatherable web 16 is unwound from a supply roll 14 and a second gatherable web 20 is unwound from a supply roll 18. The first web 16 and the second web 20 travel in the direction indicated by the arrows associated therewith as the supply rolls 14 and 18 rotate in the directions indicated by the respective arrows associated therewith. The fibrous elastic web 4 is stretched to a desired percent elongation between the S roll arrangement 5 and the pressure nip of the bonder roll arrangement 9. By virtue of the fact that the peripheral linear speed of the rollers 6 and 8 of the S roll arrangement 5 is considered less than the peripheral linear speed of the rolls 10 and 12 of the bonder roll arrangement 9, the web 4 is therefore stretched to a selected percent elongation thereof and maintained in such elongated condition during heat-bonding of the webs 16 and 20 to the web 4 in the bonder roll arrangement 9.

One or both of the patterned calendar roll 10 and the smooth anvil roll 12 may be heated and the pressure between these two rolls may be adjusted to provide the desired temperature and bonding pressure to bond the webs 16 and 20 to the stretched elastic web 4 and form the composite elastic material 22.

The composite elastic material 22, upon emerging from the pressure nip of the bonder roll arrangement 9, immediately undergoes a physical change as the elastic web 4 recovers and contracts as it tends to resume its original length. As it contracts, it gathers the attached gatherable webs 16 and 20. The relaxed (or relaxed) composite passes to a holding box 24 wherein it is maintained in its relaxed, contracted state for a length of time sufficient for the fibrous elastic web 4 to cool sufficiently to avoid cooling while it is in a stretched condition (and thereby losing all or a considerable proportion of its ability to contract from the stretched dimensions which it had assumed during bonding).

It has been found that elastic webs, in particular low basis weight elastic webs such as nonwoven fibrous elastic webs, will lose their ability to contract to or return to their original unstretched dimensions if they are maintained under tension at or above their softening temperature for any significant length of time. A brief recovery period in a relaxed, untensioned condition immediately after bonding has been found to be essential to allow the low basis weight elastic web to contract and gather the gatherable webs so that the bonded composite web attains its elasticity.

After a brief untensioned recovery period of, for example, up to about 30 seconds, e.g., about 3 to 20 seconds, in the holding box 24, the composite elastic material 22 is withdrawn and wound on a storage roll (not shown). The provision of the holding box 24 or equivalent means allows the untensioned heat-bonded composite elastic material to stabilize while it is untensioned.

The successful heat-bonding of an elastic web to one or more nonelastic webs requires that the temperature of the elastic web be raised at least to its softening point and preferably somewhat higher than its softening point. With the elastic webs that are disclosed in this application as being useful in connection with the invention, the softening point has no single fixed value because blends may be used as well as unblended copolymer resins. Generally, however, a temperature of about 65° C. is sufficient for softening of the elastic web sufficiently to cause it to become bonded to a confronting, adjacent web, under the pressure that is applied during passage between the bonder rolls or between the calendar roll 10 and the anvil roll 12. If a modifying polymer is present in the elastic web, and has a substantially higher melting point than the copolymer, then it is a simple matter to adjust the temperature applied to raise it sufficiently to obtain adequate bonding. Generally, good heat bonding is obtained at temperatures somewhat above the softening point of the elastic web, and temperatures approaching the melting point may be used in some cases.

Thus, where the calendar roll 10 is embossed so as to impose a pattern on the composite, and the temperature and pressure are sufficiently great that the fine fibers of the elastic web are softened to the extent that they may be melted and may be forced from the areas of the elastic web which are compressed by the raised portions of the embossing pattern, a pattern of fine holes may be produced in the elastic web. If the temperature and pressure of embossing are not such that the fine holes are formed, the elastic web will usually be, as a result of its softening during embossing, indented in the area of embossing. In cases where holes are present in the elastic web, the peripheries of the holes in the elastic web appear to be formed of resolidified or otherwise condensed portions of the material of the elastic web, and these portions normally are well bonded to the facing web or webs.

With reference to FIGS. 2 and 2A there is shown (schematically and not necessarily to scale, including relative thicknesses of the layers and size of the embossed areas or indentations 30) a composite material 22' made by passing overhain webs 16', 4', and 20', respectively, through the pressure nip between the calendar roll 10 and the anvil roll 12. The composite material 22' shown is comprised of a first gatherable web 16' and a second gatherable web 20' heat-bonded to the respective opposite sides of a fibrous elastic web 4'. The bond sites are spaced apart, resulting in gathers or pleats 16a and 20a (FIG. 2A) being formed in the gatherable webs 16' and 20' when the composite material 22' is in a relaxed condition as shown in FIG. 2A. The gathers 16a and 20a are not shown in FIG. 2 in order that the drawing be suggestive of the appearance of the composite material 22' in its stretched condition. The fibrous elastic web 4' has a plurality of embossed areas 26 formed therein corresponding to the raised portions of a repeating square- or diamond-shaped embossing pattern on the calendar roll 10.

The peripheral portions 28 of the indentations 30 of the web 4' illustrated in FIG. 2A include a resolidified portion of the material which was formerly located in the indented area 30 of the fibrous elastic web 4'. The peripheral portions 28, upon resolidification after softening or melting in the pressure nip of the calendar roll 10 and anvil roll 12, tend to form a strong bond with the overhain gatherable webs 16' and 20'. In examining sam-

ples of the elastic composite, the indentations 30 become visible only after peeling away one of the gatherable webs 16' or 28'. In several situations, peeling away of one or more of the gatherable webs revealed that holes had been formed through the elastic web in the embossed areas 26. However, it is possible that a thin layer in a highly indented area of the elastic web 4', within the area of the hole, was stripped away with the gatherable web upon the peeling away of the gatherable web from the elastic web. That is, the holes may have been formed as a result of the stripping-away step as opposed to the embossing step. Particularly with heavier basis weight elastic webs, the embossing may result in a waffle-like pattern in which indentations as opposed to holes are present in the elastic web.

The preferred kind of elastic web for use in the present invention is a coherent nonwoven elastic web formed of elastomeric microfibers in accordance with my copending patent application entitled "Ethylene-Vinyl Copolymers And Methods For Their Formation Into Elastomeric Fibrous Products", U.S. Ser. No. 25,557, filed 3-13-67. That application, which is incorporated herein by reference, describes the production of melt-blown microfibers and coherent nonwoven webs made from these microfibers. The microfibers are formed from certain copolymers and blends of these copolymers with one or more modifying polymers that adjust viscosity or other microfiber properties, or nonwoven web properties.

The useful copolymers disclosed in my copending application are those of ethylene with at least one other vinyl monomer selected from the group consisting of vinyl ester monomers and unsaturated aliphatic monocarboxylic acids and alkyl esters of these monocarboxylic acids, where the amount of monomer other than ethylene in the copolymer is sufficient to impart elasticity to a coherent nonwoven web formed from the melt-blown fibers. The preferred copolymers are those made of ethylene and vinyl acetate (EVA) having a melt index in the range from 32 to 50 (preferably 300) at 190° C. and comprising from 10% by weight to 50% by weight, and preferably 18% by weight to 36% by weight, of vinyl acetate.

The EVA copolymer is preferably used as is, unmodified, to develop the greatest amount of elasticity in the plastic web. However it may be formed with another polymeric material, to produce an extrudable blend that can be melt-blown to form microfibers of desired properties and characteristics. Thus, an extrudable composition can be prepared from at least about 10% by weight, and preferably 50% by weight or more, of the copolymer made of ethylene and at least one other vinyl monomer as described above, and at least one different modifying polymer. The modifying polymer must be compatible, that is, it and the copolymer must have similar rheological behavior, they must form a homogeneous melt, and after being blown into fibers and solidifying, must form a homogeneous solid product. Such a modifying polymer may be used in an amount greater than 60 0% by weight up to about 50% by weight, but preferably not in excess of 50% by weight, of the melt-blown fibers. The blend is prepared simply by blending pellets of the copolymer and of the modifying polymer, mixing them, and then subjecting the mixture to an effective 65 combination of elevated temperature and elevated pressure conditions, extruding and melt-blowing to form microfibers.

Whether the microfibers for the elastic web are made from unblended copolymer or from a copolymer blended with one or more modifying polymers, the microfibers are susceptible to coforming. While a variety of different coforming techniques are known, one suitable process is that disclosed in U.S. Pat. No. 3,939,421, which is incorporated herein by reference. In an example of such coforming, wood pulp fibers are blown into the melt-blown fibers while the melt-blown fibers remain tacky or molten. The wood pulp fibers become incorporated into the microfibers, and in the nonwoven web that is formed from the collected microfibers, the wood pulp fibers are substantially uniformly distributed. They impart to the elastic nonwoven coherent web their own properties of absorbency and bulk. They also represent an inexpensive component relative to the polymeric components.

Copolymers of ethylene with vinyl acetate that are characterized by a relatively low melt index have relatively high viscosities, and the converse is true, that is, an EVA copolymer having a melt index of 300 at 190° C. may have an extremely low viscosity to the point where it is very difficult to process. There are two ways to ameliorate this situation and improve processability. One way is to blend the EVA copolymer with a modifying polymer that increases viscosity without destroying elastomeric characteristics. The other way is to limit such high melt index polymers to those having a vinyl acetate content not in excess of about 33% by weight.

Where a modifying polymer is used, it is preferably selected from the group consisting of the polymers of ethylene, propylene, butene, styrene, and copolymers and compatible mixtures of these polymers and copolymers, and ABA' block copolymers, where A and A' are each independently a thermoplastic endblock that includes a styrenic moiety and where B is an elastomeric poly(ethylene-butene) midblock.

Webs formed from microfibers of such materials are tactically acceptable, soft, and cloth-like elastomeric nonwoven fabrics. In one preferred embodiment, the microfibers are formed from an extrudable composition that is a mixture of a copolymer made of ethylene and vinyl acetate, along with one or more modifying polyolefins, in minor amount. The polyolefin or polyolefins modify the blend, so that a web of such material is tactically acceptable, and at the same time, the polyolefin or polyolefins may be present in an amount that does not adversely affect the strength and stretch properties.

Ordinarily, microfibers made from the copolymer or copolymer blends described above may be sufficiently tacky when collected, and in such entangled form, that a coherent web is readily formed. Generally, however, tensile strength is improved simply by running the web through the nip of a pair of rolls, to compress the web. The compression may increase the frictional resistance to movement of the microfibers relative to each other in the web, and thus increase its tensile strength.

Generally, these coherent nonwoven elastomeric webs that are made in accordance with my copending application, and that are useful in the context of the present invention, are those where the microfibers have an average diameter of not greater than about 100 microns, and preferably less than 20 microns, and where the nonwoven webs have an average basis weight of not more than about 300 grams per square meter, and preferably less. Thus, an average basis weight of from about one ounce per square yard to about 10 ounces per square yard is often preferred, depending upon the end

105

was intended for the composite made from the elastomeric web.

When the elastic web is made substantially entirely from a copolymer of ethylene with vinyl acetate in accordance with the preferred embodiment of the invention, that is, from such a copolymer having a melt index in the range from 32 to about 300 at 190° C. and comprising from 10% by weight to about 50% by weight of vinyl acetate, and from microfibers formed predominantly from such a copolymer and collected as a coherent nonwoven elastomeric web, that web ordinarily will possess the requisite elasticity for use in "gatherable" facing web embodiment of the present invention. When the elastic web is formed from a blend of a suitable copolymer in connection with a modifying polymer, the requisite elasticity of the web is one of the factors that must be kept in mind in formulating the blend. Preferably, the EVA copolymer should amount to at least 50% or more by weight of the web in order to impart desirable elasticity. The remainder of the weight of the web may be taken up by a modifying polymer or by one or more secondary fibers.

Leaving aside for present purposes the secondary fibers, as to the polymeric materials in a blend from which the elastic web is formed, the modifying polymer ordinarily will contribute an amount not greater than about 50% by weight, and preferably not greater than about 40% by weight, of the web. When a secondary conforming fiber is to be used, generally it will not be present in an amount in excess of about 55% by weight of the elastic web, and preferably less, and care must be taken in selecting the polymeric material from which the web is made, to achieve the requisite elasticity.

The invention is useful in the production of soft, cloth-like materials that are suitable, for example, as body side covers for diapers, health care, tissue, and industrial products. In preferred embodiments, the cloth-like material is a composite made up as a laminate of one or two gatherable layers from spun-bonded polyolefin fibers that have been formed into coherent nonwoven fibrous webs. Preferred polyolefins for this purpose are polyethylene and polypropylene. Composites prepared in this way possess such properties as strength, drape, and stretch.

Composites in accordance with the invention may also be made from coherent nonwoven webs formed from melt-blown polyolefin fibers that are used as the facing webs. Since polypropylene structures tend to be stiffer than those containing polyethylene, where drape and hand are important, the facing webs ordinarily will be made from polyethylene or from polyethylene blended with a small amount of another polyolefin such as, for example, polypropylene. Where other composite characteristics such as strength and stiffness are important, then the facing webs may be made from spun-bonded or melt-blown polypropylene. Nonwoven webs formed from high density polyethylene, and from random copolymers of ethylene and propylene, are also useful.

A composite made from two gatherable webs that are coherent, nonwoven, nonelastic webs formed from melt-blown or spun-bonded polyethylene fibers, heat-bonded to each side of a coherent nonwoven elastic web formed from a suitable EVA copolymer, provides good cloth-like tactile acceptability and is superior in terms of drape, softness, and strength, to composites generally available.

The following composites, reported in tabular fashion in Table I, have been made. In this table, the composites described were formed from one elastic web, intercalated between two coherent nonwoven webs of spun-bonded fibers. The figures in the table represent percentages by weight of the elastic web for the respective materials. The abbreviations used in the table are as follows:

PE=polyethylene
EVA=ethylene-vinyl acetate copolymer
PP=polypropylene
Pulp=wood pulp fiber
SB=spun-bonded fiber
MB=melt-blown microfibers

TABLE I

Intercalate Nonwoven Spun-Bonded Facing Web	Intercalary Elastic Web	Intercalate Nonwoven Spun-Bonded Facing Web
PE	EVA	PE
PE	50 EVA - 50 PE	PE
PE	70 EVA - 30 PE	PE
PE	70 EVA - 30 PE - Pulp	PE
PE	75 EVA - 25 PE	PE
PE	80 EVA - 20 PP	PE
PE	60 EVA - 40 PP	PE
PE	65 EVA - 35 Pulp	PE
PE	45 EVA - 55 Pulp	PE
PE	EVA	PP
PE	45 EVA - 55 Pulp	PP
PE	85 EVA - 15 Pulp	PP
PE	50 EVA - 50 PE	PP
PE	75 EVA - 25 PE	PP
PE	45 EVA - 55 Pulp	PP
PP	65 EVA - 35 Pulp	PP
PP	50 EVA - 50 PE	PP
PP	75 EVA - 25 PE	PP
PP/PE	60 EVA - 40 PP	PP/PE
PP/PE	80 EVA - 20 PP	PP/PE
PP/PE	EVA	PP/PE

Each of these composites was soft and cloth-like. Each composite possessed desirable properties of strength, drape and stretch. Each appeared to be an excellent material for use in fabricating diapers, tissues, particularly high wet strength tissues, health care products, and disposable protective drapes and clothing for use, for example, in the operating room. Each of these composites exhibited good absorbency for both oil and water, and the composites made with an elastic web including conforming wood fiber pulp had particularly high absorbency. Generally, the presence of one or more polypropylene facing webs imparted some stiffness, while those composites made with an elastic web having a very high content of ethylene-vinyl acetate copolymer and nonwoven polyethylene fiber facing webs tended to exhibit cloth-like softness as well as good drape and strength.

The EVA copolymer used in forming the trilaminates described above was a commercially available product sold by Exxon Chemical Company under the trademark and grade designation, M-11948-077-004. This resin had a nominal melt index of 200 at 190° C., and an actual melt index of about 160. Its density was 0.930 grams per cc, and the vinyl acetate content was 28.0% by weight.

Similar good results can be expected to be obtained from the use of other EVA copolymers in the production of the nonwoven intercalary web. Preferred EVA copolymers include those having a nominal melt index in the range from 50 to 200 at 190° C., with a vinyl acetate content of 18% by weight to 36% by weight.

Also preferred are those EVA copolymers having a nominal melt index in the range from 150 to 200 at 190° C., with a vinyl acetate content in the range from 26% by weight to 30% by weight.

The polyethylene and polypropylene resins that are employed in producing the facing webs can readily be selected by those skilled in the art from among many that are available commercially. A preferred polyethylene resin is that previously identified and sold by Exxon Chemical Company under the designation LFX 61. A preferred polypropylene resin, also sold by Exxon Chemical Company, carries the designation Polypropylene 3415. It also has been previously described.

In a further demonstration of the invention, two trilaminate composites were prepared. The intercalary layer was a nonwoven web of an EVA copolymer having a nominal melt index of 200 at 190° C. and a vinyl acetate content of 28% by weight. The two facing sheets were nonwoven webs of melt-blown polypropylene. The polypropylene was the Exxon product previously described, designated as Polypropylene 3145.

The three nonwoven webs were drawn off supply rolls, placed in juxtaposition, and passed through the nip of a calendar roll that was heated sufficiently to cause enough softening of the intercalary layer so that upon discharge from the calendar roll and cooling, the three nonwoven webs were bonded together in face-to-face relationship. The properties of the composites produced in this way are summarized below, the two different runs being designated as Runs A and B in Table II below:

TABLE II

	Trilaminate Composites	
	PP/EVA/PP	
	Run A	Run B
Basis weight, oz./yd. ²	0.58	0.47
Bulk, inches	0.015	0.009
Qual. B.		
MD	0.9	1.0
CD	1.2	1.0
Peak Energy, in. lb.	1.1	0.96
	1.3	1.2
Porosity, ft ³ /min./ft. ²	295	277
Peak Stress, lb.		
MD	68	53
CD	66	59
Tens. B.		
MD	0.24	0.21
CD	0.28	0.22
Aluminum		
H ₂ O, %	321	409
Oil, %	574	864

These composites had properties of value in several applications, for example, in protective covers, diapers, and upholstery fabrics. The absorbency of both oil and water was good, indicating promise for the health care area.

The particular temperature and pressure applied at the nip to unite the laminates will depend upon the characteristics of the facing sheets as well as of the intercalary layer. Representative temperature and pressure for a typical bond set would be about 125° F. and 30 psig.

Other trilaminate composites that have been prepared are summarized in tabular form in Table III below. The EVA intercalary layer functions as an adhesive as well as an elastic layer in these composites.

TABLE III

Other Composites

1. SB PP/MB EVA
2. SB PE/MB EVA 44 oz./yd. ² /SP PE
3. SB PP/MB EVA 44 oz./yd. ² /SB PE
4. SB PE/MB 90 EVA/10 PE 2 oz./yd. ² /SB PE
5. SB PP/MB 90 EVA/10 PE 1 oz./yd. ² /SB PE
6. SB PE/MB 70 EVA/30 PE/SB PE
7. SB PE/MB 70 EVA/30 PE/SB PE plus pulp
8. SB PE/MB 90 EVA/20 PP/SB PE

Specimen 1 in Table III is a dilaminate composite. The remaining specimens are trilaminate composites. In this table, the abbreviation "SB" refers to the fact that the nonwoven web used as the facing sheet was formed from spun-bonded fiber. The abbreviation "MB" used for the intercalary layer refers to the fact that the nonwoven intercalary web was a nonwoven web of melt-blown microfibers. The resins used in making the composites in Table III are identified by abbreviations as "PP", "PE", or "EVA". The "PP" abbreviation refers to Exxon Chemical's Polypropylene 3415. The "PE" abbreviation refers to Exxon Chemical's Polyethylene designated as LFX 61. These two polyolefin resins were previously described in detail. The "EVA" abbreviation refers to another product of Exxon Chemical, a poly(ethylene-vinyl acetate) having a nominal melt index of 200 at 190° C. and a vinyl acetate content of 28% by weight. In specimens 4 through 8 inclusive, the intercalary layer microfibers were formed from a blend of the EVA resin with a polyolefin modifying resin. The numerals in Table III represent the respective percentages by weight in the blend. The basis weight for the intercalary layer is reported in specimens 2 through 5 inclusive.

In specimen 7, a conformed intercalary layer was used, where wood pulp fibers were conformed with the resin blend microfibers. The percentage by weight of wood pulp was not recorded.

These composites have properties that indicate potential applications in the health care area, for the fabrication of disposable diapers, for infant care products, and in connection with carpet and upholstery adhesive backing. The fact that these composites can be made from a spectrum of different intercalary layers and facing sheets, each having its own individual characteristics, makes them exceptionally useful in tailoring properties to particular applications. For example, for a disposable diaper, the facing sheet intended to be in contact with the skin could be made from spun-bonded or melt-blown polyethylene microfibers. However, the facing sheet intended to be in contact with the air, and possessing somewhat more stiffness, abrasion resistance, and strength, could well be formed from spun-bonded polypropylene fibers.

Other similar composites can be made up. Preferably, the facing sheets are formed from polyethylene, polypropylene, blends of these polyolefins, or from a random copolymer of propylene with ethylene. Such random copolymers are currently commercially available with ethylene contents in the range from about 3% by weight to about 5% by weight. However, ethylene contents of up to about 7% by weight are feasible, and the random copolymers produced from this kind of blend are expected to be useful in making spun-bonded fiber facing sheets.

Generally, composites that are trilaminates can be fabricated to have great commercial utility. Such

107

trilaminates composites may be designated, for convenience, as "SMS" composites. The "SMS" abbreviation refers to the fact that the preferred composites are formed with an intercalary layer formed of melt-blown microfibers in the form of a nonwoven web, and the two facing sheets are nonwoven webs of spun-bonded fibers. Generally, the intercalary layer will be formed from an unblended poly(ethylene-vinyl acetate), or from a blend of poly(ethylene-vinyl acetate) with polyethylene, polypropylene, a blend of these, or a random copolymer of ethylene and propylene of the kind previously described. For many possible applications, it is expected that an intercalary layer would be preferred that is made from a nonwoven web of microfibers melt-blown from a blend of 60% by weight of poly(ethylene-vinyl acetate) together with 40% by weight of a modifying polymer that is a polyolefin of the kind mentioned above.

For certain health care applications, a particular kind of composite seems to have great promise. In hospitals, peeling gowns and sterile wraps must be treated to be alcohol-repellent. Ordinarily this treatment is carried out by applying a fluorocarbon in solution in hexanol. With an SMS composite, where the intercalary layer has a high content of poly(ethylene-vinyl acetate), the composite may not accept the treatment. It has been found that a composite, that may be designated as an "SMS" composite will accept the treatment. Such a composite has, for the intercalary layer, three separately fabricated but united nonwoven webs made of melt-blown microfibers.

An SMS composite preferably is made on a single machine where five different nonwoven webs can be fabricated successively, one on top of the other. The first such web is a spun-bonded web. The second, third and fourth nonwoven webs are formed from melt-blown microfibers. The fifth web is another facing sheet, and is made from a spun-bonded nonwoven web.

A preferred SMS composite is one where the two facing sheets are formed from spun-bonded polyolefin fibers. The polyolefin may be, for example, high density polyethylene, low density polyethylene, polypropylene, blends of these materials, or a random copolymer of propylene with 3% by weight to 7% by weight of ethylene. Ordinarily, such random copolymers are formed by a gas phase polymerization.

The three melt-blown nonwoven webs can be designated, for convenience in description, as webs 2, 3 and 4, respectively. Webs 2 and 4 may be melt-blown from a polyolefin. The polyolefin is preferably polypropylene, but may be polyethylene, blends of polyethylene and polypropylene, or a random copolymer of propylene with 3% by weight to 7% by weight of ethylene. Web 3 is preferably formed from unblended poly(ethylene-vinyl acetate). This EVA copolymer preferably has a nominal melt index of 30 to 500 at 190° C., with a vinyl acetate content of 10% by weight to 50% by weight. A more preferred EVA copolymer is one where the melt index is in the range from 32 to 300. For ease in processing, the nominal melt index is from 50 to 200 at 190° C., with a vinyl acetate content of 18% by weight to 34% by weight. More preferably, the nominal melt index is in the range from 150 to 200 at 190° C., with a vinyl acetate content of 26% by weight to 30% by weight.

While an EVA copolymer is preferred for Web 3, it is possible to use a blend. Also, other ethylene-based copolymers may be used. Thus, the copolymer of Web

3 may be a copolymer of ethylene and at least one other vinyl monomer selected from the group consisting of vinyl ester monomers and unsaturated aliphatic monocarboxylic acids and alkyl esters of aliphatic monocarboxylic acids, wherein the amount of monomer other than the ethylene in the copolymer is sufficient to impart elasticity to microfibers produced by melt-blowing the copolymer.

While the SMS configuration has properties that make it suitable for a particular purpose, other composite configurations are within the scope of the invention and are contemplated. Generally, the facing sheets will be formed from spun-bonded polyolefin fibers for the properties that nonwoven webs of such fibers provide. However, one or more melt-blown nonwoven webs, or even combinations of melt-blown and spun-bonded nonwoven fiber webs, may be formed for interposition between the facing sheets to develop particular properties. Ideally, such composites would be formed by the in-line, sequential production of the nonwoven webs. Thus, a conveyor belt might be disposed beneath fiber-producing stations that would produce the first web as a facing sheet, then either spun-bonded or melt-blown webs respectively, as many as desired, in sequence, and finally, another facing sheet. These random webs, formed one on top of the other, could be carried by the conveyor belt directly to bonder rolls, for the application of heat and pressure, to unite the several nonwoven webs to form a unitary composite in which the webs are bonded together in face-to-face relation.

However, it would be equally feasible to form the nonwoven webs separately, and then combine them. Economics and the availability of suitable equipment will determine which production technique appears to be the more feasible. The nonwoven webs that are used in such multiple-layer composites can be formed either from single resins, from blends of two resins, from tri-blends, or from an even greater number of different resins where special properties are desired. Other SMS composites that are contemplated employ different combinations of nonwoven webs. Some exemplary combinations of the SMS composites are tabulated in Table IV below. The entries in this table are for Webs 2, 3 and 4 only, it being understood that the facing sheets ordinarily (although not necessarily) are formed from spun-bonded polyolefin fibers.

TABLE IV

Specimen	SMS Composite		
	Web 2	Web 3	Web 4
1	PE	EVA	PE
2	PE	EVA	PP
3	PP	EVA	PP
4	PP/PE	EVA	PP/PE
5	PP/EVA	EVA	PP/EVA
6	PE/EVA	EVA	PE/EVA
7	PP/EVA	EVA	PP/EVA

The abbreviations in this table correspond to those previously used to represent the same materials.

Web 3 ordinarily will be formed from melt-blown microfibers. Webs 2 and 4 may be formed from either melt-blown or spun-bonded fibers, depending upon the needs of a particular application.

These laminates ordinarily are united by passing them through the nip of a bonder set at a temperature of 150° F. to 200° F. and at a pressure of 15 psig to 30 psig. These conditions are exemplary only, and other temperatures and pressures needed for bonding particular com-

posures can easily be developed by those skilled in the art.

Exemplary STMS composites have been made up using combinations such as those of Table IV above. In some of these demonstrations of the invention, the spun-bonded facing sheets had basis weights of 0.4 ounces per square yard, and 0.8 ounces per square yard. The basis weights for Webs 2, 3 and 4 may be adjusted as desired for particular purposes but may be, for example, in ounces per square yard: 1, 0.75, 0.5, and 0.25.

The invention will be further exemplified by a description of six composites that were made up in accordance with the invention, together with a report on the properties of these composites. Each composite was a trilaminate made in the manner discussed above. In each case, the nonwoven elastic web was formed from melt-blown microfibers of poly(ethylene-vinyl acetate). The ethylene-vinyl acetate copolymer employed had a nominal melt index of 200 at 190° C. and contained 28% by weight of vinyl acetate. The nonwoven elastic web formed from the copolymer microfibers was stretched, then bonded at spaced locations relative to each other, on each of its opposite faces, to a nonwoven inelastic web. The elastic web was then relaxed, whereupon the outer laminas were gathered.

As indicated in Table V below, the inelastic nonwoven web in each case was formed of fibers of polypropylene. As shown in Table V, the inelastic webs were either formed from spun-bonded polypropylene, melt-blown polypropylene, or of polypropylene fibers formed into a bonded carded web.

The six stretchable composites that were made up had the following compositions:

TABLE V

Stretchable Composites		
Nonwoven Elastic Web of Melt-Blown Microfibers of Poly (Ethylene-Vinyl Acetate)	Elastic Web Basis Wt., g/m ²	Nonwoven Inelastic Web Laminas Stretched to Opposite Faces of the Elastic Web
Specimen		
1	80	SB ¹ PP ²
2	100	SB PP
3	80	SB PP
4	80	MB ³ PP
5	80	(BW 25 g/m ²) BCW ⁴ of PP
6	80	MB PP (BW 15 g/m ²)

¹ spun-bonded polypropylene
² melt-blown polypropylene
³ bonded carded web

Each of these composites was subjected to a series of tests to evaluate the properties of the composite. Before describing the test results, the test protocols will be described. In reporting the results of these tests, at least five observations were made and the values averaged, to obtain the values reported in the tables below.

Drape Stiffness

This test in accordance with FTMS 191 Method 5206 is intended to determine the bonding length and flexural rigidity of a fabric by employing the principle of cantilevered bending of the fabric under its own weight. The value is expressed in centimeters of one-half of the overhang while the fabric is inclined at 41.5 degrees. The lower the value the more drape or less stiff and thus presumably the softer the material is to the hand. Exemplary materials had a drape stiffness as low as 1.87 centi-

eters in the machine direction. Drape preferably should not exceed 4 cm in either direction, to provide a good subjective hand.

Tensile Strength

Grab tensile strength and elongation measured in accordance with FTMS 191A Method 5100 is a measure of breaking strength and stretch of a fabric when subjected to unidirectional stress. Values for grab tensile and grab stretch are obtained using a specified width of fabric, clamp width and constant rate of extension. The sample is wider than the clamp to give results representative of effective strength of fibers in the clamped width combined with additional strength contributed by adjacent fibers in the fabric. This closely simulates fabric stress conditions in actual use. Results are expressed as pounds to break and percent of stretch to break. Total energy can also be expressed as well as energy to break. High numbers indicate strong or stretchable fabric. Minimum acceptable grab tensile peak load is 5 lbs. in either the machine direction, MD, or in the cross direction, CD.

Trap tear as measured in accordance with FTMS 191A Method 5136 is a measure of the force required to propagate a tear across a fabric under constant rate of extension. A specified width of fabric cut on one edge is clamped along the non-parallel sides of a trapezoidal shape drawn on the sample. The same rates of pull as the grab method above are followed. A minimum trap tear peak strength is 3 lbs. in either MD or CD.

The results of these tests on specimens 1-6 inclusive were:

TABLE VI

Specimen No.	Dir.	Drape Stiffness (cm)	Grab Tensile	Grab Tensile	Trap Tear 5 Peaks (lbs)	Trap Tear 1st High (lbs)
			Peak Load (lbs)	Peak Elong. (%)		
1	MD	2.15	17.10	123.17	3.68	7.98
2	MD	1.87	17.22	129.69	4.99	7.31
3	MD	2.08	14.90	117.78	3.60	6.01
4	MD	2.15	9.83	99.99	3.51	3.58
5	MD	2.02	18.51	181.68	9.25	9.57
6	MD	1.80	7.44	83.83	2.72	3.88

TABLE VII

Specimen No.	Dir.	Drape Stiffness (cm)	Grab Tensile	Grab Tensile	Trap Tear 5 Peaks (lbs)	Trap Tear 1st High (lbs)
			Peak Load (lbs)	Peak Elong. (%)		
1	CD	1.85	18.37	59.19	7.65	7.73
2	CD	1.88	19.50	61.34	9.01	9.28
3	CD	1.98	16.79	53.63	8.19	8.19
4	CD	4.00	7.70	66.62	1.83	2.34
5	CD	3.15	7.39	162.69	3.24	3.76
6	CD	1.68	6.64	77.57	2.55	2.51

The six specimens were further evaluated in terms of thickness or fullness by the Ames bulk test.

Ames Bulk

Bulk is a measure of thickness or fullness. Subjectively, high bulk provides a good hand or cloth-like feel. Ames bulk is a measure of fabric thickness in centimeters, although reported in Table V below in inches. A high bulk fabric feels somewhat cushioned to the touch, and for many applications is desirable. High bulk con-

blended with light weight and good absorbency is particularly important for diapers and similar personal or health care items. For this reason, the absorbency and rate data were determined for both water and oil for the six specimens. The relevant data is reported below in Table VIII except for water rate, which exceeded 60 seconds in every case.

Absorbency

Capacity and rate data for both water and oil give an indication of the absorbency of the materials. The capacity is the amount of liquid absorbed relative to the weight of the material. The rate is the amount of time required for the material to absorb a given amount of liquid. The minimum amount of time allowed is sixty seconds. Preferred minimums for oil and water capacity are 400% and 150, respectively.

TABLE VIII

Specimen No.	Composite Bulk Weight (Gms)	Absorbent Bulk (in)	Water Capacity (%)	Oil Capacity (%)	Oil Rate (Sec)
1	148.04	0.072	176	394	1.70
2	145.57	0.076	133	402	1.30
3	130.57	0.070	151	433	1.58
4	138.69	0.078	153	306	1.70
5	126.67	0.080	277	430	1.32
6	137.03	0.082	139	474	1.67

The six specimens prepared and evaluated have properties that render them eminently suitable for use in a variety of garments including undergarments, menstrual and incontinence control articles, and garments such as disposal diapers and the like.

To further exemplify the invention, a series of tests may be run in which gatherable webs of different materials are heat-bonded to a nonwoven elastic web comprising melt-blown microfibers of a blend of 90 parts by weight of a copolymer made of ethylene and vinyl acetate having a nominal melt index of 190 at 190° C. and a vinyl acetate content of 28% by weight, with 10 parts by weight of linear low density polyethylene, such as the LPX 61 polyethylene described above.

The runs may be carried out in apparatus of the type schematically illustrated in FIG. 1 comprising a bonder arrangement (corresponding to 9 in FIG. 1) having a 14 inch (35.6 cm) wide bonding surface provided by a nominal 7 inch (17.8 cm) diameter, smooth stainless steel anvil roller (corresponding to 12 in FIG. 1) and a nominal 7 inch (17.8 cm) diameter stainless steel calendar roller (corresponding to 10 in FIG. 1) having thereon a raised diamond embossing pattern comprising of squares both diagonally aligned and diagonally oriented relative to the machine direction of the web. The embossing pattern may be comprised of lands raised 0.09 inch (0.229 cm) above the roller base surface, each land being a square having sides 1/16 of an inch (0.159 cm) long with the facing sides of adjacent squares being 1/2 of an inch (0.318 cm) apart as measured perpendicularly to and between adjacent sides.

The calendar and anvil rollers may be independently oil-heated, with an 8 roll (corresponding to 5 in FIG. 1) and suitable feed rolls (corresponding to 2, 14 and 16 in FIG. 1) to feed the webs to the bonder roll at controlled speeds. When composite elastic materials are made in which only one side of the fibrous elastic web is heat-bonded to a gatherable web, the supply roll corresponding to supply roll 18 of FIG. 1 may be eliminated so that the gatherable web passes over the embossing calendar

roll 10 and the fibrous elastic web passes over the smooth anvil roll 12 as illustrated in the schematic representation of FIG. 1. Both the embossing calendar roll 10 and smooth anvil roll 12 may be heated to the temperatures indicated below. The net force urging the anvil roll 12 and the calendar roll 10 toward each other in the runs described below should be, preferably, on the order of about 3,400 pounds (1,542 Kg) plus or minus about 10%. The elastic web width may be about 12 inches (30.5 cm) wide before elongation and can be expected to be from about 10 1/4 inches (26.7 cm) wide at about 25% elongation to about 7 inches (17.8 cm) wide at about 350% elongation.

A series of runs may be carried out to produce composite elastic materials having elongations of approximately 25%, 50%, 75% and 100% before failing. "Failure" is defined as occurring at the "ultimate elongation" of a composite material, which is the elongation at which the material tears or otherwise fails. Elongation may be tested in an Instron testing device.

For this testing purpose, a 2 inch by 5 inch rectangle of the material should be cut with the 5 inch long sides being substantially parallel to the machine direction of the web of composite material from which the sample is cut. The 2 inch sides are then clamped in the jaws of a properly calibrated Instron testing device. It is then attempted to elongate each sample in two stages, with one minute's rest between stages, to elongations of 50% and then 100%, after which the sample is relaxed to zero elongation. If the sample fails during either of these two stages, the percent elongation at failure is the "ultimate elongation". If the sample does not fail during either of these two stages, then after being relaxed to zero elongation, it is stretched at 10 feet per minute until it fails, the percent elongation at break or tear being the "ultimate elongation".

The desired or target elongation of 25%, 50%, etc., of the composite elastic material should not be confused with the definition given above of an elastic material as one which is in itself (not the composite) capable of at least 25% elongation and a stated degree of recovery. The stiffness, basis weight and bonding pattern of the gatherable web or webs bonded to the elastic web or webs in a composite material can be controlled in order to affect (reduce) the degree of elongation of the composite material. For example, composite materials of considerably less than 100% elongation are often desired for certain end uses.

Representative composite elastic materials for such testing purposes may be made by utilizing a fibrous elastic web of the same 90 EVA copolymer-10 polyethylene LPX 61 blend described above, and bonding to each side of the fibrous elastic web either a 22 grams per square yard poly(ethylene terephthalate) bonded carded web material made by Carolina Formed Fabrics or a one ounce per square yard spun-bonded poly(ethylene terephthalate) fiber web sold by E. I. du Pont de Nemours and Company under the registered trademark REEMAY. The elasticity observations expected would be in the range from about 25% to about 300% elongation.

The necessity of allowing the composite web to relax immediately after bonding can be demonstrated by two comparative test runs, in which similar conditions are maintained except for the omission of the relaxation step in one run. For these two runs, a 22 grams per square yard thermally-bonded poly(ethylene terephthalate)

fiber nonwoven web may be bonded to each side of a nonwoven fibrous web of fibers of the same 90 EVA copolymer-10 polyethylene LPK 61 blend described above, and having a basis weight such as, for example, 60 to 85 g/m².

In one of these two comparative runs, the bonded composite material should be maintained under tension after the bonding step by winding it directly onto a storage roll as the composite material emerges from the bonder rolls, without allowing it to relax. With respect to FIG. 1, the resultant composite web can be expected to have substantially no non-destructive elasticity because its elastic web component, as a result of the fact that the elastic web should have been wound up on the storage roll while in an elongated, tensioned condition, before cooling, and therefore can be expected to have lost its ability to contract and thus form gathers in the gatherable webs. By "non-destructive elasticity" is meant that the composite could be stretched to the desired extent, and then allowed to contract, without rupturing the gatherable webs.

In the second of these two comparative runs, the composite is allowed to run freely off the bonder rolls and the elastic web therefore contracts, forming gathers in the nonelastic web and providing an attractive, elastic composite web. This composite can be expected to be readily stretchable.

The bond strengths of composites made in accordance with the invention are easily measured. For this purpose it is convenient to express the bond strength as the force in grams that is required to peel away a three-inch wide strip of gatherable web from the elastic web to which it has been bonded. One way to make the measurement is as follows. After a composite has been made by bonding a bonded carded web of a polyester fiber on each of the two opposite surfaces of a coherent elastic web made of melt-blown microfibers of a 90/10 blend of EVA copolymer with polyethylene LPK 61 with the polyester webs gathered on the opposite sides of the stretched but relaxed elastic web, specimens may be taken for testing purposes. For example, several specimens may be cut that are three inches wide in the cross-machine direction and seven inches long in the machine direction.

For test purposes, three such specimens may be separated or delaminated in part. Thus, one of the polyester webs may be separated for a distance of approximately one inch along the machine direction of the specimen, and placed in one jaw of an Instron tester. The other two laminas or layers are placed in the opposite jaw of the tester. The tester is then set to move the jaws apart, in such fashion as to exert a force tending to separate the partly separated polyester layer from the partial composites of the elastic web and other polyester layer. The setting may be such, for example, as to move the jaws apart at a rate of about 10 inches or 25.4 cm per minute. It is advisable to take an average of several readings, that is, values obtained with several different specimens, to obtain a representative average value. The value obtained from the test is a force in grams per three inch width of specimen as required to delaminate the one polyester web from the remaining two layers of the composite. A similar test can be run on the other side, to determine if there is any substantial difference in delamination forces required between the two sides (there usually is). Representative values would generally be in the range from about 30 grams to about 300 grams per

three inch strip, and more generally from about 75 grams to about 200 grams per three inch strip.

CONCLUSION

Composite gathered elastic materials of the invention are utilizable generally in any article calling for an elastic material such as, but not limited to, stretchable protective covers and wraps, outerwear, undergarments, menstrual and incontinence control articles and garments such as disposable diapers, and the like. Their low cost relative to woven or knitted fabrics permits economic adaptations to "disposable" articles, by which is meant articles intended to be disposed of, rather than laundered and reused, after one or a few uses.

This application is closely related to but represents the disclosure of an improvement over the subject matter of the commonly assigned patent application of Jack D. Taylor and Michael J. Vander Wielen, entitled "Composite Elastomeric Material and Process for Making the Same", U.S. Ser. No. 760,437, filed July 30, 1985 now U.S. Pat. No. 4,720,415. The disclosure of that application is incorporated herein.

The subject matter of this application is also closely related to that of my own copending patent application, entitled "Ethylene-Vinyl Copolymers And Methods For Their Formation Into Elastomeric Fibrous Products", U.S. Ser. No. 25,557, filed Mar. 13, 1987, now U.S. Pat. No. 4,803,117, the subject matter of which is also incorporated herein by reference.

While the invention has been disclosed in this patent application by reference to the details of preferred embodiments of the invention, it is to be understood that this disclosure is intended in an illustrative rather than in a limiting sense, as it is contemplated that modifications will readily occur to those skilled in the art, within the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. An elastic composite material comprising at least one elastic web joined at spaced-apart locations to at least one gatherable web, said gatherable web being gathered between said spaced-apart locations, said elastic web comprising a copolymer made of ethylene and from about 10% by weight to about 30% by weight of at least one other vinyl monomer selected from the group consisting of vinyl ester monomers and unsaturated aliphatic monocarboxylic acids and alkyl esters of said monocarboxylic acids.

2. The composite material of claim 1, said composite being made by:

- (a) tensioning said elastic web to elongate it;
 - (b) bonding said elastic web to at least one gatherable web under conditions that soften at least portions of said elastic web, to form a bonded composite web, and
 - (c) relaxing said composite web immediately after the bonding step whereby said elongated elastic web can contract and the gatherable web is gathered to form said composite elastic material;
- wherein said elastic web further comprises at least 10% by weight of said web of said copolymer and from greater than 0% by weight up to about 90% by weight of at least one other compatible modifying polymer that, when blended with said copolymer and subjected to an effective combination of elevated temperature and elevated pressure conditions, is adapted to be extruded, in blended form, with said copolymer.

3. The composite material of claim 2 wherein said modifying polymer is selected from the group including polyethylene, polypropylene, polybutene, polystyrene, copolymers and mixtures of these, and an ABA' block copolymer, where A and A' are each a thermoplastic polymer endblock that includes a styrene moiety and where B is an elastomeric poly(ethylene-butene) midblock, and mixtures thereof.

4. The composite material of claim 3 wherein said copolymer is present in an amount sufficient to impart elasticity to a coherent web formed by collecting melt-blown fibers of said composition.

5. The composite material of claim 2 wherein said modifying polymer comprises at least one polymer selected from the group consisting of ethylene, propylene, polybutene, ethylene copolymers, propylene copolymers, and butene copolymers.

6. The composite material of claim 5 wherein said modifying polymer comprises a blend of two or more polymers selected from the group consisting of polyethylene, polypropylene, polybutene, ethylene copolymers, propylene copolymers, and butene copolymers.

7. The composite material of claim 5 wherein said modifying polymer comprises polyethylene.

8. The composite material of claim 5 wherein said modifying polymer comprises polypropylene.

9. The composite material of claim 5 wherein said modifying polymer is polybutene.

10. The composite material of claim 5 wherein said modifying polymer is an isobutylene-butene copolymer.

11. The composite material of claim 1 wherein said elastic web comprises a nonwoven coherent web of melt-blown microfibers.

12. The composite material of claim 5 wherein said elastic web comprises a nonwoven coherent web of melt-blown microfibers.

13. An elastic composite material comprising at least one elastic web joined at spaced-apart locations to at least one gatherable web, said gatherable web being gathered between said spaced-apart locations, said elastic web comprising poly(ethylene-vinyl acetate) having a nominal melt index in the range from 30 to 200 at 190° C. and comprising from 18% by weight to about 36% by weight of vinyl acetate, said composite material being made by

- (a) tensioning said elastic web to elongate it;
- (b) bonding said elastic web to at least one gatherable web under conditions that soften portions of said elastic web at locations that are spaced from each other, to form a bonded composite web, and
- (c) relaxing said composite web immediately after the bonding step whereby said elongated elastic web contract and the gatherable web is gathered to form said composite elastic material.

14. The composite material of claim 13 wherein said elastic web comprises a nonwoven coherent web of melt-blown microfibers.

15. The composite material of claim 14 further comprising secondary fibers intermixed with said melt-blown microfibers.

16. The composite material of claim 14 wherein said melt-blown microfibers are in the form of a nonwoven coherent web that exhibits the ability to be stretched to at least 150% of the web length as formed.

17. The composite material of claim 14 wherein said nonwoven elastomeric web comprises

- (a) microfibers comprising poly(ethylene-vinyl acetate) having a nominal melt index in the range from

32 to 300 at 190° C. and comprising from 18% by weight to about 36% by weight of vinyl acetate; and

- (b) from greater than 0% by weight to about 80% by weight of at least one different secondary fiber that is generally uniformly distributed throughout said nonwoven web.

18. The composite material of claim 17 wherein said secondary fiber comprises a fibrous material selected from the group consisting of wood pulp fiber, staple natural fiber, staple artificial fiber, and mixtures thereof.

19. The composite material of claim 14 wherein said melt-blown fibers are formed from a blend of said poly(ethylene-vinyl acetate) with from greater than 0% by weight up to about 90% by weight of said fibers of at least one other compatible modifying polymer which, when blended with said copolymer and subjected to an effective combination of elevated temperature and elevated pressure conditions, is adapted to be extruded, in blended form, with said copolymer.

20. The composite material of claim 19 wherein said modifying polymer is selected from the group including polyethylene, polypropylene, polybutene, polystyrene, copolymers and mixtures of these, and an ABA' block copolymer, where A and A' are each independently a thermoplastic polymer endblock that includes a styrene moiety and where B is an elastomeric poly(ethylene-butene) midblock, and mixtures thereof.

21. The composite material of claim 20 wherein said modifying polymer comprises at least one polymer selected from the group consisting of polyethylene, polypropylene, polybutene, ethylene copolymers, propylene copolymers, and butene copolymers.

22. The composite material of claim 21 wherein said modifying polymer comprises a blend of two or more polymers selected from the group consisting of polyethylene, polypropylene, polybutene, ethylene copolymers, propylene copolymers, and butene copolymers.

23. The composite material of claim 14 wherein said elastic web is bonded to the gatherable web at a plurality of spaced-apart locations in a repeating pattern and wherein the gatherable web is gathered between said bonded locations.

24. The composite material of claim 14 wherein said elastic web has a basis weight of up to about 300 grams per square meter.

25. The composite material of claim 13 wherein said gatherable web is a nonwoven coherent nonelastic material and is formed from an interlaced web of fibers selected from the group consisting of polyester fibers, polyolefin fibers, polyamide fibers, cellulosic fibers, and mixtures of two or more thereof.

26. The composite material of claim 25 wherein said gatherable web comprises spun-bonded or melt-blown fibers of polyethylene, polypropylene, a random copolymer of ethylene and propylene, and blends thereof.

27. An elastic composite material comprising at least one elastic web joined at spaced-apart locations to at least one gatherable web, said gatherable web being gathered between said spaced-apart locations, said elastic web comprising poly(ethylene-vinyl acetate) comprising from about 10% by weight to about 50% by weight of vinyl acetate.

28. The composite material of claim 27 wherein said elastic web comprises a nonwoven coherent web of melt-blown microfibers.

112

29. The composite material of claim 28 further comprising secondary fibers intermixed with said melt-blown microfibers.

30. The composite material of claim 28 wherein said melt-blown microfibers are in the form of a nonwoven coherent web that exhibits the ability to be stretched to at least 150 percent of the web length formed.

31. The composite material of claim 28 wherein said nonwoven elastomeric web comprises

- (a) microfibers comprising poly(ethylene-vinyl acetate) having a nominal melt index in the range from 32 to 300 at 190° C. and comprising from 10% by weight to about 50% by weight by weight of vinyl acetate; and
- (b) from greater than 0% by weight to about 80% by weight of at least one different secondary fiber that is generally uniformly distributed throughout said nonwoven web.

32. The composite material of claim 31 wherein said secondary fiber comprises a fibrous material selected from the group consisting of wood pulp fiber, staple natural fiber, staple artificial fiber, and mixtures thereof.

33. The composite material of claim 28 wherein said melt-blown fibers are formed from a blend of said poly(ethylene-vinyl acetate) with from greater than 0% by weight up to about 90% by weight of said fibers of at least one other compatible modifying polymer which, when blended with said copolymer and subjected to an effective combination of elevated temperature and elevated pressure conditions, is adapted to be extruded, in blended form, with said copolymer.

34. The composite material of claim 33 wherein said modifying polymer is selected from the group including polyethylene, polypropylene, polybutene, polystyrene, copolymers and mixtures of these, and an ABA' block copolymer, where A and A' are each independently a thermoplastic polymer endblock that includes a styrenic moiety and where B is an elastomeric poly(ethylenebutene) midblock, and mixtures thereof.

35. The composite material of claim 34 wherein said modifying polymer comprises a blend of two or more polymers selected from the group consisting of polyethylene, polypropylene, polybutene, ethylene copolymers, propylene copolymers, and butene copolymers.

36. The composite material of claim 28 wherein said elastic web has a basis weight of up to about 300 grams per square meter.

37. The composite material of claim 27 wherein said gatherable web is a nonwoven coherent nonelastic material and is formed from an interlaced web of fibers selected from the group consisting of polyester fibers, polyolefin fibers, polyamide fibers, cellulosic fibers, and mixtures of two or more thereof.

38. The composite material of claim 37 wherein said gatherable web comprises spun-bonded or melt-blown fibers of polyethylene, polypropylene, a random copolymer of ethylene and propylene, and blends thereof.

39. An elastic composite material comprising at least one elastic web joined at spaced-apart locations to at least one gatherable web, said gatherable web being gathered between said spaced-apart locations, said elastic web comprising poly(ethylene-vinyl acetate) comprising from about 18% by weight to about 36% by weight of vinyl acetate.

40. The composite material of claim 39 wherein said elastic web comprises a nonwoven coherent web of melt-blown microfibers.

41. The composite material of claim 40 further comprising secondary fibers intermixed with said melt-blown microfibers.

42. The composite material of claim 40 wherein said melt-blown microfibers are in the form of a nonwoven coherent web that exhibits the ability to be stretched to at least 150 percent of the web length formed.

43. The composite material of claim 40 wherein said nonwoven elastomeric web comprises

- (a) microfibers comprising poly(ethylene-vinyl acetate) having a nominal melt index in the range from 32 to 300 at 190° C. and comprising from 18% by weight to about 36% by weight by weight of vinyl acetate; and
- (b) from greater than 0% by weight to about 80% by weight of at least one different secondary fiber that is generally uniformly distributed throughout said nonwoven web.

44. The composite material of claim 43 wherein said secondary fiber comprises a fibrous material selected from the group consisting of wood pulp fiber, staple natural fiber, staple artificial fiber, and mixtures thereof.

45. The composite material of claim 40 wherein said melt-blown fibers are formed from a blend of said poly(ethylene-vinyl acetate) with from greater than 0% by weight up to about 90% by weight of said fibers of at least one other compatible modifying polymer which, when blended with said copolymer and subjected to an effective combination of elevated temperature and elevated pressure conditions, is adapted to be extruded, in blended form, with said copolymer.

46. The composite material of claim 45 wherein said modifying polymer is selected from the group including polyethylene, polypropylene, polybutene, polystyrene, copolymers and mixtures of these, and ABA' block copolymer, where A and A' are each independently a thermoplastic polymer endblock that includes a styrenic moiety and where B is an elastomeric poly(ethylenebutene) midblock, and mixtures thereof.

47. The composite material of claim 46 wherein said modifying polymer comprises a blend of two or more polymers selected from the group consisting of polyethylene, polypropylene, polybutene, ethylene copolymers, propylene copolymers, and butene copolymers.

48. The composite material of claim 40 wherein said elastic web has a basis weight of up to about 300 grams per square meter.

49. The composite material of claim 39 wherein said gatherable web is a nonwoven coherent nonelastic material and is formed from an interlaced web of fibers selected from the group consisting of polyester fibers, polyolefin fibers, polyamide fibers, cellulosic fibers, and mixtures of two or more thereof.

50. The composite material of claim 49 wherein said gatherable web comprises spun-bonded or melt-blown fibers of polyethylene, polypropylene, a random copolymer of ethylene and propylene, and blends thereof.

51. An elastic composite material comprising at least one elastic web joined at spaced-apart locations to at least one gatherable web, said gatherable web being gathered between said spaced-apart locations, said elastic web comprising poly(ethylene-vinyl acetate) comprising from about 26% by weight to about 30% by weight of vinyl acetate.

52. The composite material of claim 51 wherein said elastic web comprises a nonwoven coherent web of melt-blown microfibers.

53. The composite material of claim 52 further comprising secondary fibers intermixed with said melt-blown microfibers.

54. The composite material of claim 52 wherein said melt-blown microfibers are in the form of a nonwoven coherent web that exhibits the ability to be stretched to at least 150 percent of the web length formed.

55. The composite material of claim 52 wherein said nonwoven elastomeric web comprises

(a) microfibers comprising poly(ethylene-vinyl acetate) having a nominal melt index in the range from 32 to 300 at 190° C. and comprising from 26% by weight to about 30% by weight of vinyl acetate; and

(b) from greater than 0% by weight to about 80% by weight of at least one different secondary fiber that is generally uniformly distributed throughout said nonwoven web.

56. The composite material of claim 55 wherein said secondary fiber comprises a fibrous material selected from the group consisting of wood pulp fiber, staple natural fiber, staple artificial fiber, and mixtures thereof.

57. The composite material of claim 52 wherein said melt-blown fibers are formed from a blend of said poly(ethylene-vinyl acetate) with from greater than 0% by weight up to about 90% by weight of said fibers of at least one other compatible modifying polymer which, when blended with said copolymer and subjected to an effective combination of elevated temperature and elevated pressure conditions, is adapted to be extruded, in blended form, with said copolymer.

58. The composite material of claim 57 wherein said modifying polymer is selected from the group including polyethylene, polypropylene, polybutene, polystyrene, copolymers and mixtures of these, and an ABA' block copolymer, where A and A' are each independently a thermoplastic polymer endblock that includes a styrenic moiety and where B is an elastomeric poly(ethylene-butene) midblock, and mixtures thereof.

59. The composite material of claim 58 wherein said modifying polymer comprises a blend of two or more polymers selected from the group consisting of polyethylene, polypropylene, polybutene, ethylene copolymers, propylene copolymers, and butene copolymers.

60. The composite material of claim 52 wherein said elastic web has a basis weight of up to about 300 grams per square meter.

61. The composite material of claim 51 wherein said gatherable web is a nonwoven coherent nonelastic material and is formed from an interlaced web of fibers selected from the group consisting of polyester fibers, polyolefin fibers, polyamide fibers, cellulosic fibers, and mixtures of two or more thereof.

62. The composite material of claim 61 wherein said gatherable web comprises spun-bonded or melt-blown fibers of polyethylene, polypropylene, a random copolymer of ethylene and propylene, and blends thereof.

63. An elastic composite material comprising at least one elastic web joined at spaced-apart locations to at least one gatherable web, said gatherable web being gathered between said spaced-apart locations, said elastic web comprising poly(ethylene-vinyl acetate) con-

sisting essentially of from about 26% by weight to about 30% by weight of vinyl acetate.

64. The composite material of claim 63 wherein said elastic web comprises a nonwoven coherent web of melt-blown microfibers.

65. The composite material of claim 64 further comprising secondary fibers intermixed with said melt-blown microfibers.

66. The composite material of claim 64 wherein said melt-blown microfibers are in the form of a nonwoven coherent web that exhibits the ability to be stretched to at least 150 percent of the web length formed.

67. The composite material of claim 64 wherein said nonwoven elastomeric web comprises

(a) microfibers comprising poly(ethylene-vinyl acetate) having a nominal melt index in the range from 32 to 300 at 190° C. and consisting essentially of from about 26% by weight to about 30% by weight by weight of vinyl acetate; and

(b) from greater than 0% by weight to about 80% by weight of at least one different secondary fiber that is generally uniformly distributed throughout said nonwoven web.

68. The composite material of claim 67 wherein said secondary fiber comprises a fibrous material selected from the group consisting of wood pulp fiber, staple natural fiber, staple artificial fiber, and mixtures thereof.

69. The composite material of claim 64 wherein said melt-blown fibers are formed from a blend of said poly(ethylene-vinyl acetate) with from greater than 0% by weight up to about 90% by weight of said fibers of at least one other compatible modifying polymer which, when blended with said copolymer and subjected to an effective combination of elevated temperature and elevated pressure conditions, is adapted to be extruded, in blended form, with said copolymer.

70. The composite material of claim 69 wherein said modifying polymer is selected from the group including polyethylene, polypropylene, polybutene, polystyrene, copolymers and mixtures of these, and an ABA' block copolymer, where A and A' are each independently a thermoplastic polymer endblock that includes a styrenic moiety and where B is an elastomeric poly(ethylene-butene) midblock, and mixtures thereof.

71. The composite material of claim 70 wherein said modifying polymer comprises a blend of two or more polymers selected from the group consisting of polyethylene, polypropylene, polybutene, ethylene copolymers, propylene copolymers, and butene copolymers.

72. The composite material of claim 64 wherein said elastic web has a basis weight of up to about 300 grams per square meter.

73. The composite material of claim 63 wherein said gatherable web is a nonwoven coherent nonelastic material and is formed from an interlaced web of fibers selected from the group consisting of polyester fibers, polyolefin fibers, polyamide fibers, cellulosic fibers, and mixtures of two or more thereof.

74. The composite material of claim 73 wherein said gatherable web comprises spun-bonded or melt-blown fibers of polyethylene, polypropylene, a random copolymer of ethylene and propylene, and blends thereof.

114

115

**UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION**

PATENT NO. : 4,863,779
DATED : September 5, 1989
INVENTOR(S) : Diego Daponte

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

Column 13, line 34, "feels" should read --feel--;
Column 14, line 16, "so ten" should read --soften--;
Column 23, line 23, "juxtraposition" should read --juxtaposition--;
Column 27, line 55, "east" should read --least--;
Column 33, line 53, "contract" should read --can contract--;
Column 34, line 56, "melt-brown" should read --melt-blown--;
Column 35, line 27, "aid" should read --said--;
Column 35, line 53, "polyefin" should read --polyolefin--;
Column 35, line 63, "acetate" should read --acetate)--; and
Column 38, line 51, "basis of weight" should read --basis weight of--.

**Signed and Sealed this
Thirteenth Day of April, 1993**

Attest:

STEPHEN G. KUNIN

Acting Officer

Acting Commissioner of Patents and Trademarks

116

[54] NONWOVEN WEB WITH PROJECTIONS

[75] Inventors: Stephen M. Englebert, Woodstock, Ga.; Ann L. Wagner, Hortonville, Wis.; Gregory S. Hader, Atlanta, Ga.; Nanette J. Legel, Appleton, Wis.

[73] Assignee: Kimberly-Clark Corporation, Neneah, Wis.

[21] Appl. No.: 794,915

[22] Filed: Nov. 4, 1983

[31] Int. Cl.⁴ A61F 13/16; B32B 3/10; D04H 1/74; D04H 5/08

[32] U.S. Cl. 428/71; 15/209 R; 15/209 B; 15/215; 15/217; 15/223; 19/296; 19/301; 19/302; 128/132 R; 128/156; 156/176; 156/178; 156/181; 156/252; 156/270; 156/279; 428/76; 428/112; 428/113; 428/131; 428/135; 428/138; 428/141; 428/160; 428/171; 428/172; 428/179; 428/180; 428/283; 428/286; 428/287; 428/319.7; 428/303; 428/313; 604/367; 604/376; 604/380; 604/382; 604/384; 604/385 R

[36] Field of Search 428/76, 119, 131, 135, 428/138, 179, 180, 71, 112, 113, 132, 141, 283, 286, 287, 319.7, 160, 171, 172; 15/209 R, 209 R, 215, 217, 223; 19/296, 301, 302; 156/176, 178, 181, 252, 270, 279; 604/367, 376, 380, 382, 384, 385 R

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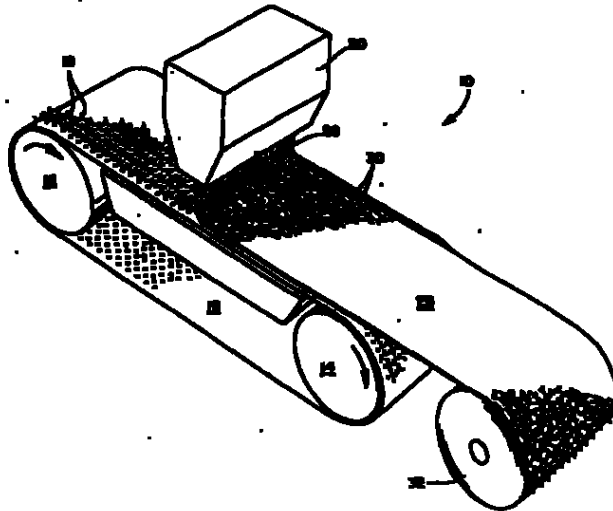
Primary Examiner—James C. Cannon

Attorney, Agent, or Firm—William D. Herrick

[57] ABSTRACT

Nonwoven web and method of making including interbonded thermoplastic fibers in an array of hollow projections extending outwardly from at least one surface of said web. The projections are separated by land areas of interbonded fibers, and the fiber orientation is greater in the projections than in the land areas. Either the projections or the land areas may be perforated as desired for controlled porosity and fluid flow properties. The nonwoven webs of the invention may be made by a number of processes but, preferably, are made by forming directly on a surface with corresponding projections with or without apertures and a vacuum assist or by forming on an apertured surface with a pressure differential sufficient to draw the fibers through the apertures forming the projections. The disclosure includes such webs with added fiber layers and as components of a wide variety of products including personal care items such as liners for sanitary napkins, household products such as cleaning materials and wipers, in the service product area such as towels, washcloths and bathmats, in the marine and automotive area as scrubbing and protective applications, and in the hospital and veterinary areas as wipes and dispensing cloths. The method and apparatus disclosed may be varied as to steps and configuration to impart desired web constructions and properties, and preferred embodiments are disclosed.

71 Claims, 12 Drawing Sheets



117

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3,857,637	12/1974	Todd	264/517	4,341,217	7/1982	Ferguson et al.	128/290 W
3,934,588	1/1976	Mosk et al.	128/290 W	4,342,807	8/1982	Rosen et al.	428/180
3,949,127	4/1976	Ostermeier et al.	428/137	4,392,862	7/1983	Mann et al.	604/366
3,983,867	11/1976	Steen	428/132	4,397,644	8/1983	Matthews et al.	604/378
3,994,771	11/1976	Morgan et al.	428/180	4,463,045	7/1984	Ahr et al.	428/131
4,005,957	2/1977	Savish	264/517	4,469,734	9/1984	Muto et al.	428/134
				4,519,798	1/1985	Diniz	604/358
				4,614,679	9/1986	Parrington et al.	428/138

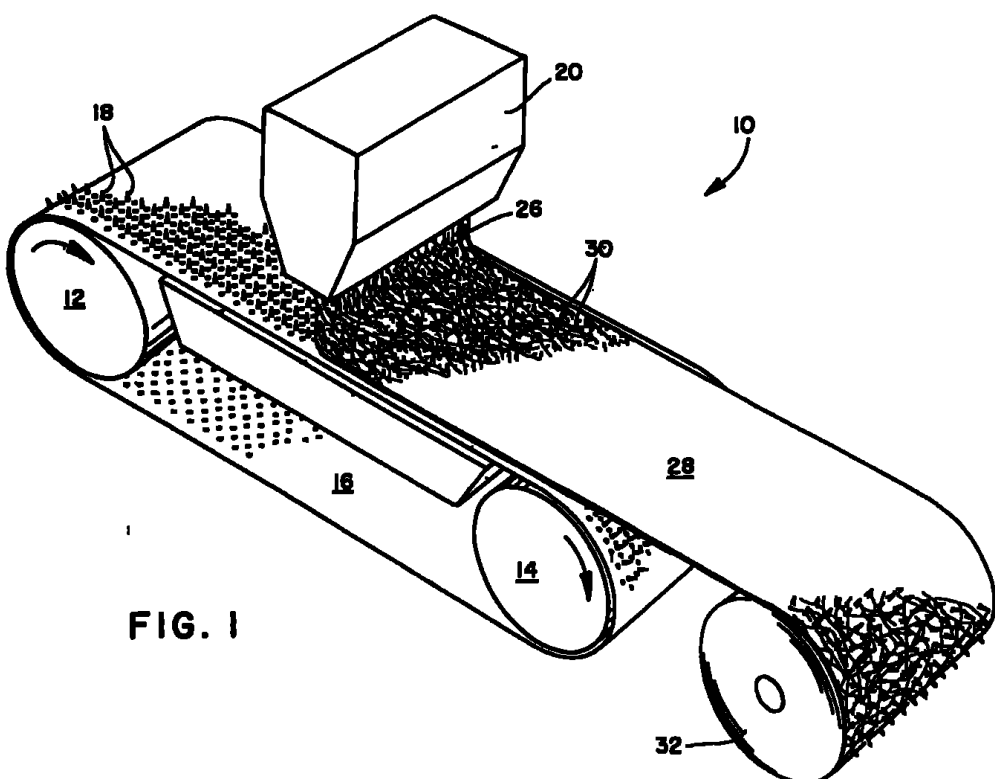


FIG. 1

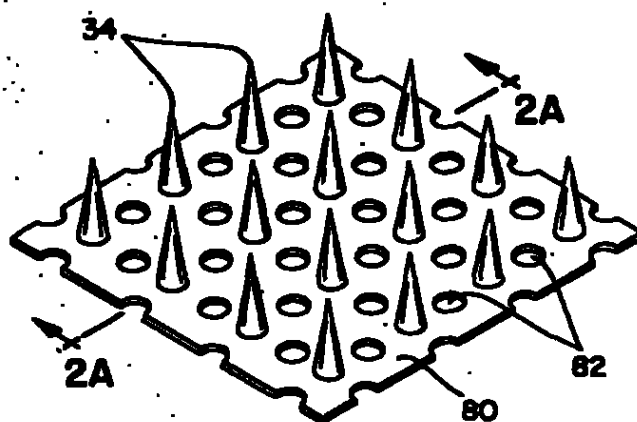


FIG. 2

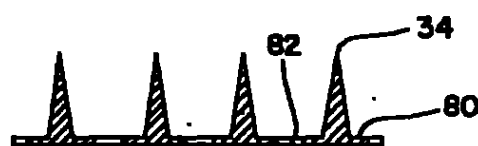


FIG. 2A

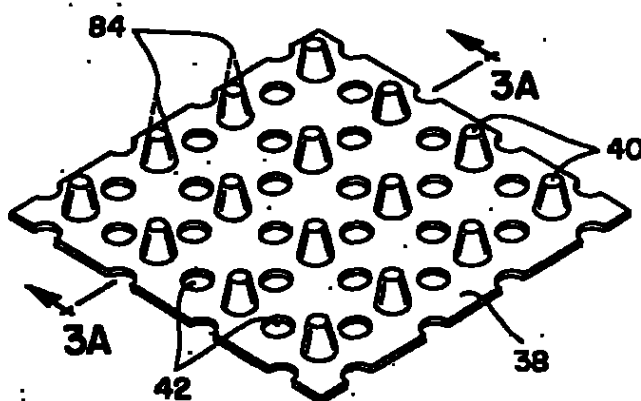


FIG. 3

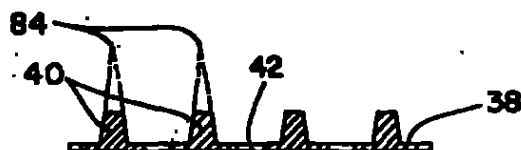


FIG. 3A

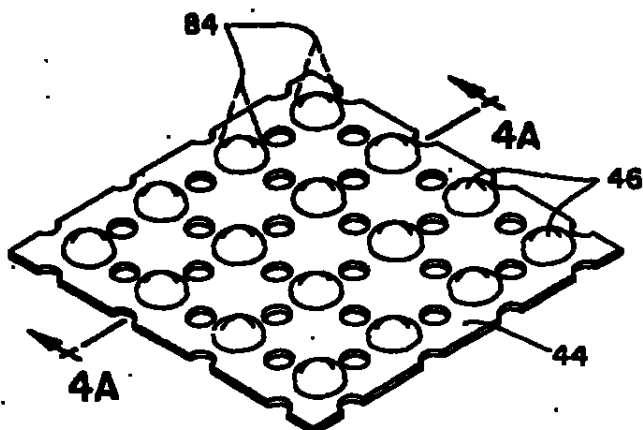


FIG. 4



FIG. 4A

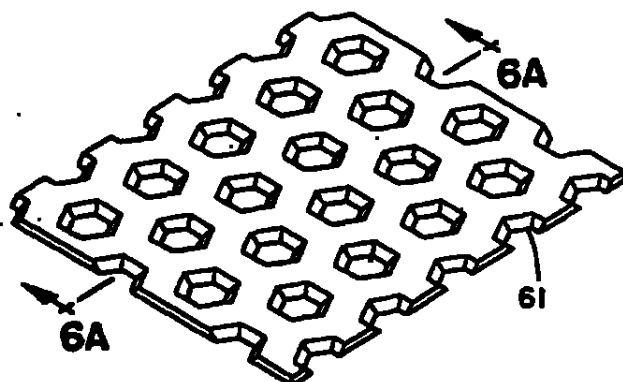


FIG. 6



FIG. 6A

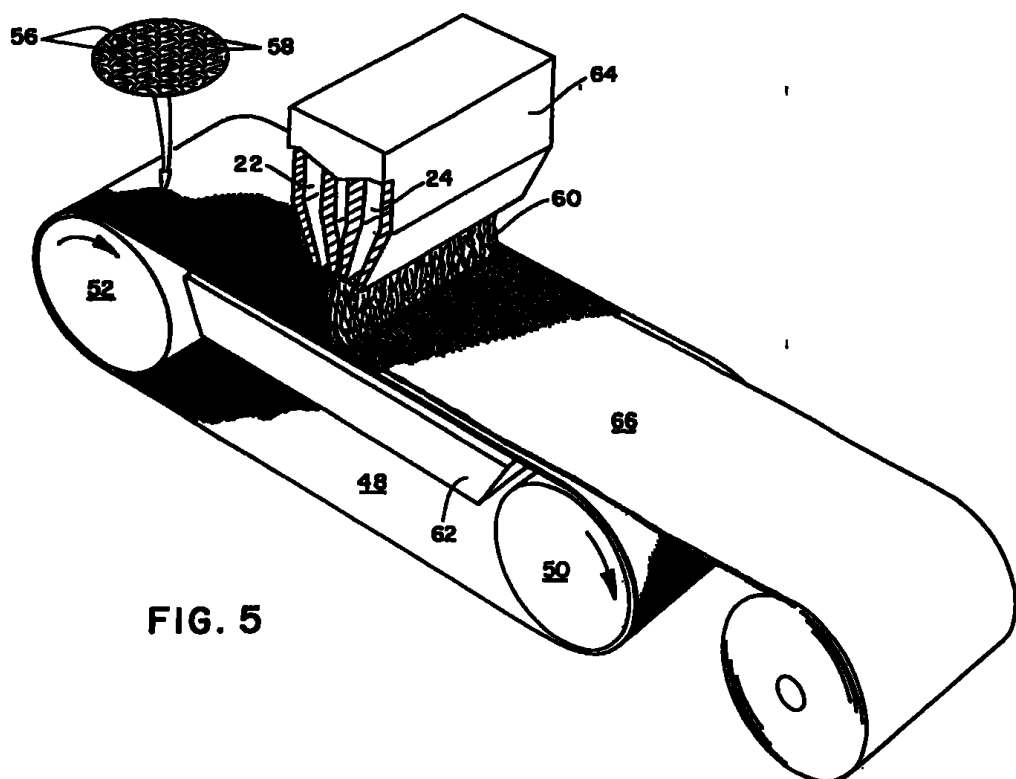


FIG. 5

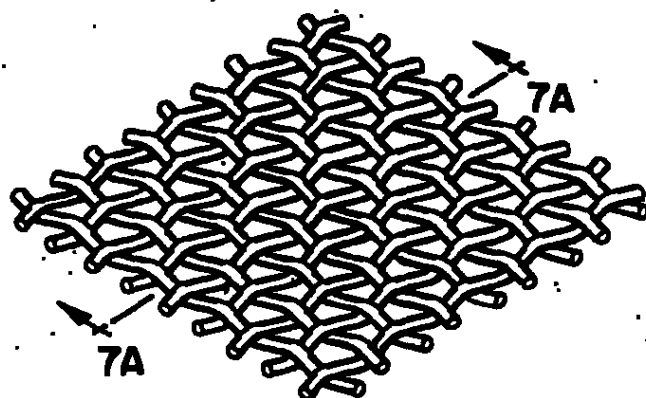


FIG. 7



FIG. 7A

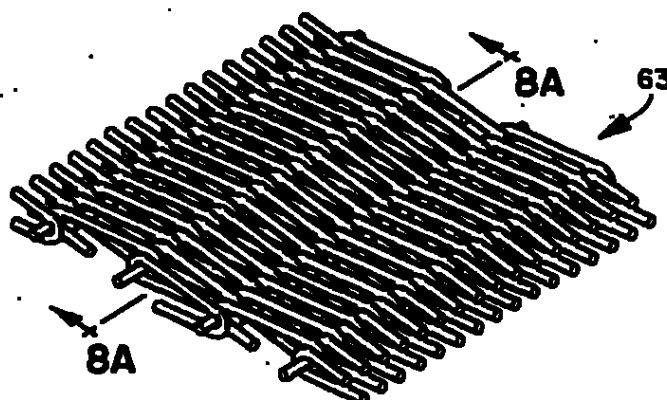


FIG. 8



FIG. 8A

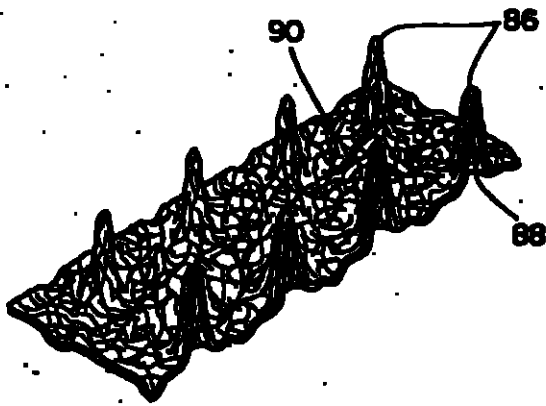


FIG. 9

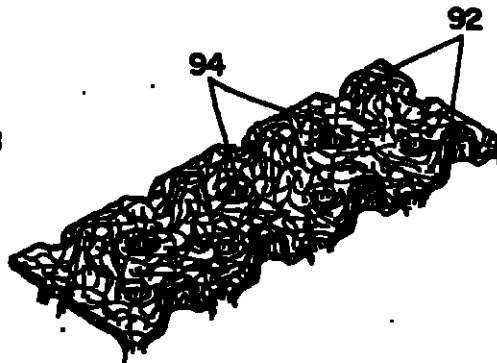


FIG. 10

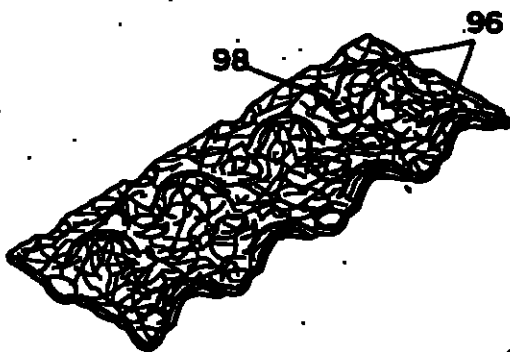


FIG. 11

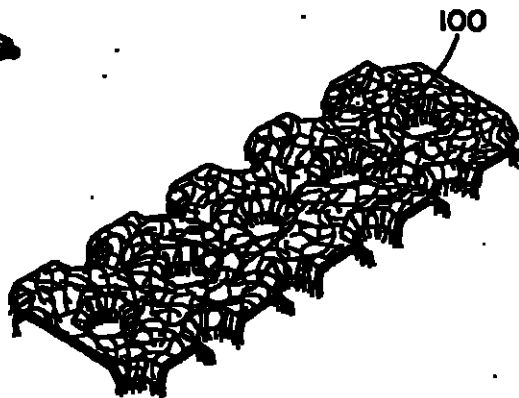


FIG. 12

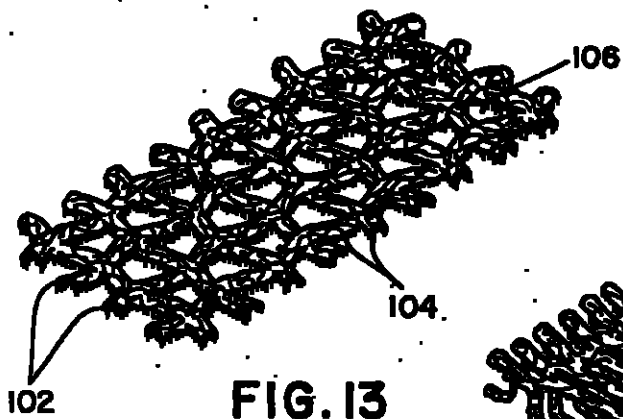


FIG. 13

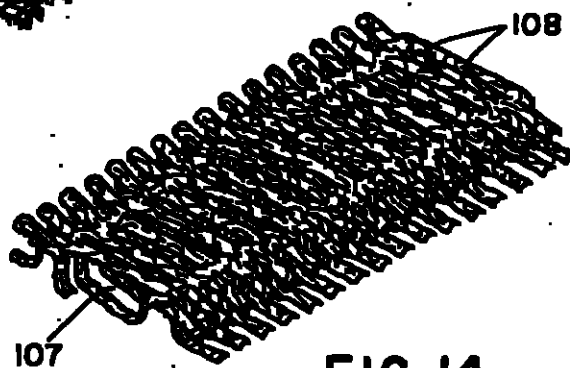


FIG. 14

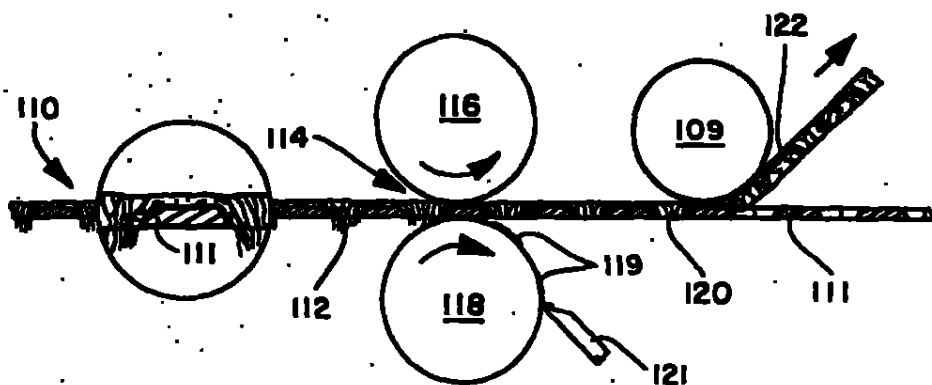


FIG. 15

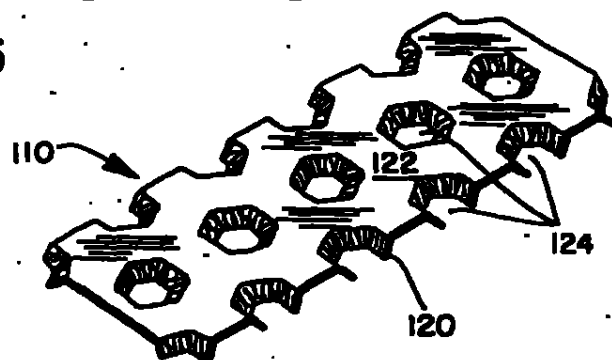


FIG. 16

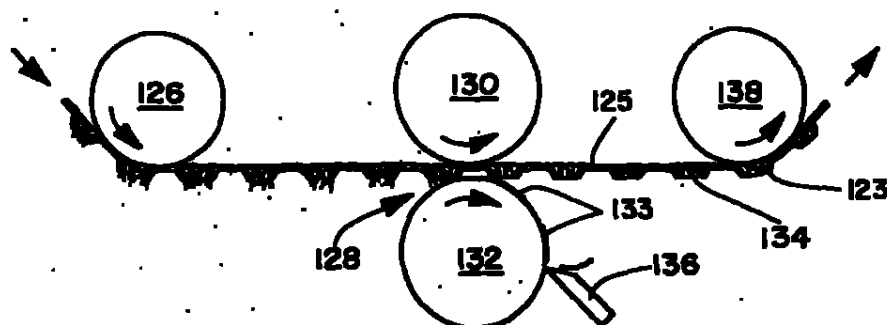


FIG. 17

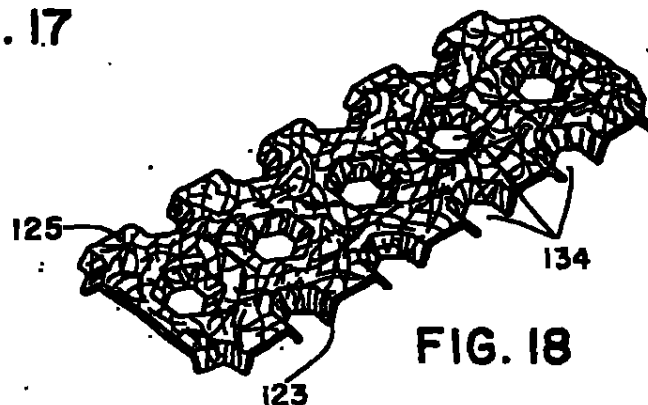


FIG. 18

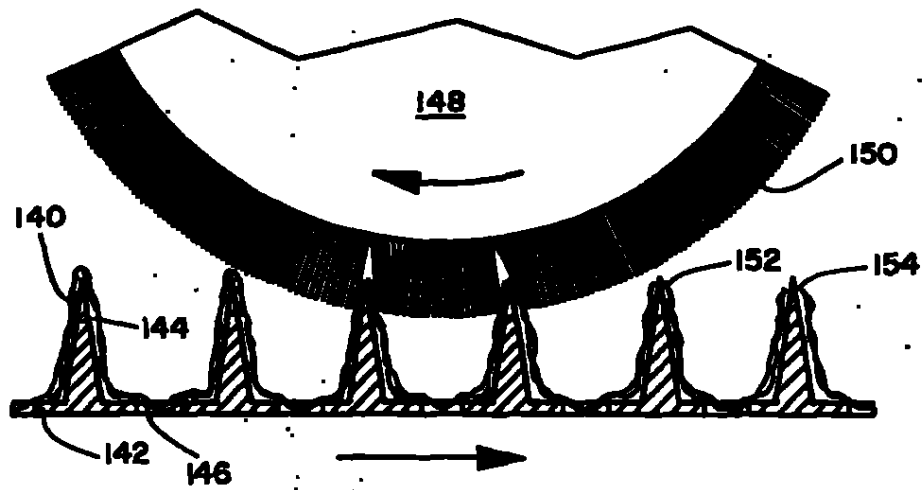


FIG. 19

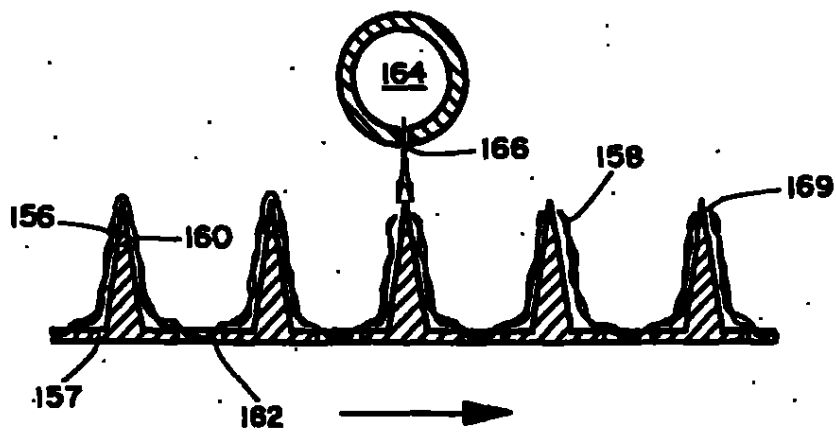


FIG. 20

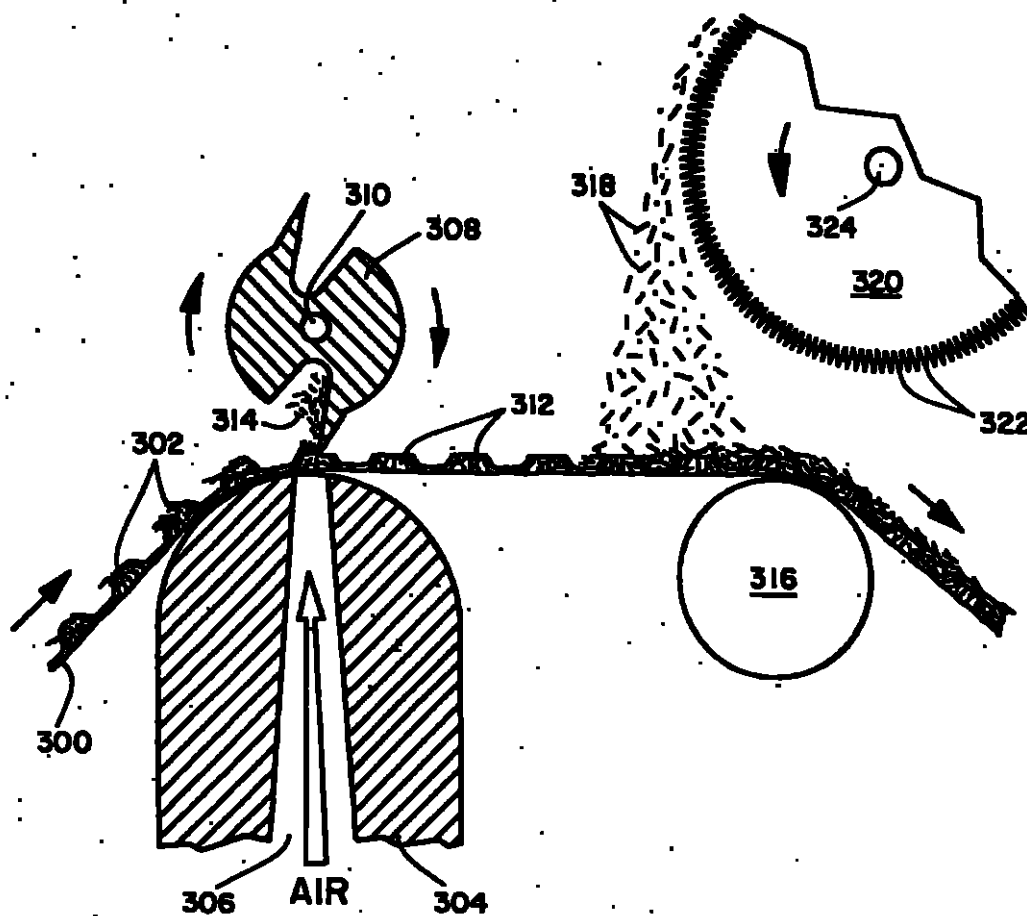


FIG. 21

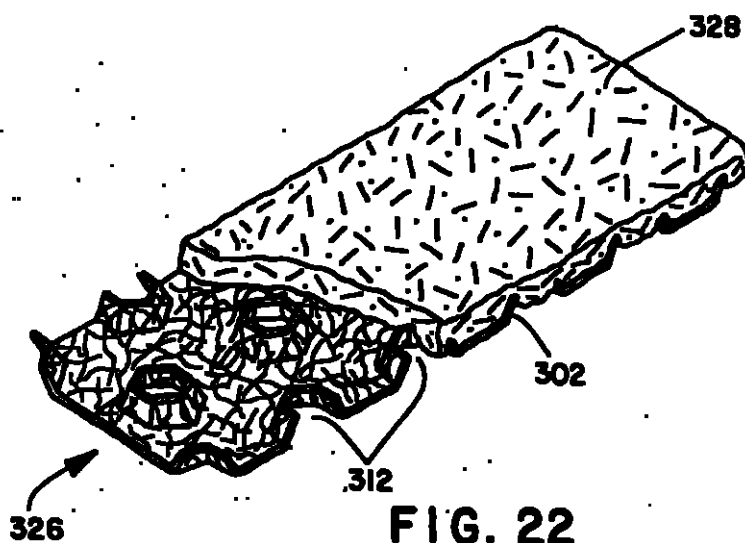


FIG. 22

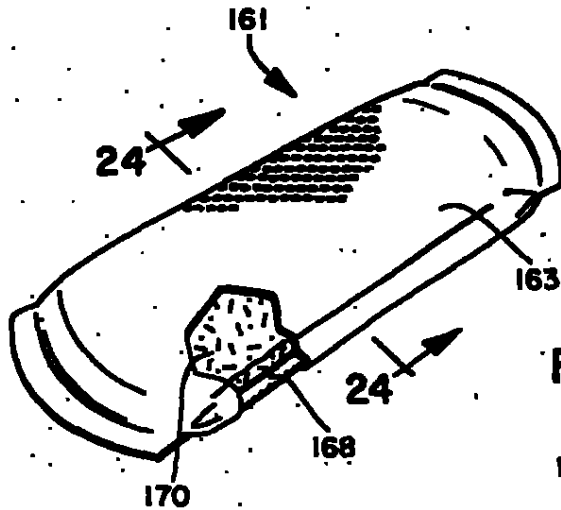


FIG. 23

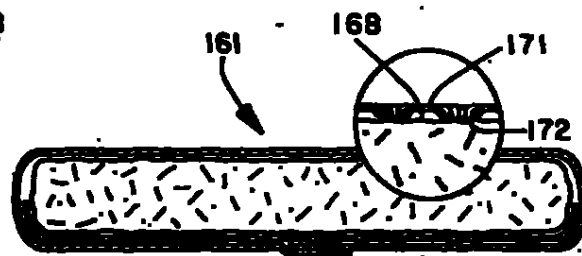


FIG. 24

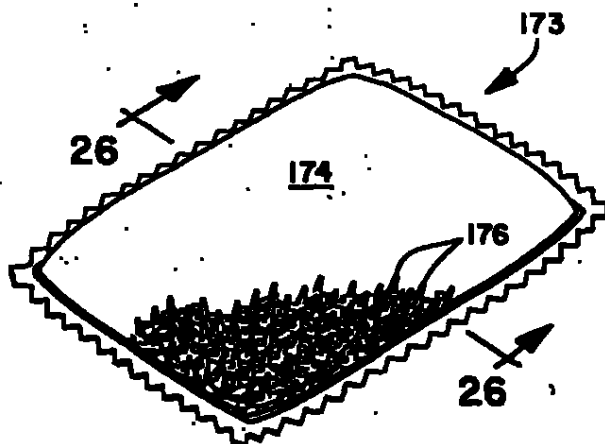


FIG. 25

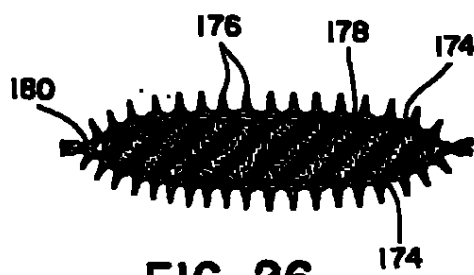
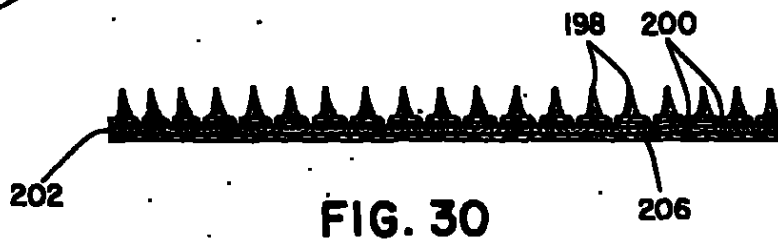
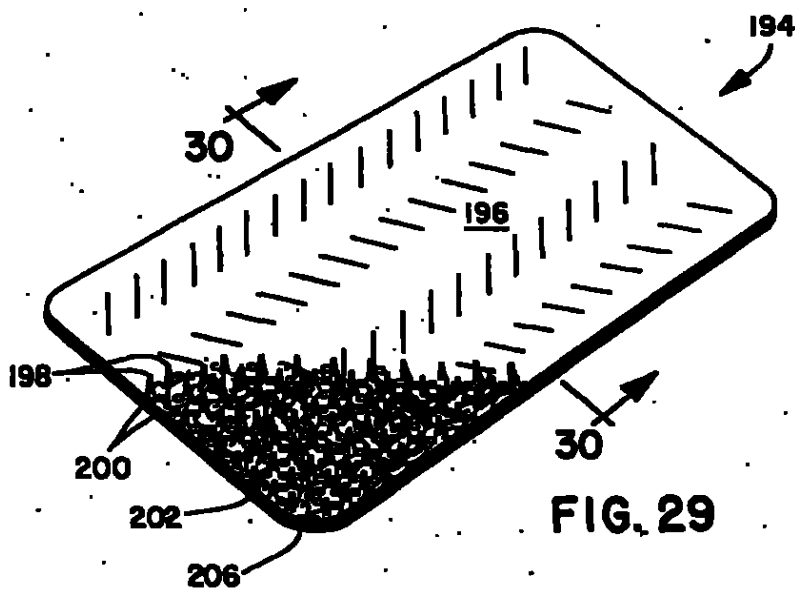
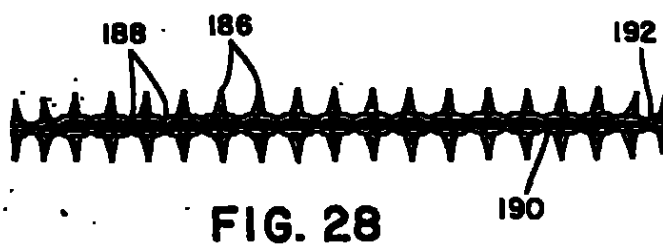
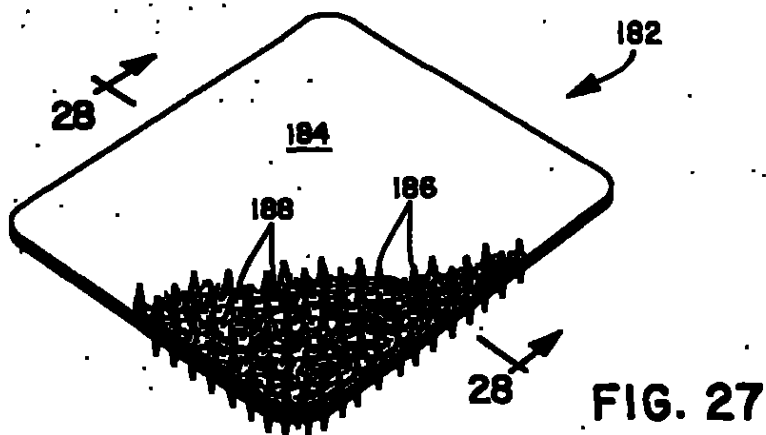


FIG. 26



SURFACE MICROPORES

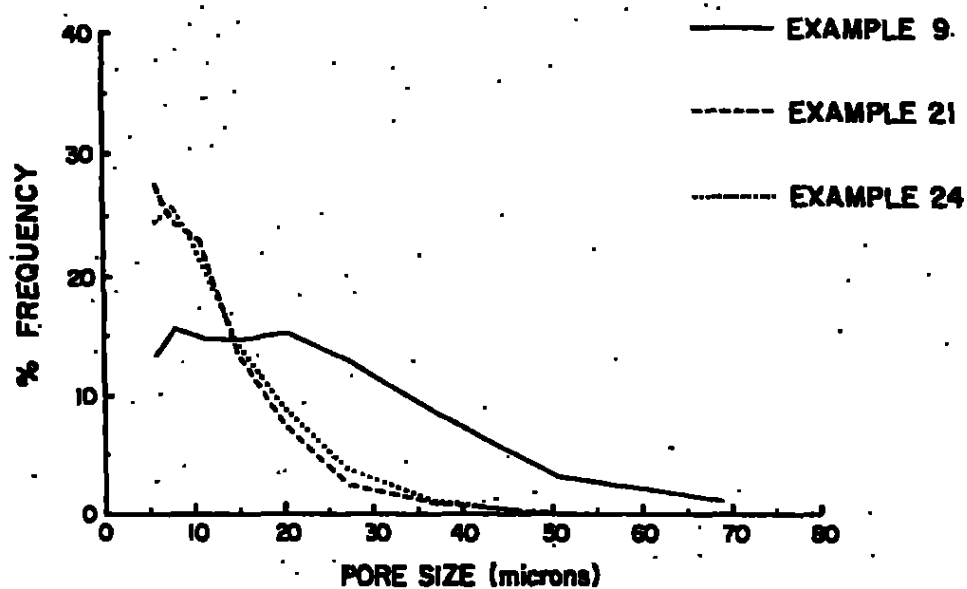


FIG. 31

SURFACE MICROPORES

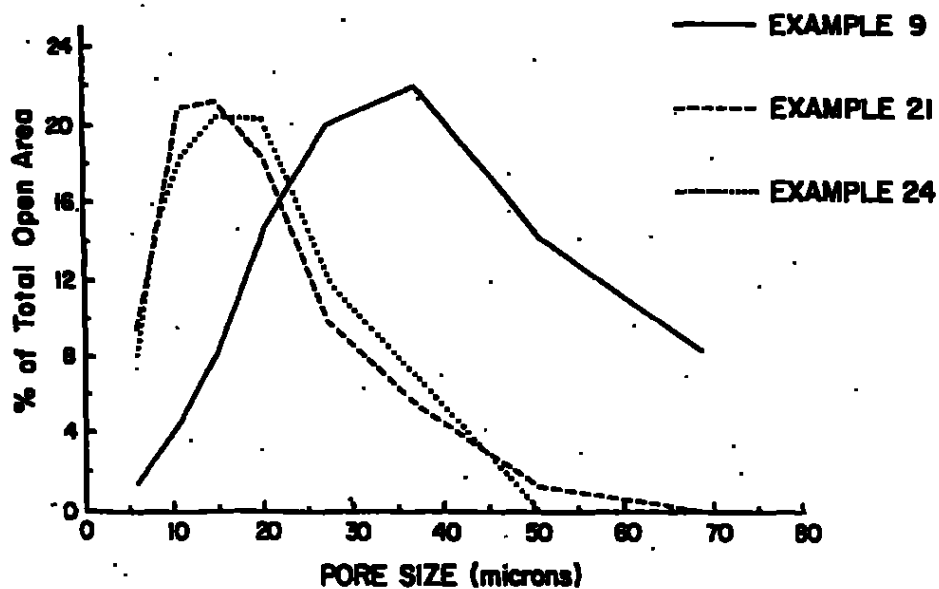


FIG. 32

NONWOVEN WEB WITH PROJECTIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is directed to nonwoven fabrics useful for a wide variety of applications. Such nonwovens in the form of lightweight, soft porous webs are used as cover liners for personal care products such as sanitary napkins and disposable diapers, for example. Other embodiments of nonwovens having engineered capillary structures are useful, for example, as intermediate transfer layers for such personal care products acting to distribute fluids and minimize leakage. Still others, frequently in heavier basis weights, are highly absorbent and serve as the absorbent medium for personal care products. In addition to nonwovens for personal care applications the field of the invention embraces nonwovens for many other uses, for example in the household as cleaning materials and wipers, in the service product area as towels, bathmats and the like, in the automotive and marine areas for scrubbing, wiping, protective and other uses and in the hospital and veterinary areas as wipes and applicators. The field includes nonwoven fabrics broadly for these and many other uses which will be apparent in light of the description below, and preferred embodiments of will be set forth hereinafter in detail. Moreover, the field embraces methods and apparatus for manufacturing such nonwovens resulting in engineered, three-dimensionally structured webs.

2. Description of the Prior Art

The manufacture of nonwoven fabrics is a highly developed art. In general, nonwoven webs and their manufacture involve forming filaments or fibers and depositing them on a carrier in such manner so as to cause the filaments or fibers to overlap or entangle as a mat of a desired basis weight. The bonding of such a mat may be achieved simply by entanglement or by other means such as adhesive, application of heat and/or pressure to thermally responsive fibers, or, in some cases, by pressure alone. While many variations within this general description are known, two commonly used processes are defined as spunbonding and meltblowing. Spunbonded nonwoven structures are defined in numerous patents including, for example, U.S. Pat. No. 3,563,729 to Hartmann dated Feb. 23, 1971, U.S. Pat. No. 4,403,297 to Appel and Morman dated Sept. 20, 1983, and U.S. Pat. No. 3,692,618 to Dornchner, Carduck, and Storckmann dated Sept. 19, 1972. Discussion of the meltblowing process may also be found in a wide variety of sources including, for example, an article entitled, "Superfine Thermoplastic Fibers" by Wendt in *Industrial and Engineering Chemistry*, Volume 48, No. 8, (1956) pages 1342-1346 as well as U.S. Pat. No. 3,978,185 to Buntin, Keller and Harding dated Aug. 31, 1976, U.S. Pat. No. 3,795,571 to Prentice dated Mar. 5, 1974, and U.S. Pat. No. 3,811,957 to Buntin dated May 21, 1974. Spunbonded webs and meltblown webs are widely used for many applications, including personal care products as described; for example, in U.S. Pat. No. 4,397,644 to Matthews, Allison, Woon, Stevens, and Bornhaefer, dated Aug. 9, 1983 or U.S. Pat. No. 4,372,312 to Fendler and Bernardin dated Feb. 8, 1983. Other nonwoven manufacturing processes include carding, wetlaying and needling, but the invention will be described with particular reference to meltblown

and spunbonded webs which represent preferred embodiments.

In addition to processes for making nonwovens, in general, it is known to form nonwoven fabrics, broadly, into so-called "three-dimensional" configurations that result in a web having a base plane but wherein fibers project out of the base plane in one, several or many different forms. For example, U.S. Pat. No. 4,103,038 to Hunsloek dated July 25, 1978 describes a pillowed web of meltblown microfibers where a pattern of pillowed low density regions is separated by high density areas formed by collecting on a perforated screen. U.S. Pat. No. 4,041,951 to Sanford dated Aug. 16, 1977 describes a nonwoven web containing a multiplicity of depressed areas providing wet resilience in a diaper top sheet that tends to isolate the wearer's skin from moisture contained in the absorbent layer. U.S. Pat. No. 3,240,657 to Hyack dated Mar. 15, 1966 describes an apertured web wherein the perforations are formed between relative low density web areas. Various forming techniques for making matting structures are described in prior art patents such as U.S. Pat. No. RE31,599 to Rasen, Vollbracht and Schenewe dated June 12, 1984 which discusses forming on a variety of surfaces having projections of different types and U.S. Pat. No. 4,488,928 to Kou and Schmitt dated Dec. 18, 1984 which discusses the use of vacuum drawing fibers onto various wire or belt forming surfaces.

Notwithstanding the intense investigation into the subject, there remains desired a nonwoven fabric that can be produced with widely varying, but carefully controlled, properties such as permeability, bulk, absorbency, liquid transmission, flexibility or stiffness, and density.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided an improved nonwoven fabric having controlled porosity, liquid flow, absorbency and other physical properties that is useful for the above-described applications in personal care, household, automotive and health care products, and for many other purposes such as scrubbers, bathmats, washcloths, and the like. In accordance with the invention, the nonwoven fabric comprises an array of interbonded thermoplastic fibers. The fabric of the invention is further defined by a pattern of hollow projections extending out of the base plane of the web wherein the fibers or filaments are more aligned than in the land areas between the projections. The projections in accordance with the invention average in the range generally of from about one per square centimeter to about eighty per square centimeter, and have an average height measured from the base plane to the most extended fibers within the range generally of from about 0.3 mm to 25 mm. The web of the invention is further characterized by an average bulk density in the range generally of from about 0.001 g/cc to about 0.11 g/cc. The fiber diameter in accordance with the invention may vary generally from about one micron to about 100 microns. Other important parameters include the variation in fiber alignment between the web land and projection areas. In accordance with the invention the projections include fibers or filaments with an average alignment of at least 5° greater than the average alignment of the fibers or filaments in the land areas. Also, the webs of the invention may be characterized by a volume ratio of volume of the projections to volume contained between

130

the projections, in both cases measured between planes at the base and tops of the projections, is the range of from about 1 to 250. In accordance with the invention the fibers or filaments forming the web may be produced by a wide variety of means including the spunbonded and meltblowing processes known to the art and mentioned above. The hollow projections in the web can also be formed in different ways. Preferably, however, the desired fiber alignment and bulk density are obtained in a manner that provides a pressure differential to the fibers or filaments such as by forming onto a surface having projections with a vacuum assist or by forming on a porous surface with a vacuum applied to the side of the surface opposite that receiving the filaments. In an alternative embodiment the nonwoven fabric of the present invention may contain apertures caused by forcing the fibers over the projections in the forming surface or by forcing the fibers through the forming surface by a pressure differential. Alternatively, various post-treatments such as shaving, for example, may be used. The present invention also includes preferred product embodiments incorporating the nonwoven fabric with hollow projections with or without apertures such as, for example, personal care products such as sanitary napkins, diapers, and incontinence garments, scrubbing devices, bathmats, washcloths, and others.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of one method in accordance with the invention for forming nonwoven webs with projections using a surface having projections and apertures.

FIGS. 2 through 4 illustrate in greater detail forming surfaces with projections useful in the process of FIG. 1. FIGS. 2A, 3A, and 4A show cross-sections taken along lines 2A—2A, 3A—3A, and 4A—4A of the respective figures.

FIG. 5 illustrates an alternative vacuum forming process useful for forming nonwoven fabrics having projections in accordance with the present invention.

FIGS. 6 through 8 illustrate forming surfaces for the vacuum forming process.

FIGS. 6A, 7A and 8A show cross-sections taken along lines 6A—6A, 7A—7A and 8A—8A in the respective figures.

FIGS. 9 through 14 schematically illustrate webs formed on the forming surfaces of FIGS. 2 through 4 and 6 through 8 using the process of FIG. 1 for FIGS. 9 through 11 and the process of FIG. 5 for FIGS. 12 through 14.

FIG. 15 illustrates calendaring means for controlling web porosity in accordance with the invention, and

FIG. 16 schematically illustrates web formed in this manner.

FIG. 17 illustrates an aperturing means in accordance with one aspect of the present invention, and FIG. 18 the resulting web in schematic form.

FIGS. 19 and 20 illustrate alternative aperturing means in accordance with the present invention.

FIG. 21 illustrates an alternative aperturing means and

FIG. 22 illustrates a resulting apertured web.

FIG. 23 illustrates a sanitary napkin product formed in accordance with the present invention, and

FIG. 24 is a cross-section of the product of FIG. 23 taken along lines 24—24.

FIG. 25 is a scrubbing device formed in accordance with the present invention, shown in schematic form, and

FIG. 26 is a cross-section of the pad of FIG. 25 taken along lines 26—26.

FIG. 27 is a disposable washcloth formed in accordance with the present invention shown in schematic form, and

FIG. 28 is a cross-section of the washcloth of FIG. 27 taken along lines 28—28.

FIG. 29 is an absorbent mat product formed in accordance with the present invention shown in schematic form, and

FIG. 30 is a cross-section of the mat of FIG. 29 taken along lines 30—30.

FIG. 31 is a graph showing pore size distribution obtained with certain embodiments of the nonwoven fabrics having apertured projections in accordance with the invention including those formed with a wax component and modified by calendaring.

FIG. 32 is a graph showing percent of total open area of the fabrics tested for FIG. 31.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

While the invention will be described in connection with preferred embodiments, it will be understood that it is not intended to limit the invention to those embodiments. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

Certain terms as used herein will be defined to facilitate an understanding of the invention. The term "base plane" is used herein to describe the plane along the surface opposite the projections or, for those embodiments with projections on both surfaces, taken along a central line parallel to the flat web ignoring the presence of any projections. The term "bulk density" refers to the density of the web using as its thickness the distance between the surface of the web away from the projections and the average height of the projections. In the case of a web having projections from both surfaces, the thickness will be the sum of the average projection height of the projections from the center of the base plane. The term "web density" is used herein to refer to the density taken in the land area between the projections. The term "fiber alignment" is used herein to refer to the tendency of fiber or filaments in a plane to be oriented in parallel directions. It is expressed as degrees and measured using Cambridge 600 SCM photos and a Cambridge Instruments Quantimet 900 image analyzer. The device was set up to measure aperture orientation between the fibers or filaments as an indicator of fiber or filament orientation. Criteria used for apertures were: 32 filter system (implying a precision of 5.625") apertures must be larger than 10 micrometers; apertures must be elongated with a shape factor $\pi L^2/4A < 2.0$; and acceptable angles between 0° and 100° with acceptable Sine (θ) values between 0 and 1.1 (to avoid sorting error).

Since it is the structure of the web of the present invention which is largely responsible for the improvements obtained, the raw materials used may be selected from a wide variety. For example, and without limiting the generality of the foregoing, thermoplastic polymers such as polyolefins including polyethylene, polypropylene as well as polystyrene may be used as may be poly-

131

esters including polyethylene terephthalate, and polyamides including nylons. Also useful are other thermoplastic polymers such as those which are elastomeric including elastomeric polyurethanes and block copolymers. Compatible blends of any of the foregoing may also be used. In addition, as will be explained in greater detail later, additives such as wax, fillers, and the like may be incorporated in amounts consistent with the fiber forming process used to achieve desired results. Other fiber or filament forming materials will suggest themselves to those skilled in the art such as glass, for example. The fibers may also be formed from solution, and examples include viscose. It is only essential that the composition be capable of spinning into filaments or fibers of some form that can be deposited onto a forming surface of the invention and thermally formed or interbonded in a manner dependent upon the forming surface.

Since most of these polymers are hydrophobic, if a wettable surface is desired, known compatible surfactants may be added to the polymer as is well known to those skilled in this art. Such surfactants include, by way of example and not limitation, anionic and nonionic surfactants such as sodium dioctyl sulfosuccinate (Aerosol OT available from American Cyanamide) and alkyl phenoxly ethanol (Triton X-100 available from Rhom & Haas). The amount of surfactant additive will depend on the desired end use as will also be apparent to those skilled in this art. Other additives such as pigments, fillers, stabilizers, and the like may also be incorporated. Further discussion of the use of such additives may be had by reference to U.S. Pat. No. 4,374,888 to Bornhaefer dated Feb. 22, 1983, for example, and U.S. Pat. No. 4,070,218 to Weber dated Jan. 24, 1978 for example.

The basis weight for nonwoven fabrics produced in accordance with the invention will vary widely depending upon the intended use. For example, very lightweight webs having a basis weight in the range of from about 10 grams per square meter to 50 grams per square meter or even lighter in some cases are useful as liners for disposable diapers or for covers, liners or transfer layers in other personal care products such as sanitary napkins. The transfer layer in such a product is positioned between the absorbent layer and the liner and serves to distribute fluid passing through the liner in a manner to achieve maximum utilization of the absorbent medium. Somewhat heavier basis weights will serve for applications such as washcloths, towels, and the like, which generally, will have a basis weight in the range of from about 20 grams per square meter to about 70 grams per square meter. Still heavier products in the basis weight range of from about 70 grams per square meter to about 300 grams per square meter or even higher can be engineered to be stiffer and find uses such as a scrubber for auto windshields, for example, or for household uses. For other applications such as, for example, bathmats, it may be useful to laminate a nonwoven fabric having hollow projections produced in accordance with the present invention with an absorbent bottom layer to provide desired absorption and rigidity to the product. Examples of other products or combinations requiring similar or different nonwoven basis weights will be apparent to those skilled in the art, and some will be discussed in detail with reference to the drawings.

The number of projections for the nonwoven fabrics produced in accordance with the invention will be within the range of from about one to about eighty per square centimeter and, for many applications, will pref-

erably be within the range of from about five to about fifty per square centimeter. The shape of the individual projections will vary depending upon how they are formed, but it is a characteristic of the present invention that the projections will be hollow and have a height in the range of from about 0.3 millimeter to about 25 millimeters preferably within the range of from about 0.5 millimeter to about 10 millimeters to provide desired properties. For example, if the projections have a greater height, they may slow fluid transfer or tend to break undesirably or fold upon themselves, in either case reducing the effectiveness of the web for many intended applications. On the other hand, hollow projections with smaller height will not achieve the desired separation from absorbent or other layers placed in contact with the projections necessary to produce improved stain hiding and resistance to flowback especially useful for sanitary personal care products.

It is also a characteristic of the present invention that the fibers or filaments in the projection areas are oriented in a parallel direction to a higher degree than those fibers or filaments in the lead areas. This results from the pressure differential applied to the fibers either as the fibers or filaments are pulled over the projections on the forming surface or drawn through apertures in the forming surface. The result, in either case, is that the alignment will be at least 5° greater in the projections than in the lead areas. As will be apparent from the test description above, a random web will have an angle reading of 45° while increased angles indicate greater fiber or filament alignment. While it is not desired to limit the invention to a particular theory, improvements in flow through the webs of the invention are believed attributable at least in part to this increased alignment. Capillaries within and between the fibers or filaments are favored and facilitate fluid transport.

To achieve the benefits described, the hollow projections will in many cases preferably be arranged such that they form or may be projected to form cones. While the term "cone" has been used, as will be appreciated by those skilled in this art, the actual shape of a given projection may vary, but, the average projection will in such cases most closely resemble a cone in shape or extension. The hollow core of the projections will, in general, be determined by the manner in which the projections are formed. For example, if the projections are formed by depositing fibers onto a surface with pins, the core will assume the general contour of the pins. On the other hand, if the projections are formed by a pressure differential across a porous carrier, the hollow core will have a configuration determined by the opening in the carrier. The term "hollow" as used herein does not completely exclude the presence of fibers or filaments in the core areas of the projections. On the contrary, as will be apparent to those skilled in this art, the forming steps described may well leave fibers in the core areas due to variabilities in air flow, fiber properties or other parameters. The term "hollow" as used herein, therefore, means that the core or centerline taken through a given projection will define a low density path substantially free from fibers or filaments when compared with the lead areas or projection walls. While the core may vary widely in shape and size, for some preferred applications in personal care products it will have a volume expressed as a ratio of the projection, including the core, in the range of between about 0.25 to about 0.75, preferably about 0.3 to about 0.6. On the other hand, preferred embodiments will have a

volume ratio of the volume of the projections to volume contained between the projections, measured between planes at the base and tops of projections, in the range of from about 1 to 250.

The fibers or filaments used to produce the nonwoven fabrics of the present invention may vary widely in shape, diameter, cross-section, and length. For example, continuous spunbond filaments may be used as well as meltblown continuous or discontinuous microfibers which frequently have a lower average diameter. Furthermore, additives to the web such as superabsorbent powders, liquids, or natural fibers such as wood pulp may also be incorporated at various loading levels depending upon desired end use properties.

In one particularly preferred embodiment pore size distribution within the nonwoven fabric of the invention is further controlled through addition of a hydrocarbon processing aid to the polymer being spun into fibers or filaments. Such hydrocarbon processing aids include those compositions that, in general, act as lubricants improving polymer flow properties such as melt stiffness. Examples include paraffin waxes, synthetic waxes, oxidized and unoxidized waxes. For example, when the polymer is polyethylene, wax may be added to the polymer in an amount of up to about 30 percent by weight, preferably in the range of from about 5 to 15 percent prior to spinning. The resulting web will then have finer fibers resulting in an improved hand and a narrower pore size distribution including lesser amounts of large pores as will be discussed further with reference to FIGS. 31 and 32 below. Examples of hydrocarbon processing aids that may be used include paraffinic waxes such as Rosin Wax 165 from Frank B. Rosin, Jr. Co. A similar controlled pore size distribution may be obtained by calendaring between the projections as will be discussed in detail with reference to FIG. 15. For many applications it is also important to have larger apertures as well as the fine pore structure already defined. Such apertures may be located in some cases in the land areas between the hollow projections or may be in some or all of the projections, themselves, either open as formed or by removing the closed portion of the projections after formation. Ways for achieving such apertures will be described below in greater detail particularly with reference to FIGS. 13, 17 and 19-21.

Turning to FIG. 1, one method for producing the nonwoven fabrics having hollow projections in accordance with the invention will be described. As shown, forming apparatus 18 includes forming surface 16 which is an endless belt disposed around support rolls 12, 14, either or both of which may be driven by means not shown such as motors, etc. Belt 16 includes pins 18 extending outward from the belt. These pins will be selected as to size and frequency so as to produce the web having the desired array and configuration of projections suitable for the intended purpose. The shape of the projections will vary according to the desired shape of the projections in the web. In this FIG. 1 a fiber forming process is schematically illustrated wherein fiber forming device 20 such as a meltblowing die, spunbonding die or spray nozzle extrudes molten filaments 26. The resulting fibers 26 are collected on the forming surface 16 as web 28 having corresponding hollow projections 30. Web 28 may be directed for further processing or, as shown, wound into roll 32.

FIG. 2 illustrates in greater detail and in perspective view one forming surface which can be used as belt 16 in FIG. 1. As shown, the surface in this case is a flat

metal sheet 38 having cone-shaped pins 34 which are disposed outwardly from the surface. In this embodiment sheet 38 also contains perforations 32 which may be used for applying vacuum to increase the pressure differential applied to the filaments 26 (FIG. 1). FIG. 2A shows the forming surface of FIG. 2 in cross-section taken along lines 2A-2A. Although shown as a flat sheet, the surface may be a portion of a belt, wire or roll as will be appreciated by those skilled in this art.

FIG. 3 is a view of an alternative forming surface 36 which, in this case, has pins 40 in the shape of truncated cones extending outwardly and apertures 42 which may be open to vacuum applied to the surface of sheet 38 opposite that to which filaments 26 (FIG. 1) are applied. FIG. 3A is a cross-section of the surface of FIG. 3 taken along lines 3A-3A. As shown in greater detail, the pins 40 in this case have a configuration the extension of which forms a cone 34.

FIGS. 4 and 4A are views like FIGS. 2 and 2A illustrating yet other forming surfaces 44 having projections 46 of a domed configuration.

FIG. 5 is a schematic perspective view of an alternative forming process. As shown, a belt or wire 48 of machine direction filaments 50 and cross-machine direction filaments 56 is carried about support rolls 58, 62, either or both of which may be driven by motor means (not shown). Filaments 48 are formed, for example, by meltblowing die 64 and contacted by air in conduits 22, 24 as in the process described in U.S. Pat. No. 3,978,185 dated Aug. 31, 1976 to Banta, Keller, and Harding, which is incorporated herein by reference. Such filaments are ejected from die 64 and are collected on the wire 48. Section box 62 applies a vacuum to the randomly entangled filaments which results in a pressure differential forming pockets that produce hollow projections from the undersurface of the web. The resulting web 66 with projections may then be directed for further processing.

FIG. 6 illustrates an alternative belt configuration useful in the apparatus illustrated in FIG. 5, and FIG. 6A shows the belt of FIG. 6 in cross-section taken along lines 6A-6A. Such a belt would produce generally hexagonal projections.

FIG. 7 illustrates an alternative wire configuration, and FIG. 7A shows the wire of FIG. 7 taken in cross-section along lines 7A-7A.

FIG. 8 illustrates a third alternative wire configuration with FIG. 8A showing the wire in cross-section taken along line 8A-8A.

FIGS. 9 through 11 illustrate schematically webs formed on the surfaces illustrated in FIGS. 2 through 4. In FIG. 9, hollow projections 86 are cone-shaped, in general, with hollow cores 88. Each projection 86 corresponds to a projection 34 (FIG. 2). The projections 86 are formed under conditions such that they retain their shape after removal from the forming surface. Also in this case depressions 90 are formed corresponding to openings 32 (FIG. 2). In cases where a lower basis weight web is formed or where higher vacuum is applied to the web, these depressions 90 may actually result in apertures in the land areas of the web. The web of FIG. 10 has hollow projections 92 in similar manner relating to pins 40 (FIG. 3). Just as an extension of pins 40 (FIG. 3) forms cones 34 (FIG. 3), an extension of projections 92 also generally forms cone-shaped structures. In this case the forming conditions have resulted in apertures 94 in the land areas as a result of higher pressure differentials caused by increased vacuum. FIG.

11 similarly illustrates a web formed on the surface of FIG. 4. In this case hollow projections 96 are rounded but still by extension form cone-shaped structures. As in the case of FIG. 9, the forming conditions are such as to produce depressions 98.

FIGS. 12 through 14 illustrate in schematic form webs formed on forming surfaces of FIGS. 6 through 8. The web of FIG. 12 includes hollow projections 100 which are homogeneously shaped but, in general, may be extended to form cone-like structures corresponding to the apertures 61 (FIG. 6). These projections are open, forming apertures as a result of the pressure differential applied to the forming surface. The web of FIG. 13 shows less well defined projections 102 formed by filament-like forms 104 surrounding apertures 106. In like manner the web of FIG. 14 contains hollow projections 107 formed by filament-like structures 108 as a result of vacuum applied to wire 63 (FIG. 8).

FIG. 15 illustrates schematically one means for controlling the porosity of the web of the present invention particularly in the land areas. As shown, web 110 having projections 112 travels with forming surface 111 in the direction indicated through nip 114 between calendar rolls 116, 118. These rolls apply pressure to the combined web and forming surface which produces compaction primarily in land areas 122. This step also serves to modify apertures 120 by removing loose fibers, particularly if roll 118 is heated at or near the polymer melting point. Such loose fibers adhere to roll 118 at areas 119, for example, and are removed by blade 121. In a preferred embodiment both rolls may be heated with bottom roll 118 at a higher temperature to cause the polymer 119 to preferentially adhere. If desired, one of these rolls may also serve as the forming surface having a surface as in FIG. 6, for example, with vacuum applied and web forming at or near the nip 114. In such a case the web, after calendaring at pressures sufficient to maintain a nip, will be compressed in the land areas 122 reducing the porosity in the land areas.

FIG. 16 illustrates in greater detail a web modified by the calendaring method of FIG. 15. In this case the projections between land areas 122 include apertures 124.

FIG. 17 illustrates one of the alternative aperturing steps using heat. As shown, the projections 123 extend downward from web 125 which is directed over guide roll 126 to nip 128 which is a fixed gap between rolls 130, 132. These rolls are rotated, and bottom roll 132 is heated to a temperature above the melting point of the polymer used to form the web 125. In a preferred embodiment roll 130 may be chilled to reduce stiffening of the sheet. The fibers covering the projections adhere to roll 132 and are drawn away forming apertures 134. Polymer 133 adhering to the roll is removed by blade 136, and the web is removed by guide roll 138.

FIG. 18 is an illustration of web 125 formed in accordance with FIG. 17.

FIG. 19 schematically illustrates means for forming webs with apertured projections starting with a process such as is illustrated in FIG. 1. In general, web 140 on carrier 142 having pins 144 and openings 146 for vacuum assist is contacted by brush roll 148 having an exterior surface covered with bristles 150. The bristles extend part way into areas between the pins 144 pushing fibers 152 away from the tops of pins 144 thus producing apertures 154.

FIG. 20 similarly illustrates an alternative projection perforating means. In this case web 156 is supported on

carrier 157 having pins 160 and openings 162 but passes under air duct 164 having slit 166 which directs air against the web 156 forcing filaments 158 away from the tops of the pins producing apertures 168.

FIG. 21 illustrates an alternative aperturing step adapted for use with webs formed as in either FIG. 1 or FIG. 3. In this case web 300 having projections 302 moves in the direction indicated over arvil 304 having air slot 306. Blade 308 rotates about pivot 310 shaving the tops of projections 302 producing apertures 312. The air flow through slot 306 which aligns fibers 314 which facilitates removal. The shaved web may be drawn over support roll 316 for storage or further processing. In a further preferred embodiment additional fibers 318 which may be of an absorbent material such as wood pulp are deposited on the side of web 300 with projections 302. The fibers may be added by means of picker roll 320 having teeth 322 rotating about pivot 324. FIG. 22 schematically illustrates a shaved web 326 resulting from the step of FIG. 21 with a wood pulp layer 328 added.

FIG. 23 schematically illustrates a conventional type of sanitary napkin 161 partially broken away to show cover of the invention 163, absorbent 170 and baffle 168.

FIG. 24 shows the sanitary napkin 161 of FIG. 23 in cross-section taken along lines 24-24 of FIG. 23. As shown, projections 172 contact absorbent 168 and permit flow through to the absorbent while limiting contact in land areas 171 providing separation and inhibiting flow back.

FIG. 25 illustrates a scrubbing device formed from a higher tensile weight material of the present invention. As shown scrubber 173 comprises a pad with outer surface of web 174 with hollow projections 176 extending outwardly. In this case, the projections 176 are not apertured.

FIG. 26 shows the scrubber of FIG. 25 in cross-section taken along lines 26-26 of FIG. 25 illustrating sponge central pad 178 which may be, for example, polyurethane and of desired hardness for the intended use. For convenience, cover 174 may be formed of two halves and bonded peripherally along line 180 by heat or adhesive as will be apparent to those skilled in this art.

FIG. 27 schematically illustrates a washcloth 182 having a cover 184 including hollow projections 186 and, in the land areas, apertures 188.

FIG. 28 shows the washcloth of FIG. 27 in cross-section taken along lines 28-28 of FIG. 27. The washcloth may be formed in much the same manner as the scrubber of FIG. 25 except that the center pad is thinner and includes an absorbent or strength enhancing layer 190 of tissue, sponbonded nonwoven or meltblown nonwoven, for example. Bonding along peripheral line 192 may be similarly achieved.

FIG. 29 illustrates schematically a product form of the present invention as a bathmat. Bathmat 194 includes a laminate of walking surface 196 including a nonwoven web of the present invention with outwardly extending hollow projections 198 and apertures 200 in the land areas. Absorbent layer 202 in one embodiment is formed from pulp fluff which, when combined imparts a desired stiffness to the bathmat. As shown in greater detail in FIG. 30 which is a cross-section taken along lines 30-30 of FIG. 29, bottom layer 206 may either be of an impervious material or a rubber-like nonwoven. In any event, the exposed bottom surface

134

has a coefficient of friction sufficient to minimize slip-stick under conditions of use.

FIG. 31 is a graph showing pore size distribution versus frequency percent occurrence. The solid line represents an untreated web, Example 9. The dotted line indicates a material of the invention, Example 24, calendared and without wax. The dashed line indicates the material of Example 21 including wax. As shown, the use of either wax or calendaring greatly increases the frequency of smaller pores thus enhancing the hiding power of the web, particularly for applications as a liner for a sanitary napkin. The smaller pore retard entrapment of, for example, menstrual fluid resulting in a cleaner, dryer cover material.

FIG. 32 is a similar graph with the same materials represented in the same manner except that pore size is shown as a function of percent total open area. Again, the greater concentration of the desirable smaller pores is demonstrated.

As will be apparent to those skilled in this art, the present invention is susceptible of many product forms, and the foregoing are illustrative only of several preferred embodiments.

The invention will now be further illustrated by way of specific examples.

EXAMPLES

Example 1

Using apparatus schematically illustrated in FIG. 1, a web was formed having an array of hollow projections as generally shown in FIG. 9. The polymer used was a linear low density polyethylene identified as DOW XV-61800.06. The die tip had orifices with a diameter of 0.3683 mm, and it was operated at a temperature of 525° F. and pressure of 154 psi. The extruded polymer was contracted on both sides by primary air at a temperature of 550° F., pressure of 1 psi and rate of 55 SCFM. The result was a throughput of 2.4 lb/in-hr which was collected at a distance of 9 inches. The forming surface was as shown in FIG. 2 with 15 projections per cm², each projection cone-shaped with a base diameter of 1.5 mm and height of 6.25 mm. The forming surface was driven at a rate to produce a basis weight of 30.33 gsm for the web.

Example 2

Example 1 was repeated except that the forming surface was driven at a rate to produce a basis weight of 101.1 gsm.

Example 3

Example 2 was repeated except that a conventional meltblowing process was used without forming surface with projections for form a web having a basis weight of 30.31 gsm.

Example 4

Example 1 was repeated using polypropylene identified as Exxon 3145. In this case the die tip was operated at a temperature of 453° F. and pressure of 104 psi. The primary air temperature was changed to 400° F. and rate to 60 SCFM and the resulting basis weight was 30.33 gsm. Example 5

Example 4 was repeated driving the forming surface at a rate to produce a web of a basis weight of 101.1 gsm.

Example 6

Example 5 was repeated using standard meltblowing as in Example 3.

Example 7

The operating conditions of the equipment of the previous examples were modified to produce a web from polyurethane identified as Estane 58887 at a throughput of 2.4 lb/in-hr for a basis weight of 250 gsm.

Example 8

Using the process schematically illustrated in FIG. 5 a web was formed having an array of open, hollow projections generally as illustrated in FIG. 12. The forming surface had a configuration as in FIG. 6 to produce a web with a projection density of about 53 projections per square centimeter with opening average diameter of about 526 microns. The polymer used was polyethylene (Dow XV 61800.06 from Dow Chemical) which was extruded at a melt temperature of 329° C., air temperature of 274° C., air flow of 140 SCFM, and collected at a forming distance of 7.6 cm. The collecting surface was moved at a rate to provide a web basis weight of 59 grams per square meter.

Example 9

Example 8 was repeated except that the forming surface pattern was changed to that producing a web with a hole size of 721 microns, 39 open, hollow projections per square centimeter, and the web had a basis weight of 66 grams per square meter.

Example 10

Example 8 was repeated except that the forming surface pattern was changed to that producing a web having about 26 open, hollow projections per square centimeter with an average diameter of about 835 microns.

Example 11

Example 8 was repeated except that the forming surface pattern and operating conditions were changed to produce a 38 grams per square meter basis weight web having about 20 open, hollow projections per square centimeter with an average diameter of about 1171 microns.

Example 12

Example 8 was repeated except that the forming surface pattern was as in FIG. 7 and operating conditions were changed to produce a 54 grams per square meter basis weight web having about 40 open, hollow projections per square centimeter with an average diameter of about 686 microns.

Example 13

Example 12 was repeated except that the forming surface pattern and operating conditions were changed to produce an 84 grams per square meter basis weight web having about 22 open, hollow projections per square centimeter with an average diameter of about 1155 microns.

Example 14

Example 8 was repeated except that the forming surface pattern was as in FIG. 8 and the operating conditions were changed to produce a 54 grams per square

135

meter basis weight web having open, hollow projections with an average hole breadth 430 microns and percent open area of 13.

Example 15

Example 9 was repeated with polypropylene (designated as 3145 from Exxon) and the forming conditions were as follows: Melt temperature of 307° C., air temperature of 232° C., air flow of 100 SCFM, forming distance of 7.6 cm and adjusted to produce a basis weight of 16 grams per square meter and average hole size of about 721 microns.

Example 16

Example 15 was repeated except at a basis weight of 33 grams per square meter.

Example 17

Example 15 was repeated except at a basis weight of 37 grams per square meter.

Example 18

Example 9 was repeated except at a basis weight of 25 grams per square meter and a melt temperature of 316° C.

Example 19

Example 18 was repeated except that 1 percent by weight hydrocarbon processing aid (identified as Rosin Wax 165, a paraffin wax) was added to the polymer; and the resulting basis weight was 23 grams per square meter.

Example 20

Example 19 was repeated except that the amount of hydrocarbon processing aid was raised to 5 percent by weight and the resulting basis weight was 22 grams per square meter.

Example 21

Example 19 was repeated except that the amount of hydrocarbon processing aid was raised to 10 percent by weight, and the resulting basis weight was 19 grams per square meter.

Example 22

Example 19 was repeated except that the amount of hydrocarbon processing aid was raised to 20 percent by

weight, and the resulting basis weight was 23 grams per square meter.

Example 23

This example was 28 grams per square meter basis weight conventional meltblown polyethylene produced generally as described in U.S. Pat. No. 3,978,185 to Banta et al dated Aug. 31, 1976 under the following conditions: melt temperature 332° C., air temperature 274° C., air flow 120 SCFM, forming distance 19 cm.

Example 24

The web of Example 9 was calendered on both sides of the web as shown in FIG. 18. The calendered web had an average hole size (breadth) of 870 microns with a percent open area of 22.

Example 25

The web of Example 10 was calendered as in Example 24 with a resulting average hole size (breadth) of 961 microns and average percent open area of 18.3.

Example 26

The web of Example 11 was calendered as in Example 24 with a resulting average hole size (breadth) of 1267 microns and average percent open area of 25.9.

Example 27

The web of Example 9 was calendered as in FIG. 15 and received a fiber layer added by fiber addition means as shown in FIG. 21. The fiber added was pulp CR54 available from Kimberly-Clark Corporation added at about 30 gm additional fiber.

Example 28

The web of Example 10 was treated as in Example 27.

Example 29

Process of FIG. 5 was to form a web on a surface having 0.075 in. diameter staggered circles, 0.1 inch centers with 115 holes per square inch and 51 percent open area using a melt temperature of 316° C., air temperature of 260° C., air flow of 145 SCFM, and forming distance of 9 cm for basis weight of 16.6 gm.

The materials of Examples 1 through 23 were tested in accordance with the present invention to determine grab tensile, elongation, energy to rupture, trap tear, bulk, Frazier porosity, and drape properties. The results of these tests are set forth in the following Table.

TABLE I

EXAMPLE	GRAB TENSILE		ELONGATION		ENERGY TO RUPTURE		TRAP TEAR		PEAK HEIGHT (cm)	FRAZIER POROSITY (cm)	DRAPE/STIFFNESS		BULK DENSITY (g/cc)
	MD	CD	MD	CD	MD	CD	MD	CD			MD	CD	
1	0.9	0.9	39	31	2.0	2.3	N/A	N/A	0.43	1220	1.57	1.89	0.007
2	1.9	4.3	63	63	8.0	7.3	1.62	1.73	0.41	485	1.57	1.225	0.004
3	1.9	5.0	30	36	9.6	7.5	2.18	2.56	0.08	N/A	4.05	2.89	0.04
4	1.7	2.1	30	30	4.3	2.1	1.05	2.50	0.38	1240	2.30	1.175	0.007
5	1.4	4.6	61	34	6.7	4.8	1.41	1.51	0.61	540	4.35	4.35	0.016
6	11.2	12.8	5	45	2.4	14.9	1.98	.78	0.08	100	6.0	4.85	0.024
7							1.16	N/A	0.26	320	2.65	N/A	0.007
8	1.5	1.7	24	48	1.6	2.4	0.59	0.57	0.104	375	2.5	2.2	0.007
9	4.2	2.4	24	20	2.0	1.9	0.68	0.58	0.094	496	1.6	2.6	0.070
10	3.8	1.6	20	12	1.5	0.8	0.50	0.21	0.076	460	2.4	2.8	0.077
11	1.2	2.6	25	19	1.6	0.9	0.48	0.33	0.079	606	2.8	2.9	0.074
12	2.0	2.3	32	28	1.1	1.2	0.58	0.34	0.105	399	2.5	3.2	0.032
13	2.0	2.0	13	21	0.5	0.8	0.39	0.52	0.183	880	3.4	4.6	0.046
14	1.3	2.0	49	20	0.9	0.7	0.30	0.50	0.241	836	1.6	4.7	0.022
15	0.9	1.3	48	33	0.8	1.4	0.14	0.19	0.053	824	N/A	N/A	0.031
16	1.1	2.7	47	40	3.1	2.5	0.59	0.22	0.112	341	N/A	N/A	0.029

TABLE I-continued

EXAMPLE	GRAB TENSILE		ELONGATION		ENERGY TO RUPTURE		TRAP TEAR		PEAK HEIGHT (cm)	FRAZIER POROSITY (cm)	DRAPE/STIFFNESS		BULK DENSITY (g/cc)
	MD	CD	MD	CD	MD	CD	MD	CD			MD	CD	
	(%)	(%)	(%)	(%)	(in/lb)	(in/lb)	(%)	(%)			(cm)	(cm)	
17	1.7	2.7	45	30	1.5	1.2	0.39	0.23	0.119	401	N/A	N/A	0.031
18	1.5	1.1	95	91	1.3	2.1	0.60	0.33	0.097	N/A	N/A	N/A	0.026
19	1.5	1.0	105	77	1.0	1.5	0.60	0.27	0.081	N/A	N/A	N/A	0.028
20	1.1	0.9	60	100	2.2	2.0	0.60	0.32	0.081	N/A	N/A	N/A	0.027
21	1.0	0.7	79	85	2.1	1.4	0.37	0.21	0.071	N/A	N/A	N/A	0.027
22	1.0	0.7	49	46	1.4	0.7	0.26	0.12	0.074	N/A	N/A	N/A	0.031
23	0.7	1.4	43	37	1.0	1.1	0.30	0.17	0.093	772	N/A	N/A	0.053
(Control) 29	0.7	0.5	105	105	1.3	1.3	0.35	0.18	0.063	1082	N/A	N/A	0.015

The materials of Examples 9-12 were tested along with apertured film from commercially available sanitary product (Always brand) (designated "APA"), apertured film on a commercially available sanitary product (Sulihonette brand) (designated "APB"), polypropylene sponbonded fabric 13 gam, (designated "SB") and bonded carded web, (designated "BCW") for surface moisture and blotter rewet. Surface moisture results were obtained by a test which uses a conductivity probe to determine surface moisture of a material as a function of time elapsed from fluid application. The fluid included droplets of oil encapsulated in gelatin and had a surface tension of 55 dynes/cm. Three cubic centimeters were added to the sample covering a type 59B conductivity probe from Delmhorst Instrument Co. A conductivity reading was taken at the indicated time intervals and, using standard decay curve for conversion factors, was recorded as % moisture content. Blotter rewet results were obtained by measuring the amount of 8 cubic centimeters of a composition (as described in U.S. Pat. No. 4,397,644 to Matthews et al dated Aug. 9, 1983 in col. 7, lines 12+, incorporated herein by reference, except that no surfactant was added) transferred from the sample to a standard Veri-Good 120 lb. basis weight blotter material from James River under conditions of 0.25 PSI for 3 minutes, 0.5 PSI pressure for 3 minutes, and a final 3 minutes at 1 PSI. Table II gives the results demonstrating that drier covers may be obtained in accordance with invention.

TABLE II

Example	Surface Moisture (%)			Blotter Rewet (After 1 p.a.)
	10 sec.	30 sec.	200 sec.	
Ex. 9	60	60	65	0.13
Ex. 10	37	38	39	0.13
Ex. 11	34	36	45	0.17
Ex. 12	35	33	42	0.1
APA	69	68	73	0.05
APB	89	91	93	0.97
SB	82	83	88	0.79
BCW	63	65	71	0.49

The materials of Examples 29 were tested for fiber orientation in the land and projection areas by the test method described above.

The results are shown in Table III.

TABLE III

Example	Land Area Orientation (°)	Projection Area (°)
1	47	72
2	47	64
29	61	72

The effect of fluff addition as in FIG. 21 was demonstrated by testing the materials of Examples 9, 10, 27 and 28 for absorbency rate as in the above described

U.S. Pat. No. 4,397,644 to Matthews et al dated Aug. 9, 1983 using the composition without surfactant and 8 ccs added. In this case the time for 6 ccs to be absorbed was recorded. The test results were 120 seconds, 23 seconds, 14.5 seconds, and 11.8 seconds for the respective examples demonstrating the rapid rate improvement obtained with the added fluff layer.

As the data above indicate, webs of the present invention provide improved properties and are extremely versatile since they may be produced in widely varying forms. In this manner the webs of the present invention having projections as described provide highly useful materials for components of personal care product and for a wide variety of other uses as well.

Thus it is apparent that there has been provided in accordance with the invention an improved nonwoven web with projections and method of making that fully satisfy the objects, aims and advantages set forth above. While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications, and variations as fall within the spirit and broad scope of the appended claims.

We claim:

1. Nonwoven fabric comprised of overlapping thermoplastic fibers or filaments defining an array of hollow projections extending out of said fabric and separated by planar land areas in a plane taken along a line parallel to said fabric ignoring the projections and said fabric characterized by at least a 5 degree higher average degree of fiber or filament alignment in the projections than in the land areas.

2. Nonwoven fabric of claim 1 wherein the fibers or filaments are selected from the group consisting of polyolefins, polyesters, polyamides and mixtures and blends thereof.

3. Nonwoven fabric of claim 2 wherein the thermoplastic is selected from the group consisting of polypropylene, polyethylene and mixtures and blends thereof.

4. Nonwoven fabric of claims 1, 2, or 3 wherein the projections have a height of about 0.3 to about 25 millimeters and the array consists of about 1 to about 80 projections per square centimeter.

5. Nonwoven fabric of claims 1, 2, or 3 wherein the projections have a height of about 0.5 to about 10 millimeters and the array consists of about 5 to about 50 projections per square centimeter.

6. Nonwoven fabric of claim 4 having a bulk density in the range of from about 0.001 to about 0.11 grams per cubic centimeter.

7. Nonwoven fabric of claim 5 having a bulk density in the range of from about 0.001 to about 0.11 grams per cubic centimeter.

8. Nonwoven fabric of claim 6 having a basis weight in the range of from about 20 to 300 grams per square meter.

9. Nonwoven fabric of claim 7 having a basis weight in the range of from about 20 to 300 grams per square meter.

10. Nonwoven fabric of claim 6 having a basis weight in the range of from about 20 to 70 grams per square meter.

11. Nonwoven fabric of claim 7 having a basis weight in the range of from about 20 to 70 grams per square meter.

12. Nonwoven fabric of claim 8 having a volume ratio of projections to volume between projections in the range of from about 1 to 250.

13. Nonwoven fabric of claim 9 having a volume ratio of projections to volume between projections in the range of from about 1 to 250.

14. Nonwoven fabric of claim 4 wherein the projections are apertured.

15. Nonwoven fabric of claim 5 wherein the projections are apertured.

16. Nonwoven fabric of claim 6 wherein the projections are apertured.

17. Nonwoven fabric of claim 7 wherein the projections are apertured.

18. Nonwoven fabric of claim 8 wherein the projections are apertured.

19. Nonwoven fabric of claim 9 wherein the projections are apertured.

20. Nonwoven fabric of claim 10 wherein the projections are apertured.

21. Nonwoven fabric of claim 11 wherein the projections are apertured.

22. Nonwoven fabric of claim 12 wherein the projections are apertured.

23. Nonwoven fabric of claim 13 wherein the projections are apertured.

24. Nonwoven fabric of claim 4 wherein the projections are cone-shaped.

25. Nonwoven web of claim 5 wherein the projections are cone-shaped.

26. Nonwoven web of claim 14 wherein the projections are cone-shaped by extension.

27. Nonwoven web of claim 15 wherein the projections are cone-shaped by extension.

28. Nonwoven web of claim 4 combined with a layer of absorbent fibers deposited onto and covering said projections.

29. Nonwoven web of claim 5 combined with a layer of absorbent fibers deposited onto and covering said projections.

30. Nonwoven web of claim 14 combined with a layer of absorbent fibers deposited onto and covering said projections.

31. Nonwoven web of claim 15 combined with a layer of absorbent fibers deposited onto and covering said projections.

32. Nonwoven web of claim 4 wherein the ratio of the average hollow core volume to the average total projection volume is in the range of from about 0.25 to 0.75.

33. Nonwoven web of claim 5 wherein the ratio of the average hollow core volume to the average total

projection volume is in the range of from about 0.25 to 0.75.

34. Nonwoven web of claim 14 wherein the ratio of the average hollow core volume to the average total projection volume is in the range of from about 0.25 to 0.75.

35. Nonwoven web of claim 15 wherein the ratio of the average hollow core volume to the average total projection volume is in the range of from about 0.25 to 0.75.

36. Nonwoven web of claim 4 wherein the land areas are densified.

37. Nonwoven web of claim 5 wherein the land areas are densified.

38. Nonwoven web of claim 14 wherein the land areas are densified.

39. Nonwoven web of claim 15 wherein the land areas are densified.

40. Nonwoven web of claim 4 wherein the fibers or filaments are formed from a blend including a hydrocarbon processing aid.

41. Nonwoven web of claim 5 wherein the fibers or filaments are formed from a blend including a hydrocarbon processing aid.

42. Nonwoven web of claim 14 wherein the fibers or filaments are formed from a blend including a hydrocarbon processing aid.

43. Nonwoven web of claim 15 wherein the fibers or filaments are formed from a blend including a hydrocarbon processing aid.

44. A personal care product comprising an absorbent layer, impervious backing, and liner wherein the liner comprises the nonwoven web of claim 4 having a basis weight in the range of from about 20 to 70 grams per square meter.

45. A personal care product comprising an absorbent layer, impervious backing, and liner wherein the liner comprises the nonwoven web of claim 5 having a basis weight in the range of from about 20 to 70 grams per square meter.

46. A personal care product comprising an absorbent layer, impervious backing, and liner wherein the liner comprises the nonwoven web of claim 14 having a basis weight in the range of from about 20 to 70 grams per square meter.

47. A personal care product comprising an absorbent layer, impervious backing, and liner wherein the liner comprises the nonwoven web of claim 15 having a basis weight in the range of from about 20 to 70 grams per square meter.

48. A scrubbing device comprising a pad enclosed within an outer surface of the nonwoven web of claim 4.

49. A scrubbing device comprising a pad enclosed within an outer surface of the nonwoven web of claim 5.

50. A scrubbing device comprising a pad enclosed within an outer surface of the nonwoven web of claim 14.

51. A scrubbing device comprising a pad enclosed within an outer surface of the nonwoven web of claim 15.

52. A washcloth comprising the nonwoven web of claim 4 bonded to opposing surfaces of a flexible reinforcing layer.

53. A washcloth comprising the nonwoven web of claim 5 bonded to opposing surfaces of a flexible reinforcing layer.

138

139

54. A washcloth comprising the nonwoven web of claim 14 bonded to opposing surfaces of a flexible reinforcing layer.

55. A washcloth comprising the nonwoven web of claim 15 bonded to opposing surfaces of a flexible reinforcing layer.

56. An absorbent mat comprising a walking surface of the nonwoven web of claim 4 bonded to one side of an absorbent layer and an impervious layer on the opposite side of said absorbent layer.

57. An absorbent mat comprising a walking surface of the nonwoven web of claim 5 bonded to one side of an absorbent layer and an impervious layer on the opposite side of said absorbent layer.

58. An absorbent mat comprising a walking surface of the nonwoven web of claim 14 bonded to one side of an absorbent layer and an impervious layer on the opposite side of said absorbent layer.

59. An absorbent mat comprising a walking surface of the nonwoven web of claim 15 bonded to one side of an absorbent layer and an impervious layer on the opposite side of said absorbent layer.

60. Nonwoven web of claim 4 having apertures in said land areas.

61. Nonwoven web of claim 5 having apertures in said land areas.

62. Nonwoven web of claim 14 having apertures in said land areas.

63. Nonwoven web of claim 15 having apertures in said land areas.

64. Method of forming a nonwoven web comprising the steps of,

(a) depositing thermoplastic fibers or filaments as a web onto a forminous shaped surface,

(b) applying a pressure differential to said fibers or filaments while on said surface, to form an array of projections and land areas corresponding to said shaped surface,

(c) increasing the alignment of said fibers or filaments in the projection areas by at least 5 degrees, and

(d) separating said web from said surface.

65. Method of claim 64 wherein said pressure differential is applied to projections on said forminous surface.

66. Method of claim 64 wherein said pressure differential is applied to projection forming apertures in said forminous surface.

67. Method of claims 64, 65, or 66 including the step of aperturing said projections.

68. Method of claims 64, 65, or 66 including the step of aperturing said land areas.

69. Method of claim 67 including the step of aperturing said land areas.

70. Method of claim 65 including the additional step of densifying said land areas.

71. Method of claims 64, 65, or 66 including the additional step of covering said projections with a layer of absorbent fibers.

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**UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION**

PATENT NO. : 4,741,941

DATED : May 3, 1988

INVENTOR(S) : Stephen M. Englebert, Ann L. Wagner, Gregory S. Hafer
Nanette J. Logsdon

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

Column 1, Line 23 "automotive" should read --automotive--

Column 1, Line 67 "needing" should read --needling--

Column 2, Line 68 "porjections" should read --projections--

Column 3, Line 9 "denisty" should read--density--

Column 6, Line 4 "characteristics" should read --characteristic--

Column 6, Line 42 "give" should read --given--

Column 7, Line 36 "For for" should read --For--

Column 11, Line 37 "contracted" should read --contacted--

Column 11, Line 56 "for" should read --to--

Column 14, Line 39 "FIG. 5 was to form" should read --FIG. 5 was
used to form--

Column 15, Line 42 "with invention" should read --with the invention--

Column 16, Line 55, Claim 3 "theremo-" should read --thermo---

Column 18, Line 24, Claim 44 "air" should read --aid--

Column 18, Line 31, Claim 44 "person" should read --personal--

Column 11, Line 65 "Example 5" should be centered.

Signed and Sealed this

Twenty-first Day of February, 1989

Agent:

DONALD J. QUIGG

Attesting Officer

Commissioner of Patents and Trademarks



US005731062A

United States Patent [19]
Klin et al.

[11] Patent Number: 5,731,062
[45] Date of Patent: Mar. 24, 1998

141

[54] THERMOPLASTIC THREE-DIMENSIONAL FIBER NETWORK

[75] Inventors: Dai W. Klin, Chatham, N.J.; Joseph Steven Wiley Haas; William Edward Bessy, both of Charlotte, N.C.

[73] Assignee: Hoechst Celanese Corp., Somerville, N.J.

[21] Appl. No.: 577,655

[22] Filed: Dec. 22, 1995

[51] Int. Cl.⁶ B32B 1/00; B32B 7/00

[52] U.S. Cl. 428/175; 428/167; 428/178; 442/182; 442/197; 442/308

[58] Field of Search 428/174, 175, 428/166, 128, 212; 264/257, 258, 177; 442/181, 182, 189, 197, 304, 308

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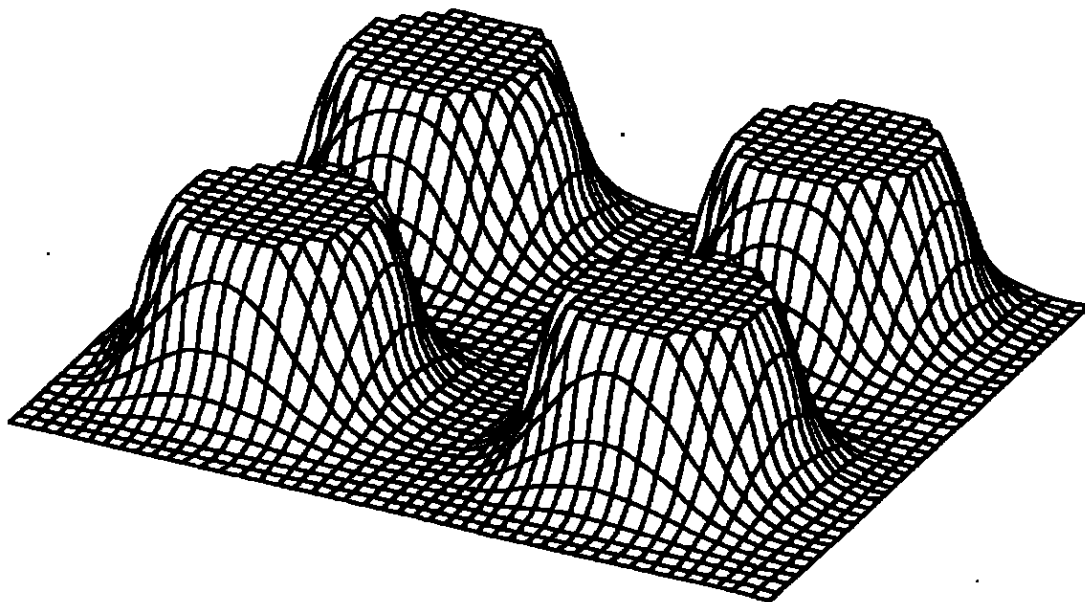
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Primary Examiner—Donald Loney
Attorney Agent, or Firm—James L. McGinnis

[57] ABSTRACT

Three dimensional fiber networks which are semi-rigid and dimensionally stable are made from textile fabrics that have projections and optional depressions which are compressible and return to their original shape after being compressed. The fiber networks are made by the thermo-mechanical deformation of textile fabrics that are in turn made from thermoplastic fibers. The fiber networks have particular utility as cushioning and impact absorbing materials.

17 Claims, 2 Drawing Sheets



142

FIG. 1

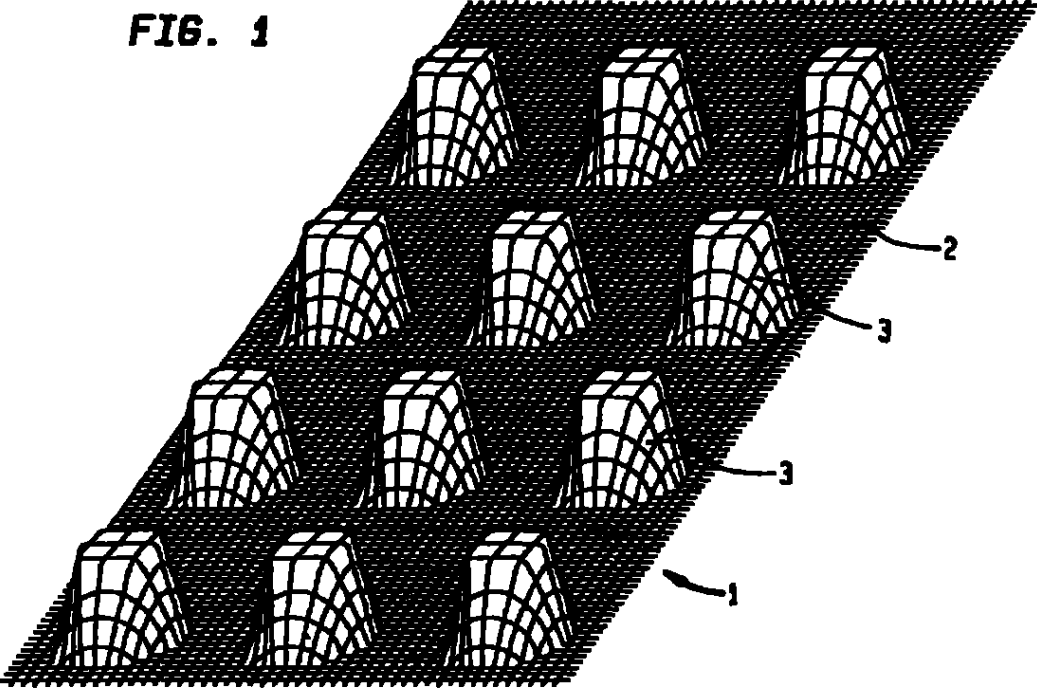
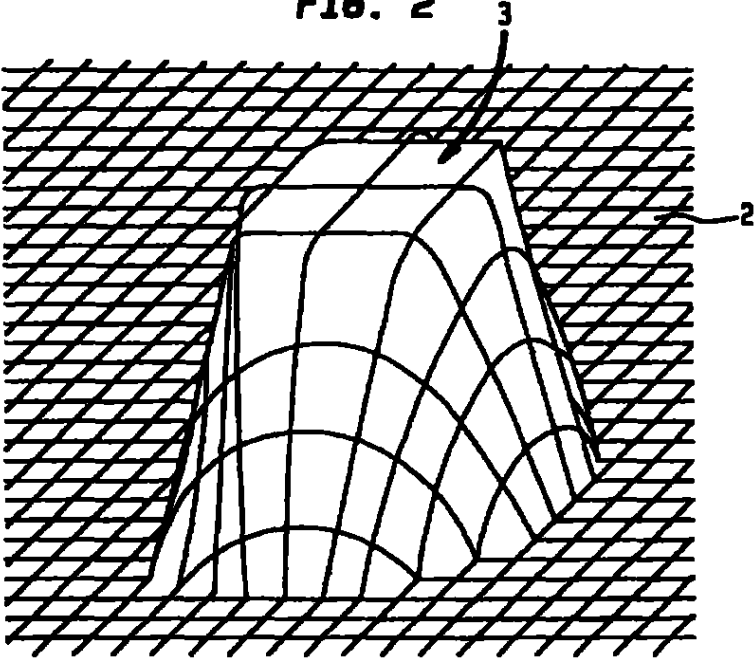


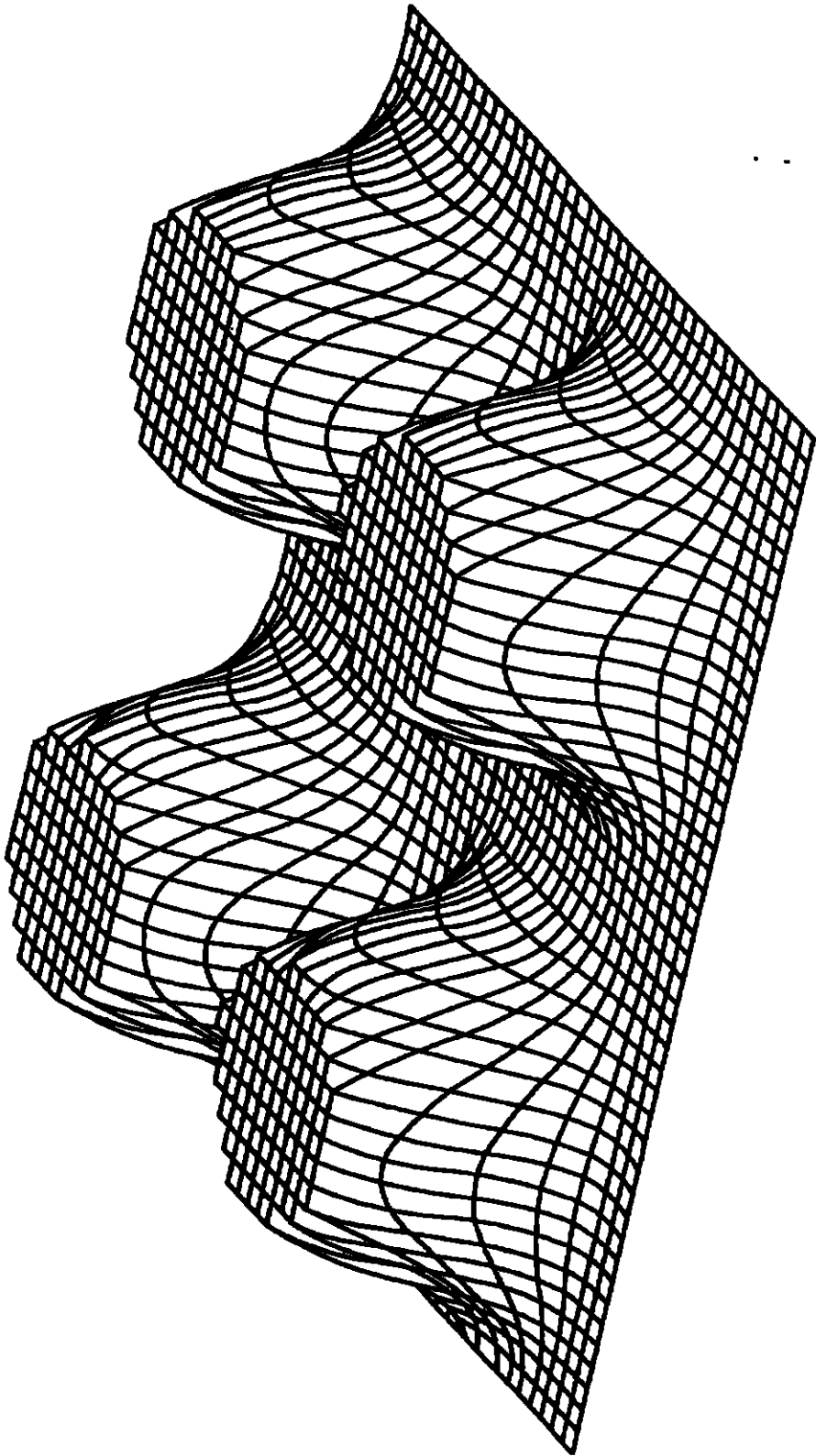
FIG. 2



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FIG. 3



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THERMOPLASTIC THREE-DIMENSIONAL FIBER NETWORK

FIELD OF THE INVENTION

This invention relates to three-dimensional networks of thermoplastic fibers.

BACKGROUND OF THE INVENTION

Three-dimensional fiber networks are known. These are generally derived from textile fabrics that have been impregnated with a thermoset polymer or a low melting thermoplastic and then molded into the desired shape. For example, U.S. Pat. No. 4,631,221 describes a laminate containing a rigid three-dimensional fiber network having regularly arranged projections. The three-dimensional network is placed between two sheets of rigid material. The three-dimensional network used in the laminate is made by the deep-drawing of a sheet-like textile fabric to make projections. The textile fabric was previously impregnated with a thermoset resin and dried to yield a pre-preg, and is cured after deep-drawing. The textile fabric is made from a multifilament yarn so that a larger amount of resin can be absorbed in the interfilament regions. U.S. Pat. No. 5,364,686 describes a three-dimensional shaped material which is made from a fabric comprising a yarn that has thermoplastic fibers mixed with higher melting reinforcing fibers; the fabric is shaped by deep drawing at a temperature high enough to melt the lower melting thermoplastic material but not the reinforcing fiber to yield a three-dimensional structure which becomes rigid after it is cooled, possibly due to the fixing of fiber crossover points. Finally, U.S. Pat. No. 4,890,877 describes an energy absorbing structure for use in automobile doors, wherein the energy absorbing structure is a highly stretchable lightweight material that has been coated with a resin (e.g. a thermoset) and then molded so that it has a series of projections, which are perfectly truncated cones. The structure after molding does not appear to have an open fiber network appearance.

The fiber network structures described above and elsewhere generally are rigid and are intended for use mainly as lightweight structural materials.

SUMMARY OF THE INVENTION

Three dimensional fiber network structures can be made that are semi-rigid and dimensionally stable, but have sufficient flexibility to be useful as cushioning materials. These fiber network structures are compressible, and when the compressive force is removed, the materials return to their original shape (i.e. they are resilient). These fiber network structures comprise filaments that are made of a single thermoplastic polymer and do not include a thermoset polymer. The networks are made up of a multiplicity of projections rising from the plane of the textile fabric from which the fiber network is made. Projections are portions of the textile fabric that rise above the base plane, generally in an abrupt way. Depressions, which are projections on the opposite side and in the opposite direction from the base plane, may optionally also be present. The projections and optional depressions have retained an open fabric-like appearance, consisting of discrete filaments which are generally not bonded at the intersections where the individual filaments cross over one another. There may be bonds at the intersections if the attachments are easily broken (i.e. they are not "tightly bonded") when the network is initially compressed, after which the network becomes resilient. The network is "resilient" if the projections and optional de-

2

pressions substantially recover their shape after being compressed to 50% of their height. However, there may be minor changes in the shapes of the projections and optional depressions, as for example a change in the curvature of the edges at the top of the projection. As the density of tight bonds at the points at which the fibers cross over one another increases, the fiber network structure and the projections become more rigid, and the projections lose their resiliency.

Because of the open structure of the textile fabric and the large void volume within the projections and/or depressions, the network has a low density compared with the polymer (generally less than about 10%, preferably less than about 5%) based on the amount of space occupied by the network. Air and other fluids can flow through the fiber network structure with little resistance. The filaments can be in the form of a monofilament having a diameter of at least about 0.1 mm, corresponding to about 100 dpf in the case of poly(ethylene terephthalate). The filaments used in the fiber networks can also be derived from multifilament yarns having approximately the same total diameter, provided that the individual filaments of the yarns have coalesced to larger filaments under heat and pressure during the shaping process, and further provided that the multifilament yarns have not become so firmly bonded at the points where they cross over one another that these bonds can't be broken when the fiber networks are compressed.

The fibers are made of a single thermoplastic polymer or copolymer (or optionally a blend or polymer alloy) that generally melts at a temperature in the range of about 80° C. to about 375° C. The fiber is not derived from hybrid yarn or bi-component fiber. The polymer is preferably made into fiber by a melt spinning process. Preferred classes of polymers include polyesters, polyamides, thermoplastic copoly-etherester elastomers, poly(arylene sulfides), polyolefins, aliphatic-aromatic polyamides, polyacrylates, and thermotropic liquid crystalline polymers.

The three-dimensional fiber network structure is generally made by deforming a textile fabric into the desired shape at a temperature high enough that the fibers can be permanently deformed, as would occur, for example, in a fiber drawing process. The temperature will generally be above the glass transition temperature (T_g), and, preferably will also remain below the melting temperature. The deformation is brought about using a thermomechanical process, which means the application of a mechanical force at an elevated temperature. The mechanical force can be applied using numerous methods, such as solid phase pressure forming, vacuum bladder match plate molding, interdigitation, deep drawing, use of a heated mold, and the like. Heat and pressure are applied for a sufficient time that the textile fabric is permanently deformed, but not for such a long time or at such a high temperature (e.g. well above the melting temperature) that the filaments coalesce, causing the shaped fiber network to lose its open net-like structure and resiliency. The individual filaments in the three-dimensional fiber network structure still have retained much of their individual fiber-like appearance and properties.

The starting two-dimensional textile fabric that is utilized in making the three-dimensional fiber network structure is selected from any of the standard classes of fabrics, such as knit, woven, or non-woven textile fabrics. The type of fabric depends on the kind of resulting network structure that is desired. Knit fabrics have the advantage that their structure is readily deformed without excessive elongation of individual fibers, which leads to breakage of the fibers. They are also drapable. Woven fabrics have the advantage that they are more readily produced from larger diameter fibers, such as monofil.

3

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows schematically a section of a three-dimensional fiber network structure 1 having a multiplicity of "bat-shaped" projections 3 on base area 2. The open mesh structure of the fiber network is illustrated. These illustrative bat-shaped projections have a square base and square top, with the top having smaller dimensions than the base.

FIG. 2 schematically depicts an enlargement of one of the bat shaped projections 3 of FIG. 1, showing the widening of the mesh structure of the textile material which occurs in the area that is deformed.

FIG. 3 schematically depicts an enlargement of four projections that are in the shape of truncated cones.

DETAILED DESCRIPTION OF THE INVENTION

The three-dimensional fiber networks that have particular utility as cushioning materials are made up of a multiplicity of projections on the plane of the textile fabric from which the network is made. Depressions may optionally also be present on the opposite side of the fabric from the projections. Examples of three-dimensional fiber networks and methods of making them are summarized in U.S. Pat. Nos. 5,364,686 and 4,631,221, herein incorporated by reference. The projections and optional depressions can be in the shape of cones or truncated cones, pyramids or truncated pyramids having polygonal bases, cylinders, prisms, spherical elements, and the like. Generally, the apex points or surfaces of the projections define a plane parallel to the base plane. Similarly if there are also depressions, their apex points or surfaces define a second surface, such as a plane parallel to the base plane. As a result, the preferred three-dimensional networks define two surfaces or planes, one being defined by the tops of the projections and the other being defined by the depressions. Furthermore, the projections and optional depressions are generally arranged in a uniform or repetitive pattern with a uniform spacing. However, the shapes, heights, sizes and spacings of the projections and optional depressions can be modified to suit a specific application. For example, they may vary to conform to a specific shape, such as the shape of the human foot for use in shoes, and they may vary in rigidity to increase or decrease their weight-bearing capacity. The projections and/or depressions can also be elongated along one direction of the plane, and in the extreme case, can run the entire length or width of the textile, in which case the projections are really corrugations, like those typically seen in cardboard. Non-corrugated structures are preferred for most applications.

The sizes, heights, shapes and spacings of the pattern of projections and depressions affect the cushioning properties and "feel" of the three-dimensional networks. The rigidity of the individual fibers in the network structure also is a major factor in determining the cushioning properties of the three-dimensional networks, and the rigidity of the fibers in turn depends on the diameter of the filaments and the kind of materials (e.g. polymers) from which the filaments are made. For most applications, filament diameters are in the range of about 0.15 mm to about 0.7 mm. An example of a preferred structure of regularly spaced projections having a square base and a square top that has shorter sides than the base is shown in FIG. 1. Another preferred structure consists of a regular array of projections which are truncated cones of similar size and shape, as shown in FIG. 3, for example.

The polymers used as filaments in the three-dimensional fiber networks consist essentially of a single thermoplastic

4

polymer rather than composites of a reinforcing fiber and a matrix polymer, such as a thermoset, which have been utilized previously for making rigid networks. The polymers may include minor amounts of additives, such as flame retardants, spinning lubricants, and the like. The thermoplastic polymers generally have a melting temperature in the range of about 80° C. to about 375° C., preferably about 150° C. to about 350° C. Thermoplastic polymers that are preferred include: (1) polyesters of alkylene glycols having 2-10 carbon atoms and aromatic diacids. Poly(alkylene terephthalates), especially poly(ethylene terephthalate) and poly(butylene terephthalate), are particularly preferred. Also preferred are poly(alkylene naphthalates), which are polyesters of 2,6-naphthalenedicarboxylic acid and alkylene glycols, as for example poly(ethylene naphthalate); (2) thermoplastic copolyetherester elastomers, described in more detail below; (3) polyamides, especially nylon 6 and nylon 66, which are commonly used in making fibers; (4) poly(arylene sulfides), especially poly(phenylene sulfide); (5) polyolefins, particularly polyethylene and polypropylene; (6) aliphatic aromatic polyamides, such as polyamides derived from terephthalic acid and 2-methyl-1,5-pentanediamine; (7) polyesters derived from 1,4-cyclohexanedicarboxylic acid and terephthalic acid; and (8) thermotropic liquid crystalline polymers, such as for example polyesters derived from 6-hydroxy-2-naphthoic acid and 4-hydroxybenzoic acid.

Specific preferred polymers include poly(ethylene terephthalate) (PET), thermoplastic copolyetherester elastomers, nylon 6 and 66, and polypropylene. PET is widely available from many manufacturers, including Hoechst Celanese Corporation, Somerville, N.J. The PET should be of high enough molecular weight to be suitable for spinning into fibers; generally a molecular weight corresponding to an intrinsic viscosity (I.V.) of at least about 0.6 dl/gm is suitable, where the I.V. is determined by measuring the relative viscosity of a 4% solution (weight/volume) in o-chlorophenol at 25° C. The relative viscosity is then converted to intrinsic viscosity. Polypropylene and nylons are also widely available from many manufacturers.

Thermoplastic copolyetherester elastomers, also referred to as thermoplastic elastomers, consist essentially of a multiplicity of recurring long chain ester units and short chain ester units joined head-to-tail through ester linkages. The long chain ester units are made up of poly(alkylene oxide) glycol units attached by way of ester linkages to terephthalic and/or isophthalic acid. The short chain ester units are the product of the reaction of a short chain glycol with isophthalic and/or terephthalic acid. The short chain ester units make up about 15% to about 95% by weight of the thermoplastic elastomer. Thermoplastic elastomers used in making the three-dimensional fiber networks are well known and are described in numerous references, including U.S. Pat. Nos. 3,023,192, 3,651,014, 3,763,109, 3,766,146, 3,784,320, 4,355,153, 4,405,749 and 4,520,150. Poly(tetramethylene oxide) glycol, also known as poly-THF, is the preferred poly(alkylene oxide) glycol for the long chain ester units. The preferred glycol in the short chain ester units is a mixture of 1,4-butanediol with up to about 40% by weight of 1,4-butanediol. Most preferably, the short chain glycol is only 1,4-butanediol. The preferred aromatic diacid used in making the short and long chain ester units is terephthalic acid containing up to about 20% isophthalic acid. Most preferably, terephthalic acid is the only diacid that is present. Thermoplastic copolyetherester elastomers that are composed of long chain ester units of poly-THF and terephthalic acid and short chain ester units

5

of 1,4-butanediol and terephthalic acid are commercially available from Hoechst Celanese Corporation under the RITFLEX® trademark.

Many of the polymers listed above, such as PET and nylon are flammable. Since many of the uses of these materials are in vehicles, homes, furniture, and apparel, the polymers will often need to have a flame retardant additive included. Most flame retardants come from one of six chemical classes: aluminum trihydride; organochlorine compounds; organobromine compounds; organophosphorus (including halogenated phosphorus) compounds; antimony oxides; and boron compounds. Flame retardants can also be divided into additives which are blended with the substrate, and reactives, which are chemically bound to the substrate during polymerization in a separate step. Polymers that contain reactives as comonomers may contain up to about 10 mole % of the flame retardant monomers in the polymer composition. Other kinds of flame retardants that are sometimes used include intumescent coatings, sulfur or sulfur compounds (e.g. ammonium sulfamate and thiourea compounds) and oxides and carbonates of bismuth, tin, iron, and molybdenum. All of the above classes and kinds of flame retardants are reviewed in an article entitled "Flammability," by R. G. Gema, et al., in *Encyclopedia of Polymer Science and Engineering*, Second Edition, Volume 7, John Wiley and Sons, New York, 1967, pages 184-195. For PET, the preferred flame retardant is a reactive phosphorus compound that is incorporated into the polymer structure during polymerization and is available from Hoechst AG under the name Oxa-phospholane (a solid) or Oxa-phospholane Glycol Ester (a solution). The Oxa-phospholane products contain 2-carboxyethylmethylphosphinic acid as the free acid or as one or more ethylene glycol esters and diesters of the phosphinic acid. The 2-carboxyethylmethylphosphinic acid is incorporated into the polyester backbone at a level of up to about 5% of the polyester monomer units and acts as a flame retardant. The reactive phosphinic acid and its use as a flame retardant monomer are in U.S. Pat. Nos. 4,033,936 and 3,941,752, incorporated herein by reference.

The spacing, size, height, and shape of the projections and optional depressions, the diameter of the filaments, and fabric construction are chosen to give the desired cushioning properties for the specific application. The shapes of the deformations also depend on the process used to make them. For example, in a deformation process in which the textile fabric is held against a plate with round holes and a cylindrical rod is pushed through the hole on the same side as the textile fabric, so that the textile fabric is pushed through the hole, the projections that are made in the textile fabric will be in the shape of truncated cones (i.e., the base and top of the projections will both be round), with the diameter of the top of the cone being the diameter of the rod that pushes the textile through the hole. Similarly, if a plate with square holes and a rod with a square cross section is used, the projections will be "bat-shaped".

The fiber networks described herein are lightweight, durable and breathable. They are springy and resilient which means that they can be compressed (preferably repeatedly) without a significant loss in properties. Depending on the stiffness of the fibers and the sizes of the projections, they may be used as cushioning materials, as impact absorbing materials, or as semi-rigid support materials. Because they are generally made of only one polymer, such as PET, they can be easily recycled after use with other recyclable plastics, (e.g. bottles in the case of PET). The fiber network materials can be used as single layers, they can be nested

6

face to face, with the projections interlocking, or they can be stacked with the projections of one layer against the base plane of the next layer or with the base planes of the two layers against each other to provide thicker spacers and cushions. The materials having more than one layer can be bonded together by such methods as adhesive bonding or ultrasonic welding. The fiber network structures can be used as components or sub-components in numerous applications, including mattresses, mattress topper pads, infant mattresses and mattress covers to prevent suffocation, footwear, (sock liners, collar linings, and insoles for shoes), pads for protective head gear, seat cushions such as for example automobile seats, wrappings for medical casts, protective linings, protective helmet liners, space-bound barriers for wall partitions and panels, protective packaging for electronics, automotive headliners which provide head cushioning and channels for wiring, liners for athletic and outdoor clothing, carpet pads, liners for women's brassieres and men's athletic supporters, and cushions for outdoor furniture, which dry easily and don't retain moisture. The invention is further described in the following non-limiting examples.

EXAMPLES

Example 1

RITFLEX®640 copolyetherester elastomer having a melting temperature of about 180° C., obtained from Hoechst Celanese Corporation, was melt spun to yield a 0.20 mm (435 denier) monofil having the following properties. The fiber tenacity was measured by ASTM Test Method D-3822 as 2.8 gpd, with 98% elongation at break. The elastic recovery of the fiber was measured by the same test method as 100% after 100 cycles at either 20% or 50% elongation. The monofil was knitted into a textile fabric having a wale of 8 wales/inch and a welt of 42 courses/inch.

The knit fabric was shaped into a three-dimensional structure by using a heated press plate. The press plate was a metallic plate having 1/4 inch diameter holes, and was heated to about 160°-230° C. The fabric was pressed against the heated plate for 9 seconds, and pins that were 1/4 inch in diameter were then pushed through the holes. This yielded truncated cone shaped projections on the fabric which were about 1/4 inch in diameter at the base and 1/4 inch in diameter at the top. The projections were about 1/8 inches in height and were spaced in a square grid array with the nearest distance between the projections (center to center) being about 3/4 inch.

This shaped fiber network had a soft springy feel and could be repeatedly compressed without a loss of springiness.

Example 2

RITFLEX®672 thermoplastic copolyetherester elastomer, which melts at about 205° C., was obtained from Hoechst Celanese Corporation, and was melt spun into 823 denier monofil (about 0.28 mm in diameter). The tenacity at break of the fiber was 2.4 gpd, and it had an elongation at break of 87%, as measured by ASTM Test Method D-3822. The elastic recovery of the fiber, measured by the same method, was 100% after 100 cycles at either 20% or 50% elongation.

The fiber was knitted into a fabric having the same wale and welt as that in Example 1. The fabric was deformed into a three-dimensional network using the press plate apparatus of Example 1 under the same conditions as in Example 1.

This shaped fiber network also had a soft springy feel and could be repeatedly compressed without a loss of springiness.

Example 3

Commercial PET that was made for use in textile fabrics was spun into a 0.182 mm monofil (about 321 denier). The monofil was then made into a plain knit fabric with 16 wales and 24 courses per inch.

The fabric samples were deformed into a three-dimensional network using a similar kind of apparatus as described in Example 1, but having 1/4 inch holes in the press plate and 1/4 inch diameter cylindrical pins to yield conical projections with flat tops. The base and tops of the projections were the same as the diameter of the holes in the base plate and the diameter of the pins. The projections were arranged in a square grid array and were separated by 1/4 inch (center to center). The height of the projections was about 1/4 inch. The projections were made by heating the base plate and the pins to 240° C. and pressing the fabric through the holes for about 30 seconds. The deformed fabric was resilient and had a comfortable, springy feel when pressed down by hand, and retained its feel even after multiple compressions.

Example 4

A series of poly(ethylene terephthalate) (PET) fabric samples (both knit and woven) were made into three dimensional fiber network materials by the method of pressing the fabric against a heated base plate having a square grid array of evenly spaced holes at about 200° C. for two minutes and then pushing the fabric through holes in the base plates using cylindrical pins that were heated to about 180° C. The pins were kept in place (projected through the holes at temperature) for 15 seconds before being withdrawn, except in Sample No. 4 (below), where the pins were kept in place for 600 seconds. This resulted in three-dimensional networks of cone-shaped projections with flat tops which were evenly spaced and in which the bases of the projections had the diameter of the holes and the tops of the projections had the diameter of the pins. The heights of the projections (the

thickness of the samples) was somewhat less than the depth of the penetrations through the holes by the pins due to shrinkage after the mechanical force was removed. Both knit and woven fabrics were tested.

These samples were subjected to compression tests using a modification of methods that are used for polyurethane foams and latex foams. Samples of the materials were placed between the plates of an Instron tensile tester and then pre-loaded to a load of 0.02 psi. The distance between the plates at 0.02 psi of compression was defined as the thickness of the sample. The samples were then compressed to 60% compression for two cycles at test speeds of 0.2 in/min for samples 0.10–0.29 inches in thickness, 0.5 in/min for samples 0.30–0.69 inches in thickness, and 1.0 in/min for samples 0.70–1.39 inches in thickness. The two pre-cycles above made a significant change in two of the samples (Nos. 4 and 6 in Table 1); the precycling measurements are also reported for these two samples. Six minutes after the precycling above, a compression test was run to 60% compression at the same speed as in the pre-cycling. Stress and percent compression were measured, and the stress at 25% and 50% compression was measured. These values are recorded in Table I, along with the averages for runs where there were duplicate measurements. These measurements show an increase in stress with increasing compression, which is a characteristic that is desirable for cushioning applications.

The apparent volume was computed based on the thickness as measured at 0.02 psi above and the measured dimensions of the sample. This was used to compute the apparent density, which ranged from 0.016 to 0.067 gme/cc. By comparison solid PET has a density of about 1.4 gme/cc. Thus the apparent density of the three dimensional fiber network is less than about 5% of the density of solid PET (1.1%–4.9% in these examples). The apparent densities of the samples in gme/cc are also listed in Table 1; these can be converted to nondens. ft. by multiplying by 62.4.

It is to be understood that the above embodiments of the invention are illustrative only and that modification throughout may occur to one skilled in the art. Accordingly, this invention is not to be regarded as limited to the embodiments disclosed herein.

TABLE 1

Compression Tests.									
Sample No.	Fabric Type ⁽¹⁾	Penetration (inches)	Fiber Diameter (mm)	Moisture Thickness ⁽²⁾ (inches)	Network Spacing ⁽³⁾ (inches)	Apparent Density (gm/cc)	Specimen No.	Stress @ 25% Compression (psi)	Stress @ 50% Compression (psi)
1	Woven 37 x 37	0.383	0.25	0.195	1/4 x 1/4 x 1	0.047	1	1.07	1.73
							2	1.11	1.73
							avg	1.09	1.73
2	Woven 20 x 20	0.313	0.40	0.200	1/4 x 1/4 x 1	0.063	1	2.23	2.26
							2	2.32	3.37
							avg	2.27	3.31
3	Knit	0.363	0.20	0.345	1/4 x 1/4 x 1	0.023	1	0.37	0.79
							2	0.20	0.83
							avg	0.28	0.81
4	Knit	0.363	0.20	0.495	1/4 x 1/4 x 1	0.016	1	0.33	0.80
							2	0.35	0.80
							3	0.83	1.00
							— ⁽⁴⁾	—	—
5	Woven 37 x 37	0.188	0.25	0.140	1/4 x 1/4 x 1/4	0.064	1	3.44	8.01
							2	3.68	9.09
							avg	3.56	8.55
6	Woven 20 x 20	0.188	0.40	0.195	1/4 x 1/4 x 1/4	0.067	1	13.73	23.45
							2	20.31	34.07
							— ⁽⁴⁾	—	—

14.8

TABLE 1-continued

Compression Tests									
Sample No.	Fabric Type ⁽¹⁾	Projections (inches)	Fiber Diameter (mm)	Measured Thickness ⁽²⁾ (inches)	Network Spacing ⁽³⁾ (inches)	Apparent Density (g/cm ³)	Specimen No.	Stress @ 25% Compression (psi)	Stress @ 50% Compression (psi)
7	Knot	0.013	0.20	0.095	1/4 x 1/4 x 1/4	0.040	1	1.11	2.88
							2	1.11	3.04
							avg	1.11	3.01

⁽¹⁾The knot fabric was a plain Jersey knit having approximately 17 wale/inch and approximately 38 course/inch. For the woven fabric, the units are given in yards per inch.
⁽²⁾At 0.62 psi.
⁽³⁾Diameter at top of projection x diameter at bottom of projection x spacing (center to center), in inches.
⁽⁴⁾Pre-cycling significantly changes load curve characteristics. Specimens #1 and #2 were run with pre-cycling. Specimen #3 was run without pre-cycling.
⁽⁵⁾Pre-cycling significantly changes load curve characteristics. Specimen #1 was run with pre-cycling. Specimen #2 was run without pre-cycling.

We claim:

1. A three-dimensional fiber network consisting of a textile fabric having a multiplicity of compressible projections having a shape selected from the group consisting of cones, truncated cones, pyramids having polygonal bases, truncated pyramids having polygonal bases, cylinders, prisms, spherical elements, and mixtures thereof which return substantially to their original shape after being compressed by 50%, said textile fabric comprising thermoplastic filaments, said filaments having a diameter of at least about 0.1 mm, said filaments in said fabric crossing over one another at intersections, said filaments at said intersections not being bonded, wherein said textile fabric is selected from the group consisting of knit and woven fabrics.

2. The fiber network recited in claim 1, said projections having apex points or flat tops, wherein said apex points or flat tops define a surface.

3. The fiber network recited in claim 1, wherein said thermoplastic filaments are monofila.

4. The fiber network recited in claim 1, wherein said thermoplastic filaments consist essentially of a thermoplastic polymer having a melting temperature in the range of about 80° C. to about 375° C.

5. The fiber network recited in claim 1, wherein the apparent density of said fiber network is less than about 10% of the density of said thermoplastic fiber.

6. The fiber network recited in claim 4, wherein said thermoplastic polymer is selected from the group consisting of polycarbon, polyanides, thermoplastic copolyetherester elastomers, poly(arylene sulfides), polyolefins, aliphatic-aromatic polyamides, polyacrylates, and thermoplastic liquid crystalline polymers.

7. The fiber network recited in claim 4, wherein said thermoplastic polymer is a thermoplastic copolyetherester

elastomer comprising long chain ether ester units and short chain ester units joined head-to-tail through ester linkages.

8. The fiber network recited in claim 7 wherein said long chain ether ester units consist essentially of the residues of poly(tetramethylene oxide) glycol and terephthalic acid and said short chain ester units consist essentially of the residues of 1,4-butanediol and terephthalic acid.

9. The fiber network recited in claim 4, wherein said thermoplastic polymer is poly(ethylene terephthalate).

10. The fiber network recited in claim 4, wherein said thermoplastic polymer is selected from polypropylene, nylon 6, or nylon 66.

11. The fiber network recited in claim 1, wherein said network also comprises depressions.

12. The fiber network recited in claim 11, said depressions having apex points or flat tops, wherein said apex points or flat tops define a surface.

13. The fiber network recited in claim 1, said filaments having a diameter in the range of about 0.15 mm to about 0.7 mm.

14. The fiber network recited in claim 4, wherein said thermoplastic polymer contains a flame retardant.

15. The fiber network recited in claim 9, wherein said poly(ethylene terephthalate) comprises up to about 5% of monomer units that contain phosphorus.

16. The fiber network as recited in claim 1, wherein said thermoplastic filaments comprise multifilament yarns that have condensed to form said thermoplastic filaments.

17. The fiber network as recited in claim 1, wherein said thermoplastic filaments do not include a thermoset resin.

* * * * *



149

UNITED STATES PATENT AND TRADEMARK OFFICE

UNDER SECRETARY OF COMMERCE FOR INTELLECTUAL PROPERTY AND
DIRECTOR OF THE UNITED STATES PATENT AND TRADEMARK OFFICE

DECEMBER 05, 2003

PTAS



102477471A

JENKINS, WILSON & TAYLOR, P.A.
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DURHAM, NC 27707

UNITED STATES PATENT AND TRADEMARK OFFICE
NOTICE OF RECORDATION OF ASSIGNMENT DOCUMENT

THE ENCLOSED DOCUMENT HAS BEEN RECORDED BY THE ASSIGNMENT DIVISION OF THE U.S. PATENT AND TRADEMARK OFFICE. A COMPLETE MICROFILM COPY IS AVAILABLE AT THE ASSIGNMENT SEARCH ROOM ON THE REEL AND FRAME NUMBER REFERENCED BELOW.

PLEASE REVIEW ALL INFORMATION CONTAINED ON THIS NOTICE. THE INFORMATION CONTAINED ON THIS RECORDATION NOTICE REFLECTS THE DATA PRESENT IN THE PATENT AND TRADEMARK ASSIGNMENT SYSTEM. IF YOU SHOULD FIND ANY ERRORS OR HAVE QUESTIONS CONCERNING THIS NOTICE, YOU MAY CONTACT THE EMPLOYEE WHOSE NAME APPEARS ON THIS NOTICE AT 703-308-9723. PLEASE SEND REQUEST FOR CORRECTION TO: U.S. PATENT AND TRADEMARK OFFICE, ASSIGNMENT DIVISION, BOX ASSIGNMENTS, CG-4, 1213 JEFFERSON DAVIS HWY, SUITE 320, WASHINGTON, D.C. 20231.

RECORDATION DATE: 06/16/2003

REEL/FRAME: 014176/0804
NUMBER OF PAGES: 6

BRIEF: ASSIGNMENT OF ASSIGNOR'S INTEREST (SEE DOCUMENT FOR DETAILS).

ASSIGNOR:

POURDEYHIMI, BEHNAM

DOC DATE: 05/28/2003

ASSIGNOR:

LITTLE, TREVOR J.

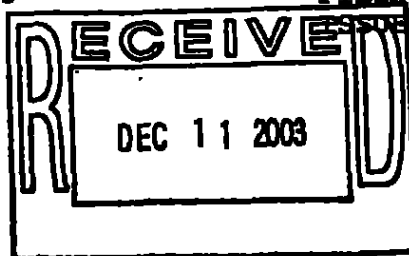
DOC DATE: 05/28/2003

ASSIGNEE:

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SERIAL NUMBER: 60467943
PATENT NUMBER:

FILING DATE: 05/05/2003
ISSUE DATE:



DOCKET DATES: N/A
ASSIGNED ATTY: EEJ
FILE NO. 297168 PROV
DOCKETED BY: HMD
DATE: 12/11/03

014176/0804 PAGE 2

150

JEFFREY OLSEN, EXAMINER
ASSIGNMENT DIVISION
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151

Form PTO-1595 (Rev. 10/02) OMB No. 0651-0027 (exp. 6/30/2005) Tab settings $\Rightarrow \Rightarrow \Rightarrow$		06-19-2003 102477471	U.S. DEPARTMENT OF COMMERCE U.S. Patent and Trademark Office
To the Honorable Commissioner of Patents		original documents or copy thereof.	
1. Name of conveying party(ies): Behnam Pourdeyhimi Trevor J. Little Additional name(s) of conveying party(ies) attached? ☐ Yes ☒ No		2. Name and address of receiving party(ies) Name: <u>North Carolina State University</u> Internal Address: <u>Office of Technology Transfer</u> Street Address: <u>Campus Box 8210</u> City: <u>Raleigh</u> State: <u>NC</u> Zip: <u>27695-8210</u> Additional name(s) & address(es) attached? ☐ Yes ☒ No	
3. Nature of conveyance: ☒ Assignment ☐ Merger ☐ Security Agreement ☐ Change of Name ☐ Other _____ Execution Date: <u>May 28, 2003</u>		4. Application number(s) or patent number(s): If this document is being filed together with a new application, the execution date of the application is _____ A. Patent Application No.(s) <u>60/467,943</u> B. Patent No.(s) _____ Additional numbers attached? ☐ Yes ☒ No	
5. Name and address of party to whom correspondence concerning document should be mailed: Name: <u>Richard E. Jenkins</u> Internal Address: <u>Jenkins, Wilson & Taylor, P.A.</u> Street Address: <u>Suite 1400 University Tower</u> <u>3100 Tower Boulevard</u> City: <u>Durham</u> State: <u>NC</u> Zip: <u>27707</u>		6. Total number of applications and patents involved ☒ 7. Total fee (37 CFR 3.41).....\$40.00 ☐ Enclosed ☒ Authorized to be charged to deposit account 8. Deposit account number: <u>50-0426</u> (Attach duplicate copy of this page if paying by deposit account)	
DO NOT USE THIS SPACE			
9. Statement and signature. <i>To the best of my knowledge and belief, the foregoing information is true and correct and any attached copy is a true copy of the original document.</i> Name of Person Signing: <u>Richard E. Jenkins</u> Signature: <u>Richard E. Jenkins</u> Date: <u>6-12-03</u> Total number of pages including cover sheet, attachments, and documents: <u>4</u>			

Mail documents to be recorded with required cover sheet information to:
Commissioner of Patents & Trademarks, Box Assignments
Washington, D.C. 20231

152

PATENT

Atty Docket: 297/166 PROV

ASSIGNMENT

WHEREAS, we, Behnam Pourdeyhimi, of Cary, North Carolina; and Trevor J. Little of Cary, North Carolina (hereinafter "Assignors"), have invented certain new and useful improvements in THREE DIMENSIONAL DEEP MOLDED STRUCTURES WITH ENHANCED PROPERTIES for which application for a U.S. Patent was made on May 5, 2003 as U.S. Provisional Patent Application Serial No. 60/467,943.

AND, WHEREAS, North Carolina State University, a non-profit organization located at Raleigh, North Carolina (hereinafter "Assignee"), is desirous of acquiring an interest therein.

NOW, THEREFORE, To Whom It May Concern, be it known that for good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, Assignors have sold and by these presents do hereby sell, assign, transfer and convey unto the said Assignee, its successors and assigns, their entire right, title and interest in and to the said invention and application, and in and to any and all United States patent applications filed pursuant to 35 U.S.C. § 111(a) pertaining to said invention and/or which claim priority to the United States provisional patent application referenced above, and in and to any and all foreign patent applications filed on the invention, and in and to any and all continuations, continuations-in-part, or divisions of any U.S. or foreign patent application filed on the invention, and in and to any and all Letters Patent of the United States of America and all foreign countries or reissues thereof which may be granted therefor or thereon, for the full end of the term for which said Letters Patent may be granted, together with their right to claim the priority of said application in all foreign countries in accordance with the International Convention, the same to be held and enjoyed by said Assignee, its successors and assigns, as fully and entirely as the same would have been held and enjoyed by Assignors if this assignment and sale had not been made.

Assignors further covenant and agree that, at the time of the execution and delivery of these presents, Assignors possess full title to the invention and application above-mentioned, and that they have the unencumbered right and authority to make this assignment.

153

Assignors further covenant and agree, and likewise bind their heirs, legal representatives and assigns, to promptly communicate to said Assignee or its representatives any facts known to them relating to said invention, to testify in any interference or legal proceedings involving said invention, to execute any additional papers which may be requested to confirm the right of the Assignee, its representatives, successors and assigns to secure patent or similar protection for the said invention in all countries and to vest in the Assignee complete title to the invention and Letters Patent, without further compensation, but at the expense of said Assignee, its successors, assigns and other legal representatives.

Executed this 14th day of May 2003.

B. Pourdeylimi
Behnam Pourdeylimi

Witnessed by:

Don Ooley 5.14.03
Name Date

Kathy Powell 5/14/03
Name Date

154

Executed this 28 day of May 2003.

Trevor J. Little
Trevor J. Little

Witnessed by:

A. Jessica Owens 5/28/03
Name Date

Kam Bupples 5/28/03
Name Date

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum) 297/168 PCT

155

Box No. I TITLE OF INVENTION

THREE-DIMENSIONAL DEEP MOLDED STRUCTURES WITH ENHANCED PROPERTIES

Box No. II APPLICANT

☐ This person is also inventor

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

NORTH CAROLINA STATE UNIVERSITY
2401 Research Drive, Suite 1122
Campus Box 8210
Raleigh, NC 27695-8210
UNITED STATES OF AMERICA

Telephone No.

001-919-515-7199

Facsimile No.

001-919-515-3773

Teleprinter No.

Applicant's registration No. with the Office

State (that is, country) of nationality:

US

State (that is, country) of residence:

US

This person is applicant for the purposes of:

☐ all designated States

☒ all designated States except the United States of America

☐ the United States of America only

☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

POURDEYHIMI, Behnam
108 Tropez Lane
Cary, NC 27511
UNITED STATES OF AMERICA

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only (If this check-box is marked, do not fill in below.)

Applicant's registration No. with the Office

State (that is, country) of nationality:

US

State (that is, country) of residence:

US

This person is applicant for the purposes of:

☐ all designated States

☐ all designated States except the United States of America

☒ the United States of America only

☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:

☒ agent

☐ common representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

JENKINS, Richard E.
Jenkins, Wilson & Taylor, P.A.
Suite 1400 University Tower
3100 Tower Boulevard
Durham, NC 27707
UNITED STATES OF AMERICA

Telephone No.

001-919-493-8000

Facsimile No.

001-919-419-0383

Teleprinter No.

Agent's registration No. with the Office

28,428

☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

156

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
<i>If none of the following sub-boxes is used, this sheet should not be included in the request.</i>	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> LITTLE, Trevor J. 317 Glen Echo Lane Cary, NC 27511-8416 UNITED STATES OF AMERICA	This person is: ☐ applicant only ☒ applicant and inventor ☐ inventor only <i>(If this check-box is marked, do not fill in below.)</i> Applicant's registration No. with the Office
State (that is, country) of nationality: US	State (that is, country) of residence: US
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> 	This person is: ☐ applicant only ☐ applicant and inventor ☐ inventor only <i>(If this check-box is marked, do not fill in below.)</i> Applicant's registration No. with the Office
State (that is, country) of nationality:	State (that is, country) of residence:
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> 	This person is: ☐ applicant only ☐ applicant and inventor ☐ inventor only <i>(If this check-box is marked, do not fill in below.)</i> Applicant's registration No. with the Office
State (that is, country) of nationality:	State (that is, country) of residence:
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> 	This person is: ☐ applicant only ☐ applicant and inventor ☐ inventor only <i>(If this check-box is marked, do not fill in below.)</i> Applicant's registration No. with the Office
State (that is, country) of nationality:	State (that is, country) of residence:
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box	
☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.	

157

Box No. V DESIGNATIONS

The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.

However,

- ☐ DE Germany is not designated for any kind of national protection
- ☐ KR Republic of Korea is not designated for any kind of national protection
- ☐ RU Russian Federation is not designated for any kind of national protection

(The check-boxes above may be used to exclude (irrevocably) the designations concerned in order to avoid the causing of the effect, under the national law, of an earlier national application from which priority is claimed. See the Notes to Box No. V as to the consequences of such national law provisions in these and certain other States)

Box No. VI PRIORITY CLAIM

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country or Member of WTO	regional application:* regional Office	international application: receiving Office
item (1) 05 May 2003 (05.05.03)	60/467,943	US		
item (2) 04 February 2004 (04.02.04)	10/771,924	US		
item (3)				

☐ Further priority claims are indicated in the Supplemental Box.

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office) identified above as:

☒ all items ☐ item (1) ☐ item (2) ☐ item (3) ☐ other, see Supplemental Box

* Where the earlier application is an APIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)):

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):

ISA /US

Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):

Date (day/month/year) Number Country (or regional Office)

Box No. VIII DECLARATIONS

The following declarations are contained in Boxes Nos. VIII (i) to (v) (mark the applicable check-boxes below and indicate in the right column the number of each type of declaration):

Number of
declarations

- | | | |
|---|--|---|
| ☐ Box No. VIII (i) | Declaration as to the identity of the inventor | : |
| ☐ Box No. VIII (ii) | Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent | : |
| ☐ Box No. VIII (iii) | Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application | : |
| ☐ Box No. VIII (iv) | Declaration of inventorship (only for the purposes of the designation of the United States of America) | : |
| ☐ Box No. VIII (v) | Declaration as to non-prejudicial disclosures or exceptions to lack of novelty | : |

158

Box No. IX CHECK LIST; LANGUAGE OF FILING

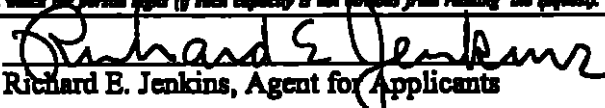
This international application contains:	This international application is accompanied by the following item(s) (mark the applicable check-boxes below and indicate in right column the number of each item):	Number of items
(a) In paper form, the following number of sheets:	1. ☒ fee calculation sheet	: 1
request (including declaration sheets) : 4 sheets	2. ☐ original separate power of attorney	:
description (excluding sequence listings and/or tables related thereto) : 13 sheets	3. ☒ original general power of attorney	: 1
claims : 5 sheets	4. ☒ copy of general power of attorney; reference number, if any:	: 1
abstract : 1 sheet	5. ☐ statement explaining lack of signature	:
drawings : 9 sheets	6. ☐ priority document(s) identified in Box No. VI as item(s):	:
Sub-total number of sheets : 32	7. ☐ translation of international application into (language):	:
sequence listings :	8. ☐ separate indications concerning deposited microorganism or other biological material	:
tables related thereto :	9. ☐ sequence listings in computer readable form (indicate type and number of carriers)	:
(for both, actual number of sheets if filed in paper form, whether or not also filed in computer readable form; see (c) below)	(i) ☐ copy submitted for the purposes of international search under Rule 13ter only (and not as part of the international application) :	:
Total number of sheets : 32	(ii) ☐ (only where check-box (b)(i) or (c)(i) is marked in left column) additional copies including, where applicable, the copy for the purposes of international search under Rule 13ter :	:
(b) ☐ only in computer readable form (Section 801(a)(i))	(iii) ☐ together with relevant statement as to the identity of the copy or copies with the sequence listings mentioned in left column :	:
(i) ☐ sequence listings	10. ☐ tables in computer readable form related to sequence listings (indicate type and number of carriers)	:
(ii) ☐ tables related thereto	(i) ☐ copy submitted for the purposes of international search under Section 802(b-quater) only (and not as part of the international application) :	:
(c) ☐ also in computer readable form (Section 801(a)(ii))	(ii) ☐ (only where check-box (b)(ii) or (c)(ii) is marked in left column) additional copies including, where applicable, the copy for the purposes of international search under Section 802(b-quater) :	:
(i) ☐ sequence listings	(iii) ☐ together with relevant statement as to the identity of the copy or copies with the tables mentioned in left column :	:
(ii) ☐ tables related thereto	11. ☐ other (specify):	:
Type and number of carriers (diskette, CD-ROM, CD-R or other) on which are contained the		
☐ sequence listings:		
☐ tables related thereto:		
(additional copies to be indicated under items 9(ii) and/or 10(ii), in right column)		

Figure of the drawings which should accompany the abstract: 1

Language of filing of the international application: English

Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the signature).


 Richard E. Jenkins, Agent for Applicants

For receiving Office use only		2. Drawings: ☐ received: ☐ not received:
1. Date of actual receipt of the purported international application:		
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:		
4. Date of timely receipt of the required corrections under PCT Article 11(2):		
5. International Searching Authority (if two or more are competent): ISA /	6. ☐ Transmittal of search copy delayed until search fee is paid	

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REQUISITOS NECESARIOS PARA PRESENTACION Y AGILIZACION DEL TRAMITE

	USUARIO	RADICADOR
PATENTE DE INVENCION <i>PCT</i> MODELO DE UTILIDAD	()	()
- Indicación de que se solicita la concesión de una patente.	()	(X)
- Datos de identificación del solicitante o de la persona que se presenta la solicitud.	()	(X)
- Descripción de la invención.	()	(X)
- Dibujos de ser estos pertinentes.	()	(X)
- Comprobante de Pago de las tasas establecidas.	()	()
COMPLETA <i>(X)</i> INCOMPLETA	()	()
DISEÑO INDUSTRIAL ()		
- Indicación de que se solicita el registro de Diseño Industrial	()	()
- Datos de identificación del solicitante o de la persona que presenta la solicitud.	()	()
- Representación gráfica o fotográfica del Diseño Industrial o muestra del Material que incorpora el diseño.	()	()
- Comprobante de pago de las tasas establecidas	()	()
COMPLETA () INCOMPLETA	()	()
ESQUEMA DE TRAZADO ()		
- Indicación de que solicita el registro de un Esquema de trazado.	()	()
- Datos de identificación del solicitante o de la persona que presenta La solicitud.	()	()
- Representación gráfica del esquema de trazado	()	()
- Comprobante de pago de las tasas establecidas.	()	()
COMPLETA () INCOMPLETA	()	()

Firma Responsable:

Fecha:

160

REPUBLICA DE COLOMBIA
SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO

Bogotá,
2020

Doctor(a)
RODRIGUEZ D'ALEMAN DILIA MARIA

REFERENCIA Radicación No. 5 111223
 Solicitud internacional US2004/010685
 Fecha inicio fase nacional 05/12/2005
 Trámite 11
 Evento 379
 Actuación 430
 Oficio No. 13618

P' 641

Como resultado del examen de forma, realizado con fundamento en el artículo 38 de la Decisión 486 de la Comisión de la Comunidad Andina, artículo 27 del Tratado de Cooperación en Materia de Patentes (PCT), regla 51 bis del Reglamento y Circular Única de la Superintendencia de Industria y Comercio, se le comunica que:

1. El solicitante deberá presentar el documento en que consta la cesión del derecho a la patente del inventor al solicitante o a su causante, debidamente autenticada y apostillada.

2. La solicitud no contiene el poder debidamente otorgado, con el lleno de los requisitos exigidos por los artículos 63 y subsiguientes del Código de Procedimiento Civil. Adicionalmente, deberá presentar el documento que acredita la existencia y representación legal de la sociedad solicitante, cuando ésta fuere persona jurídica.

En cumplimiento de lo dispuesto por el artículo 39 de la Decisión 486, se le requiere para que dentro del término de dos meses siguientes a la fecha de notificación del presente oficio, complete los requisitos anteriormente enunciados. En caso de no dar cumplimiento al presente requerimiento, la solicitud se considerará abandonada y perderá su prelación.

Notifíquese el presente oficio conforme a lo dispuesto en el numeral 5.2, literal e), del capítulo quinto del título primero de la Circular Unica No.10 de 2001.


CLARA DE JARAMA
Jefe de la división de Nuevas Creaciones (E)

El anterior requerimiento fue notificado por fijación en lista de fecha 23 DIC 2020
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