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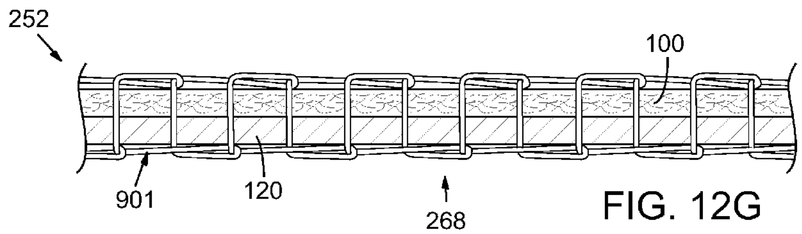

FIG. 12G

(57) Abstract: An article with a component joined with stitchbonding to a nonwoven textile formed from a plurality of thermoplastic polymer filaments. The nonwoven material, component, yarn, and stitch pattern can be optimized using disclosed structures and components to provide the article with desirable characteristics such as increased tensile and tear strength, improved aesthetics, moisture resistance and to limit or modify the stretch of the article in one or more directions and the like. A variety of products, including apparel (e.g., shirts, pants, footwear) may incorporate the article. In some of these products, the nonwoven textile may also be joined to the component with other bonding structures such as heat bonding, adhesives and the like.

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STITCHBONDED THERMOPLASTIC NONWOVEN TEXTILE ELEMENTS

BACKGROUND

[01] A variety of products are at least partially formed from textiles. As examples, articles of apparel (e.g., shirts, pants, socks, jackets, undergarments, footwear), containers (e.g., backpacks, bags), and upholstery for furniture (e.g., chairs, couches, car seats) are often formed from various textile elements that are joined through stitchbonding or adhesive bonding. Textiles may also be utilized in bed coverings (e.g., sheets, blankets), table coverings, towels, flags, tents, sails, and parachutes. Textiles utilized for industrial purposes are commonly referred to as technical textiles and may include structures for automotive and aerospace applications, filter materials, medical textiles (e.g. bandages, swabs, implants), geotextiles for reinforcing embankments, agrotextiles for crop protection, and industrial apparel that protects or insulates against heat and radiation. Accordingly, textiles may be incorporated into a variety of products for both personal and industrial purposes.

[02] Textiles may be defined as any manufacture from fibers, filaments, or yarns having a generally two-dimensional structure (i.e., a length and a width that are substantially greater than a thickness). In general, textiles may be classified as mechanically-manipulated textiles or nonwoven textiles. Mechanically-manipulated textiles are often formed by weaving or interlooping (e.g., knitting) a yarn or a plurality of yarns, usually through a mechanical process involving looms or knitting machines. Nonwoven textiles are webs or mats of filaments that are bonded, fused, interlocked, or otherwise joined. As an example, a nonwoven textile may be formed by randomly depositing a plurality of polymer filaments

upon a surface, such as a moving conveyor. Various embossing or calendaring processes may also be utilized to ensure that the nonwoven textile has a substantially constant thickness, impart texture to one or both surfaces of the nonwoven textile, or further bond or fuse filaments within the nonwoven textile to each other. Whereas spunbonded nonwoven textiles are formed from filaments having a cross-sectional thickness of 10 to 100 microns, meltblown nonwoven textiles are formed from filaments having a cross-sectional thickness of less than 10 microns.

[03] Although some products are formed from one type of textile, many products may also be formed from two or more types of textiles in order to impart different properties to different areas. As an example, shoulder and elbow areas of a shirt may be formed from a textile that imparts durability (e.g., abrasion-resistance) and stretch-resistance, whereas other areas may be formed from a textile that imparts breathability, comfort, stretch, and moisture-absorption. As another example, an upper for an article of footwear may have a structure that includes numerous layers formed from various types of textiles and other materials (e.g., polymer foam, leather, synthetic leather), and some of the layers may also have areas formed from different types of textiles to impart different properties. As yet another example, straps of a backpack may be formed from non-stretch textile elements, lower areas of a backpack may be formed from durable and water-resistant textile elements, and a remainder of the backpack may be formed from comfortable and compliant textile elements. Accordingly, many products may incorporate various types of textiles in order to impart different properties to different portions of the products.

[04] In order to impart the different properties to different areas of a product, textile elements formed from the materials must be cut to desired shapes and then joined together, usually with stitching or adhesive bonding. As the number and types of textile elements incorporated into a product increases, the time and expense associated with transporting, stocking, cutting, and joining the textile elements may also increase. Waste material from cutting and stitchbonding processes also accumulates to a greater degree as the number and types of textile elements incorporated into a product increases. Moreover, products with a greater number of textile elements and other materials may be more difficult to recycle than products formed from few elements and materials. By decreasing the number of elements and materials utilized in a product, therefore, waste may be decreased while increasing the manufacturing efficiency and recyclability.

SUMMARY

[05] An article formed from nonwoven textile and products incorporating the nonwoven textile that is joined to a component with stitchbonding is disclosed below. The nonwoven material, component, thread, and stitch pattern can be optimized to provide the article with desirable characteristics such as increased tensile and tear strength, improved aesthetics, moisture resistance, and to limit or modify the stretch of the article in one or more directions.

[06] The nonwoven textile may be formed from a plurality of filaments that are at least partially formed from a thermoplastic polymer material. In some configurations of the nonwoven textile, the filaments or the thermoplastic polymer material may be elastomeric or may stretch at least one-hundred percent prior to tensile failure.

[07] The component can be selected from suitable materials for a desired purpose of the article. Exemplar materials may include a layer of woven-textile, another layer of nonwoven textile, a natural material such as leather or the like, polymer foam, a breathable gas-permeable but liquid impermeable material, and other composite materials that are sturdy enough to receive and hold a stitch. Fusing

the nonwoven textile to the component may further alter and optimize properties such as permeability, durability, and stretch-resistance.

[08] The thread and stitch patterns can be selected to provide a particular aesthetic or structural effect. In some aspects, the stitch pattern may include a zigzag or chevron patter to allow for two way stretchability. In other aspects a plurality of spaced-apart and parallel-aligned stitch lines can limit stretchability, or alternative concave and convex stitch patterns can be used.

[09] A variety of products, including apparel (e.g., shirts, pants, footwear), may incorporate the article formed of the nonwoven textile secured to the component. In addition, the nonwoven textile can also be secured to the component with other structures such as heat sealing, adhesive or the like to further improve the desirable characteristic of the article.

[10] The advantages and features of novelty characterizing aspects of the invention are pointed out with particularity in the appended claims. To gain an improved understanding of the advantages and features of novelty, however, reference may be made to the following descriptive matter and accompanying figures that describe and illustrate various configurations and concepts related to the invention.

FIGURE DESCRIPTIONS

[11] The foregoing Summary and the following Detailed Description will be better understood when read in conjunction with the accompanying figures.

[12] Figure 1 is a perspective view of a nonwoven textile.

[13] Figure 2 is a cross-sectional view of the nonwoven textile, as defined by section line 2-2 in Figure 1.

[14] Figure 3 is a perspective view of the nonwoven textile with a plurality of fused regions.

[15] Figures 4A-4C are cross-sectional views, as defined by section line 4-4 in Figure 3, depicting different configurations of the fused regions in the nonwoven textile.

[16] Figures 5A-5H are perspective views of further configurations of the fused regions in the nonwoven textile.

[17] Figures 6A-6F are cross-sectional views corresponding with Figures 4A-4C and depicting further configurations of the fused regions in the nonwoven textile.

[18] Figures 7A-7C are perspective views of a first process for forming the fused regions in the nonwoven textile.

[19] Figures 8A-8C are perspective views of a second process for forming the fused regions in the nonwoven textile.

[20] Figure 9 is a perspective view of a third process for forming the fused regions in the nonwoven textile.

[21] Figure 10 is a perspective view of a first composite element that includes the nonwoven textile.

[22] Figure 11 is a cross-sectional view of the first composite element, as defined by section line 11-11 in Figure 10.

[23] Figures 12A-12C are perspective views of a first process for forming a first composite element from the nonwoven textile and another component.

[24] Figures 12D-12G are perspective views of a second process for securing the nonwoven textile to another textile.

[25] Figure 13 is a schematic perspective view of another process for forming the first composite element.

[26] Figure 14 is a perspective view of a second composite element that includes the nonwoven textile.

[27] Figure 15 is a cross-sectional view of the second composite element, as defined by section line 15-15 in Figure 14.

[28] Figure 16 is a perspective view of a third composite element that includes the nonwoven.

[29] Figure 17 is a cross-sectional view of the third composite element, as defined by section line 17-17 in Figure 16.

[30] Figures 18A-18C are perspective views of further configurations of the third composite element.

[31] Figure 19 is a perspective view of a fourth composite element that includes the nonwoven textile.

[32] Figure 20 is a cross-sectional view of the fourth composite element, as defined by section line 20-20 in Figure 19.

[33] Figure 21 is a perspective view of a fifth composite element that includes the nonwoven textile.

[34] Figure 22 is a cross-sectional view of the fifth composite element, as defined by section line 22-22 in Figure 21.

[35] Figures 23A-23F are perspective views of further configurations of the fifth composite element.

[36] Figure 24 is a perspective view of two elements of the nonwoven textile joined with a first seam configuration.

[37] Figure 25 is a cross-sectional view of the first seam configuration, as defined by section line 25-25 in Figure 24.

[38] Figures 26A-26D are side elevational views of a process for forming the first seam configuration.

[39] Figure 27 is a perspective view of another process for forming the first seam configuration.

[40] Figures 28A and 28B are perspective views of elements of the nonwoven textile joined with other elements to form the first seam configuration.

[41] Figures 29A-29C are cross-sectional views corresponding with Figure 25 and depicting further examples of the first seam configuration.

[42] Figure 30 is a perspective view of two elements of the nonwoven textile joined with a second seam configuration.

[43] Figure 31 is a cross-sectional view of the second seam configuration, as defined by section line 31-31 in Figure 30.

[44] Figures 32A-32C are side elevational views of a process for forming the second seam configuration.

[45] Figure 33 is a perspective view of another process for forming the second seam configuration.

[46] Figures 34A-34C are cross-sectional views corresponding with Figure 31 and depicting further configurations of the second seam configuration.

[47] Figures 35A-35H are front elevational views of various configurations of a shirt that includes the nonwoven textile.

[48] Figures 36A-36H are cross-sectional views of the configurations of the shirt, as respectively defined by section lines 36A-36A through 36H-36H in Figures 35A-35H.

[49] Figures 37A-37C are front elevational views of various configurations of a pair of pants that includes the nonwoven textile.

[50] Figure 38 is a cross-sectional view of the pair of pants, as defined by section line 38-38 in Figure 33A.

[51] Figures 39A-39G are side elevational views of various configurations of an article of footwear that includes the nonwoven textile.

[52] Figures 40A-40D are cross-sectional views of the configurations of the article of footwear, as respectively defined by section lines 40A-40A through 40D-40D in Figures 39A-39D.

[53] Figure 41 is a perspective view of a lace loop for the article of footwear that includes the nonwoven textile.

[54] Figures 42A-42C are perspective views of three-dimensional configurations of the nonwoven textile.

[55] Figures 43A-43C are perspective views of a process for forming the three-dimensional configurations of the nonwoven textile.

[56] Figures 44A-44D are perspective views of textured configurations of the nonwoven textile.

[57] Figures 45A-45C are perspective views of a process for forming the textured configurations of the nonwoven textile.

[58] Figures 46A-46F are perspective views of stitched configurations of the nonwoven textile.

[59] Figures 46G-46R are perspective views of stitched textile articles that include the nonwoven textile stitched to a second component;

[60] Figure 47 is a perspective view of an element of tape that includes the nonwoven textile.

[61] Figure 48 is a cross-sectional view of the tape, as defined by section line 48-48 in Figure 47.

[62] Figures 49A-49C are perspective views of additional configurations of the element of tape.

[63] Figure 50 is a schematic view of a recycling process.

DETAILED DESCRIPTION

[64] The following discussion and accompanying figures disclose a nonwoven textile 100 and various products incorporating nonwoven textile 100. Although nonwoven textile 100 is disclosed below as being incorporated into various articles of apparel (e.g., shirts, pants, footwear) for purposes of example, nonwoven textile 100 may also be incorporated into a variety of other products. For example, nonwoven textile 100 may be utilized in other types of apparel, containers, and upholstery for furniture. Nonwoven textile 100 may also be utilized in bed coverings, table coverings, towels, flags, tents, sails, and parachutes. Various configurations of nonwoven textile 100 may also be utilized for industrial purposes, as in automotive and aerospace applications, filter materials, medical textiles, geotextiles, agrotextiles, and industrial apparel. Accordingly, nonwoven textile 100 may be utilized in a variety of products for both personal and industrial purposes.

[65] I - Nonwoven Textile Configuration

[66] Nonwoven textile 100 is depicted in Figures 1 and 2 as having a first surface 101 and an opposite second surface 102. Nonwoven textile 100 is primarily formed from a plurality of filaments 103 that include a thermoplastic polymer material. Filaments 103 are distributed randomly throughout nonwoven textile 100 and are bonded, fused, interlocked, or otherwise joined to form a structure with a relatively constant thickness (i.e., distance between surfaces 101 and 102). An individual filament 103 may be located on first surface 101, on second surface 102, between surfaces 101 and 102, or on both of surfaces 101 and 102. Depending upon the manner in which nonwoven textile 100 is formed, multiple portions of an individual filament 103 may be located on first surface 101, different portions of the individual filament 103 may be located on second surface 102, and other portions of the individual filament 103 may be located between surfaces 101 and 102. In order to impart an interlocking structure, the various filaments 103 may wrap around each other, extend over and under each other, and pass through various areas of nonwoven textile 100. In areas where two or more filaments 103 contact each other, the thermoplastic polymer material forming filaments 103 may be bonded or fused to join filaments 103 to each other. Accordingly, filaments 103 are effectively joined to each other in a variety of ways to form a cohesive structure within nonwoven textile 100.

[67] Fibers are often defined, in textile terminology, as having a relatively short length that ranges from one millimeter to a few centimeters or more, whereas filaments are often defined as having a longer length than fibers or even an indeterminate length. As utilized within the present document, the term “filament” or variants thereof is defined as encompassing lengths of both fibers and filaments from the textile terminology definitions. Accordingly, filaments 103 or other filaments referred to herein may generally have any length. As an example, therefore, filaments 103 may have a length that ranges from one millimeter to hundreds of meters or more.

[68] Filaments 103 include a thermoplastic polymer material. In general, a thermoplastic polymer material melts when heated and returns to a solid state when cooled. More particularly, the thermoplastic polymer material transitions from a solid state to a softened or liquid state when subjected to sufficient heat, and then the thermoplastic polymer material transitions from the softened or liquid state to the solid state when sufficiently cooled. As such, the thermoplastic polymer material may be melted, molded, cooled, re-melted, re-molded, and cooled again through multiple cycles. Thermoplastic polymer materials may also be bonded or fused, as described in greater detail below, to other textile elements, plates, sheets, polymer foam elements, thermoplastic polymer elements, thermoset polymer elements, or a variety of other elements formed from various materials. In contrast with thermoplastic polymer materials, many thermoset polymer materials do not melt when heated, simply burning instead. Although a wide range of thermoplastic polymer materials may be utilized for filaments 103, examples of some suitable thermoplastic polymer materials include thermoplastic polyurethane, polyamide, polyester, polypropylene, and polyolefin. Although any of the thermoplastic polymer materials mentioned above may be utilized for nonwoven textile 100, an advantage to utilizing thermoplastic polyurethane relates to heatbonding and colorability. In comparison with various other thermoplastic polymer materials (e.g., polyolefin), thermoplastic polyurethane is relatively easy to bond with other elements, as discussed in greater detail below, and colorants may be added to thermoplastic polyurethane through various conventional processes.

[69] Although each of filaments 103 may be entirely formed from a single thermoplastic polymer material, individual filaments 103 may also be at least partially formed from multiple polymer materials. As an example, an individual filament 103 may have a sheath-core configuration, wherein an exterior sheath of the individual filament 103 is formed from a first type of thermoplastic polymer material, and an interior core of the individual filament 103 is formed from a second type of thermoplastic polymer material. As a similar example, an individual filament 103 may have a bi-component configuration, wherein one half of the individual filament 103 is formed from a first type of thermoplastic polymer material, and an opposite half of the individual filament 103 is formed from a second type of thermoplastic polymer material. In some configurations, an individual filament 103 may be formed from both a thermoplastic polymer material and a thermoset polymer material with either of the sheath-core or bi-component arrangements. Although all of filaments 103 may be entirely formed from a single thermoplastic polymer material, filaments 103 may also be formed from multiple polymer materials. As an example, some of filaments 103 may be formed from a first type of thermoplastic polymer material, whereas other filaments 103 may be formed from a second type of thermoplastic polymer material. As a similar example, some of filaments 103 may be formed from a thermoplastic polymer material, whereas other filaments 103 may be formed from a thermoset polymer material. Accordingly, each filament 103, portions of filaments 103, or at least some of filaments 103 may be formed from one or more thermoplastic polymer materials.

[70] The thermoplastic polymer material or other materials utilized for nonwoven textile 100 (i.e., filaments 103) may be selected to have various stretch properties, and the materials may be considered elastomeric. Depending upon the specific product that nonwoven textile 100 will be incorporated into, nonwoven textile 100 or filaments 103 may stretch between ten percent to more than eight-hundred percent prior to tensile failure. For many articles of apparel, in which stretch is an advantageous property, nonwoven textile 100 or filaments 103 may stretch at least one-hundred percent prior to tensile failure. As a related matter, thermoplastic polymer material or other materials utilized for nonwoven textile 100 (i.e., filaments 103) may be selected to have various recovery properties. That is, nonwoven textile 100 may be formed to return to an original shape after being stretched or nonwoven textile 100 may be formed to remain in an elongated or stretched shape after being stretched. Many products that incorporate nonwoven textile 100, such as articles of apparel, may benefit from properties that allow nonwoven textile 100 to return or otherwise recover to an original shape after being stretched by one-hundred percent or more.

[71] A variety of conventional processes may be utilized to manufacture nonwoven textile 100. In general, a manufacturing process for nonwoven textile 100 includes (a) extruding or otherwise forming a plurality of filaments 103 from a thermoplastic polymer material, (b) collecting, laying, or otherwise depositing filaments 103 upon a surface, such as a moving conveyor, (c) joining filaments 103, and (d) imparting a desired thickness through compressing or other processes. Because filaments 103 may be relatively soft or partially melted when deposited upon the surface, the polymer materials from filaments 103 that contact each other may become bonded or fused together upon cooling.

[72] Following the general manufacturing process discussed above, various post-processing operations may be performed on nonwoven textile 100. For example, embossing or calendaring processes may be utilized to ensure that nonwoven textile 100 has a substantially constant thickness, impart texture to one or both of surfaces 101 and 102, or further bond or fuse filaments 103 to each other. Coatings may also be applied to nonwoven textile 100. Furthermore, other processes that modify the filaments in nonwoven textile 100 such as hydrojet, hydroentangelment, needlepunching, or stitchbonding processes may also be utilized to modify properties of nonwoven textile 100. In particular, stitchbonding is described herein below.

[73] Nonwoven textile 100 may be formed as a spunbonded or meltblown material. Whereas spunbonded nonwoven textiles are formed from filaments having a cross-sectional thickness of 10 to 100 microns, meltblown nonwoven textiles are formed from filaments having a cross-sectional thickness of less than 10 microns. Nonwoven textile 100 may be either spunbonded, meltblown, or a combination of spunbonded and meltblown. Moreover, nonwoven textile 100 may be formed to have spunbonded and meltblown layers, or may also be formed such that filaments 103 are combinations of spunbonded and meltblown.

[74] In addition to differences in the thickness of individual filaments 103, the overall thickness of nonwoven textile 100 may vary significantly. With reference to the various figures, the thickness of nonwoven textile 100 and other elements may be amplified or otherwise increased to show details or other features associated with nonwoven textile 100, thereby providing clarity in the figures. For many applications, however, a thickness of nonwoven textile 100 may be in a range of 0.5 millimeters to 10.0 millimeters, but may vary considerably beyond this range. For many articles of apparel, for example, a thickness of 1.0 to 3.0 millimeters may be appropriate, although other thicknesses may be utilized. As discussed in greater detail below, regions of nonwoven textile 100 may be formed such that the thermoplastic polymer material forming filaments 103 is fused to a greater degree than in other regions, and the thickness of nonwoven textile 100 in the fused regions may be substantially reduced. Accordingly, the thickness of nonwoven textile 100 may vary considerably.

[75] II - Fused Regions

[76] Nonwoven textile 100 is depicted as including various fused regions 104 in Figure 3. Fused regions 104 are portions of nonwoven textile 100 that have been subjected to heat in order to selectively change the properties of those fused regions 104. Nonwoven textile 100, or at least the various filaments 103 forming nonwoven textile 100, are discussed above as including a thermoplastic polymer material. When exposed to sufficient heat, the thermoplastic polymer material transitions from a solid state to either a softened state or a liquid state. When sufficiently cooled, the thermoplastic polymer material then transitions back from the softened state or the liquid state to the solid state. Nonwoven textile 100 or regions of nonwoven textile 100 may, therefore, be exposed to heat in order to soften or melt the various filaments 103. As discussed in greater detail below, exposing various regions (i.e., fused regions 104) of nonwoven textile 100 to heat may be utilized to selectively change the properties of those regions. Although discussed in terms of heat alone, pressure may also be utilized either alone or in combination with heat to form fused regions 104, and pressure may be required in some configurations of nonwoven textile 100 to form fused regions 104.

[77] Fused regions 104 may exhibit various shapes, including a variety of geometrical shapes (e.g., circular, elliptical, triangular, square, rectangular) or a variety of non-defined, irregular, or otherwise non-geometrical shapes. The positions of fused regions 104 may be spaced inward from edges of nonwoven textile 100, located on one or more edges of nonwoven textile 100, or located at a corner of nonwoven textile 100. The shapes and positions of fused regions 104 may also be selected to extend across portions of nonwoven textile 100 or between two edges of nonwoven textile 100. Whereas the areas of some fused regions 104 may be relatively small, the areas of other fused regions 104 may be relatively large. As described in greater detail below, two separate elements of nonwoven textile 100 may be joined together, some fused regions 104 may extend across a seam that joins the elements, or some fused regions may extend into areas where other components are bonded to nonwoven textile 100. Accordingly, the shapes, positions, sizes, and other aspects of fused regions 104 may vary significantly.

[78] When exposed to sufficient heat, and possibly pressure, the thermoplastic polymer material of the various filaments 103 of nonwoven textile 100 transitions from a solid state to either a softened state or a liquid state. Depending upon the degree to which filaments 103 change state, the various filaments 103 within fused regions 104 may (a) remain in a filamentous configuration, (b) melt entirely into a liquid that cools into a non-filamentous configuration, or (c) take an intermediate configuration wherein some filaments 103 or portions of individual filaments 103 remain filamentous and other filaments 103 or portions of individual filaments 103 become non-filamentous. Accordingly, although filaments 103 in fused regions 104 are generally fused to a greater degree than filaments 103 in other areas of nonwoven textile 100, the degree of fusing in fused regions 104 may vary significantly.

[79] Differences between the degree to which filaments 103 may be fused in fused regions 104 are depicted in Figures 4A-4C. Referring specifically to Figure 4A, the various filaments 103 within fused region 104 remain in a filamentous configuration. That is, the thermoplastic polymer material forming filaments 103 remains in the configuration of a filament and individual filaments 103 remain identifiable. Referring specifically to Figure 4B, the various filaments 103 within fused region 104 melted entirely into a liquid that cools into a non-filamentous configuration. That is, the thermoplastic polymer material from filaments 103 melted into a non-filamentous state that effectively forms a solid polymer sheet in fused region 104, with none of the individual filaments 103 being identifiable. Referring specifically to Figure 4C, the various filaments 103 remain in a partially-filamentous configuration. That is, some of the thermoplastic polymer material forming filaments 103 remains in the configuration of a filament, and some of the thermoplastic polymer material from filaments 103 melted into a non-filamentous state that effectively forms a solid polymer sheet in fused region 104. The configuration of the thermoplastic polymer material from filaments 103 in fused regions 104 may, therefore, be filamentous, non-filamentous, or any combination or proportion of filamentous and non-filamentous. Accordingly, the degree of fusing in each of fused regions 104 may vary along a spectrum that extends from filamentous on one end to non-filamentous on an opposite end.

[80] A variety of factors relating to the configuration of nonwoven textile 100 and the processes by which fused regions 104 are formed determine the degree to which filaments 103 are fused within fused regions 104. As examples, factors that determine the degree of fusing include (a) the particular thermoplastic polymer material forming filaments 103, (b) the temperature that fused regions 104 are exposed to, (c) the pressure that fused regions 104 are exposed to, and (d) the time at which fused regions 104 are exposed to the elevated temperature and/or pressure. By varying these factors, the degree of fusing that results within fused regions 104 may also be varied along the spectrum that extends from filamentous on one end to non-filamentous on an opposite end.

[81] The configuration of fused regions 104 in Figure 3 is intended to provide an example of the manner in which the shapes, positions, sizes, and other aspects of fused regions 104 may vary. The configuration of fused regions 104 may, however, vary significantly. Referring to Figures 5A, nonwoven textile 100 includes a plurality of fused regions 104 with generally linear and parallel configurations. Similarly, Figure 5B depicts nonwoven textile 100 as including a plurality of fused regions 104 with generally curved and parallel configurations. Fused regions 104 may have a segmented configuration, as depicted in Figure 5C. Nonwoven textile 100 may also have a plurality of fused regions 104 that exhibit the configuration of a repeating pattern of triangular shapes, as in Figure 5D, the configuration of a repeating pattern of circular shapes, as in Figure 5E, or a repeating pattern of any other shape or a variety of shapes. In some configurations of nonwoven textile 100, as depicted in Figure 5F, one fused region 104 may form a continuous area that defines discrete areas for the remainder of nonwoven textile 100. Fused regions 104 may also have a configuration wherein edges or corners contact each other, as in the checkered pattern of Figure 5G. Additionally, the shapes of the various fused regions 104 may have a non-geometrical or irregular shape, as in Figure 5H. Accordingly, the shapes, positions, sizes, and other aspects of fused regions 104 may vary significantly.

[82] The thickness of nonwoven textile 100 may decrease in fused regions 104. Referring to Figures 4A-4C, for example, nonwoven textile 100 exhibits less thickness in fused region 104 than in other areas. As discussed above, fused regions 104 are areas where filaments 103 are generally fused to a greater degree than filaments 103 in other areas of nonwoven textile 100. Additionally, nonwoven textile 100 or the portions of nonwoven textile 100 forming fused regions 104 may be compressed while forming fused regions 104. As a result, the thickness of fused regions 104 may be decreased in comparison with other areas of nonwoven textile 100. Referring again to Figures 4A-4C, surfaces 102 and 103 both exhibit a squared or abrupt transition between fused regions 104 and other areas of nonwoven textile 100. Depending upon the manner in which fused regions 104 are formed, however, surfaces 102 and 103 may exhibit other configurations. As an example, only first surface 101 has a squared transition to fused regions 104 in Figure 6A. Although the decrease in thickness of fused regions 104 may occur through a squared or abrupt transition, a curved or more gradual transition may also be utilized, as depicted in Figures 6B and 6C. In other configurations, an angled transition between fused regions 104 and other areas of nonwoven textile 100 may be formed, as in Figure 6D. Although a decrease in thickness often occurs in fused regions 104, no decrease in thickness or a minimal decrease in thickness is also possible, as depicted in Figure 6E. Depending upon the materials utilized in nonwoven textile 100 and the manner in which fused regions 104 are formed, fused regions 104 may actually swell or otherwise increase in thickness, as depicted in Figure 6F. In each of Figures 6A-6F, fused regions 104 are depicted as having a non-filamentous configuration, but may also have the filamentous configuration or the intermediate configuration discussed above.

[83] Based upon the above discussion, nonwoven textile 100 is formed from a plurality of filaments 103 that include a thermoplastic polymer material. Although filaments 103 are bonded, fused, interlocked, or otherwise joined throughout nonwoven textile 100, fused regions 104 are areas where filaments 103 are generally fused to a greater degree than filaments 103 in other areas of nonwoven textile 100. The shapes, positions, sizes, and other aspects of fused regions 104 may vary significantly. In addition, the degree to which filaments 103 are fused may also vary significantly to be filamentous, non-filamentous, or any combination or proportion of filamentous and non-filamentous.

[84] III - Properties Of Fused Regions

[85] The properties of fused regions 104 may be different than the properties of other regions of nonwoven textile 100. Additionally, the properties of one of fused regions 104 may be different than the properties of another of fused regions 104.

In manufacturing nonwoven textile 100 and forming fused regions 104, specific properties may be applied to the various areas of nonwoven textile 100. More particularly, the shapes of fused regions 104, positions of fused regions 104, sizes of fused regions 104, degree to which filaments 103 are fused within fused regions 104, and other aspects of nonwoven textile 100 may be varied to impart specific properties to specific areas of nonwoven textile 100. Accordingly, nonwoven textile 100 may be engineered, designed, or otherwise structured to have particular properties in different areas.

[86] Examples of properties that may be varied through the addition or the configuration of fused regions 104 include permeability, durability, and stretch-resistance. By forming one of fused regions 104 in a particular area of nonwoven textile 100, the permeability of that area generally decreases, whereas both durability and stretch-resistance generally increases. As discussed in greater detail below, the degree to which filaments 103 are fused to each other has a significant effect upon the change in permeability, durability, and stretch-resistance. Other factors that may affect permeability, durability, and stretch-resistance include the shapes, positions, and sizes of fused regions 104, as well as the specific thermoplastic polymer material forming filaments 103.

[87] Permeability generally relates to ability of air, water, and other fluids (whether gaseous or liquid) to pass through or otherwise permeate nonwoven textile 100. Depending upon the degree to which filaments 103 are fused to each other, the permeability may vary significantly. In general, the permeability is highest in areas of nonwoven textile 100 where filaments 103 are fused the least, and the permeability is lowest in areas of nonwoven textile 100 where filaments 103 are fused the most. As such, the permeability may vary along a spectrum depending upon the degree to which filaments 103 are fused to each other. Areas of nonwoven textile 100 that are separate from fused regions 104 (i.e., non-fused areas of nonwoven textile 100) generally exhibit a relatively high permeability. Fused regions 104 where a majority of filaments 103 remain in the filamentous configuration also exhibit a relatively high permeability, but the permeability is generally less than in areas separate from fused regions 104. Fused regions 104 where filaments 103 are in both a filamentous and non-filamentous configuration have a lesser permeability. Finally, areas where a majority or all of the thermoplastic polymer material from filaments 103 exhibits a non-filamentous configuration may have a relatively small permeability or even no permeability. Modifications made to nonwoven textile 100 may also affect its permeability. For example, stitching may increase the permeability of nonwoven textile 100 depending on the nature of the stitch and the nature of the thread used in the stitch. Namely, a loose stitch with a thread made from a material with a high permeability will increase the permeability of nonwoven fabric 100. Alternatively, the permeability of nonwoven textile 100 that includes stitching may remain unchanged, if the stitching is in a tight pattern.

[88] Durability generally relates to the ability of nonwoven textile 100 to remain intact, cohesive, or otherwise undamaged, and may include resistances to wear, abrasion, and degradation from chemicals and light. Depending upon the degree to which filaments 103 are fused to each other, the durability may vary significantly. In general, the durability is lowest in areas of nonwoven textile 100 where filaments 103 are fused the least, and the durability is highest in areas of nonwoven textile 100 where filaments 103 are fused the most. As such, the durability may vary along a spectrum depending upon the degree to which filaments 103 are fused to each other. Areas of nonwoven textile 100 that are separate from fused regions 104 generally exhibit a relatively low durability. Fused regions 104 where a majority of filaments 103 remain in the filamentous configuration also exhibit a relatively low durability, but the durability is generally more than in areas separate from fused regions 104. Fused regions 104 where filaments 103 are in both a filamentous and non-filamentous configuration have a greater durability. Finally, areas where a majority or all of the thermoplastic polymer material from filaments 103 exhibits a non-filamentous configuration may have a relatively high durability. Other factors that may affect the general durability of fused regions 104 and other areas of nonwoven textile 100 include the initial thickness and density of nonwoven textile 100, the type of polymer material forming filaments 103, and the hardness of the polymer material forming filaments 103.

[89] Stretch-resistance generally relates to the ability of nonwoven textile 100 to resist stretching when subjected to a textile force. As with permeability and durability, the stretch-resistance of nonwoven textile 100 may vary significantly depending upon the degree to which filaments 103 are fused to each other. As with durability, the stretch-resistance is lowest in areas of nonwoven textile 100 where filaments 103 are fused the least, and the stretch-resistance is highest in areas of nonwoven textile 100 where filaments 103 are fused the most. As noted above, the thermoplastic polymer material or other materials utilized for nonwoven textile 100 (i.e., filaments 103) may be considered elastomeric or may stretch at least one-hundred percent prior to tensile failure. Although the stretch-resistance of nonwoven textile 100 may be greater in areas of nonwoven textile 100 where filaments 103 are fused the most, fused regions 104 may still be elastomeric or may stretch at least one-hundred percent prior to tensile failure. Other factors that may affect the general stretch properties of fused regions 104 and other areas of nonwoven textile 100 include the initial thickness and density of nonwoven textile 100, the type of polymer material forming filaments 103, and the hardness of the polymer material forming filaments 103. Modifications made to nonwoven textile 100 may also affect the stretch properties. Namely, stitching may restrict the ability of nonwoven textile 100 to stretch in one or more directions, depending on the pattern of stitching used.

[90] As discussed in greater detail below, nonwoven textile 100 may be incorporated into a variety of products, including various articles of apparel (e.g., shirts, pants, footwear). Taking a shirt as an example, nonwoven textile 100 may form a majority of the shirt, including a torso region and two arm regions. Given that moisture may accumulate within the shirt from perspiration, a majority of the shirt may be formed from portions of nonwoven textile 100 that do not include fused regions 104 in order to provide a relatively high permeability. Given that elbow areas of the shirt may be subjected to relatively high abrasion as the shirt is worn, some of fused regions 104 may be located in the elbow areas to impart greater durability. Additionally, given that the neck opening may be stretched as the shirt is put on an individual and taken off the individual, one of fused regions 104 may be located around the neck opening to impart greater stretch-resistance. Accordingly, one material (i.e., nonwoven textile 100) may be used throughout the shirt, but by fusing different areas to different degrees, the properties may be advantageously-varied in different areas of the shirt.

[91] The above discussion focused primarily on the properties of permeability, durability, and stretch-resistance. A variety of other properties may also be varied through the addition or the configuration of fused regions 104. For example, the overall density of nonwoven textile 100 may be increased as the degree of fusing of filaments 103 increases. The transparency of nonwoven textile 100 may also be increased as the degree of fusing of filaments 103 increases. Depending upon various factors, the darkness of a color of nonwoven textile 100 may also increase as the degree of fusing of filaments 103 increases. Although somewhat discussed above, the overall thickness of nonwoven textile 100 may decrease as the degree of fusing of filaments 103 increases. The degree to which nonwoven textile 100 recovers after being stretched, the overall flexibility of nonwoven textile 100, and resistance to various modes of failure may also vary depending upon the degree of fusing of filaments 100. Accordingly, a variety of properties may be varied by forming fused regions 104.

[92] IV - Formation Of Fused Regions

[93] A variety of processes may be utilized to form fused regions 104. Referring to Figures 7A-7C, an example of a method is depicted as involving a first plate 111 and a second plate 112, which may be platens of a press. Initially, nonwoven textile 100 and an insulating element 113 are located between plates 111 and 112, as depicted in Figure 7A. Insulating element 113 has apertures 114 or other absent areas that correspond with fused regions 104. That is, insulating element 113 exposes areas of nonwoven textile 100 corresponding with fused regions 104, while covering other areas of nonwoven textile 100.

[94] Plates 111 and 112 then translate or otherwise move toward each other in order to compress or induce contact between nonwoven textile 100 and insulating element 113, as depicted in Figure 7B. In order to form fused regions 104, heat is applied to areas of nonwoven textile 100 corresponding with fused regions 104, but a lesser heat or no heat is applied to other areas of nonwoven textile 100 due to the presence of insulating element 113. That is, the temperature of the various areas of nonwoven textile 100 corresponding with fused regions 104 is elevated without significantly elevating the temperature of other areas. In this example method, first plate 111 is heated so as to elevate the temperature of nonwoven textile 100 through conduction. Some areas of nonwoven textile 100 are insulated, however, by the presence of insulating element 113. Only the areas of nonwoven textile 100 that are exposed through apertures 114 are, therefore, exposed to the heat so as to soften or melt the thermoplastic polymer material within filaments 103. The material utilized for insulating element 113 may vary to include metal plates, paper sheets, polymer layers, foam layers, or a variety of other materials (e.g., with low thermal conductivity) that will limit the heat transferred to nonwoven textile 100 from first plate 111. In some processes, insulating element 113 may be an integral portion of or otherwise incorporated into first plate 111.

[95] Upon separating plates 111 and 112, as depicted in Figure 7C, nonwoven textile 100 and insulating element 113 are separated from each other. Whereas areas of nonwoven textile 100 that were exposed by apertures 114 in insulating element 113 form fused regions 104, areas covered or otherwise protected by insulating element 113 remain substantially unaffected. In some methods, insulating element 113 may be structured to allow some of fused regions 104 to experience greater temperatures than other fused regions 104, thereby fusing the thermoplastic polymer material of filaments 103 more in some of fused regions 104 than in the other fused regions 104. That is, the configuration of insulating element 113 may be structured to heat fused regions 104 to different temperatures in order to impart different properties to the various fused regions 104.

[96] Various methods may be utilized to apply heat to specific areas of nonwoven textile 100 and form fused regions 104. As noted above, first plate 111 may be heated so as to elevate the temperature of nonwoven textile 100 through conduction. In some processes, both plates 111 and 112 may be heated, and two insulating elements 113 may be located on opposite sides of nonwoven textile 100. Although heat may be applied through conduction, radio frequency heating may also be used, in which case insulating element 113 may prevent the passage of specific wavelengths of electromagnetic radiation. In processes where chemical heating is utilized, insulating element 113 may prevent chemicals from contacting areas of nonwoven textile 100. In other processes where radiant heat is utilized, insulating element 113 may be a reflective material (i.e., metal foil) that prevents the radiant heat from raising the temperature of various areas of nonwoven textile 100. A similar process involving a conducting element may also be utilized. More particularly, the conducting element may be used to conduct heat directly to fused regions 104. Whereas insulating element 113 is absent in areas corresponding with fused regions 104, the conducting element would be present in fused regions 104 to conduct heat to those areas of nonwoven textile 100.

[97] An example of another process that may be utilized to form fused regions 104 in nonwoven textile 100 is depicted in Figures 8A-8C. Initially, nonwoven textile 100 is placed adjacent to or upon second plate 112 or another surface, as depicted in Figure 8A. A heated die 115 having the shape of one of fused regions 104 then contacts and compresses nonwoven textile 100, as depicted in Figure 8B, to heat a defined area of nonwoven textile 100. Upon removal of die 115, one of fused regions 104 is exposed. Additional dies having the general shapes of other fused regions 104 may be utilized to form the remaining fused regions 104 in a similar manner. An advantage to this process is that die 115 and each of the other dies may be heated to different temperatures, held in contact with nonwoven textile 100 for different periods of time, and compressed against nonwoven textile 100 with different forces, thereby varying the resulting properties of the various fused regions 104.

[98] An example of yet another process that may be utilized to form fused regions 104 in nonwoven textile 100 is depicted in Figure 9. In this process, nonwoven textile 100 is placed upon second plate 112 or another surface, and a laser apparatus 116 is utilized to heat specific areas of nonwoven textile 100, thereby fusing the thermoplastic polymer material of filaments 103 and forming fused regions 104. By adjusting any or all of the power, focus, or velocity of laser apparatus 116, the degree to which fused regions 104 are heated may be adjusted or otherwise varied. Moreover, different fused regions 104 may be heated to different temperatures to modify the degree to which filaments 103 are fused, thereby varying the resulting properties of the various fused regions 104. An example of a suitable laser apparatus 116 is any of a variety of conventional CO_2 or Nd:YAG laser apparatuses.

[99] V - Composite Elements

[100] Nonwoven textile 100 may be joined with various textiles, materials, or other components to form composite elements. By joining nonwoven textile 100 with other components, properties of both nonwoven textile 100 and the other components are combined in the composite elements. An example of a composite element is depicted in Figures 10 and 11, in which a component 120 is joined to nonwoven textile 100 at second surface 102. Although component 120 is depicted as having dimensions that are similar to dimensions of nonwoven textile 100, component 120 may have a lesser or greater length, a lesser or greater width, or a lesser or greater thickness. If, for example, component 120 is a textile that absorbs water or wicks water away, then the combination of nonwoven textile 100 and component 120 may be suitable for articles of apparel utilized during athletic activities where an individual wearing the apparel is likely to perspire. As another example, if component 120 is a compressible material, such as a polymer foam, then the combination of nonwoven textile 100 and component 120 may be suitable for articles of apparel where cushioning (i.e., attenuation of impact forces) is advantageous, such as padding for athletic activities that may involve contact or impact with other athletes or equipment. As a further example, if component 120 is a plate or sheet, then the combination of nonwoven textile 100 and component 120 may be suitable for articles of apparel that impart protection from acute impacts. In yet another aspect, component 120 may be another nonwoven textile. This second nonwoven textile may be the same as nonwoven textile 100, or it may differ in one or more regards. For example, the second nonwoven textile may have a different degree of fusion of the filaments therein than first nonwoven textile 100, or may have a different placement of the fused regions than first nonwoven textile 100. Accordingly, a variety of textiles, materials, or other components maybe joined with a surface of nonwoven textile 100 to form composite elements with additional properties.

[101] The thermoplastic polymer material in filaments 103 may be utilized to secure nonwoven textile 100 to component 120 or other components. As discussed above, a thermoplastic polymer material melts when heated and returns to a solid state when cooled sufficiently. Based upon this property of thermoplastic polymer materials, heatbonding processes may be utilized to form a heatbond that joins portions of composite elements, such as nonwoven textile 100 and component 120. As utilized herein, the term “heatbonding” or variants thereof is defined as a securing technique between two elements that involves a softening or melting of a thermoplastic polymer material within at least one of the elements such that the materials of the elements are secured to each other when cooled. Similarly, the term “heatbond” or variants thereof is defined as the bond, link, or structure that joins two elements through a process that involves a softening or melting of a thermoplastic polymer material within at least one of the elements such that the materials of the elements are secured to each other when cooled. As examples, heatbonding may involve (a) the melting or softening of two elements incorporating thermoplastic polymer materials such that the thermoplastic polymer materials intermingle with each other (e.g., diffuse across a boundary layer between the thermoplastic polymer materials) and are secured together when cooled; (b) the melting or softening of a first textile element incorporating a thermoplastic polymer material such that the thermoplastic polymer material extends into or infiltrates the structure of a second textile element (e.g., extends around or bonds with filaments or fibers in the second textile element) to secure the textile elements together when cooled; and (c) the melting or softening of a textile element incorporating a thermoplastic polymer material such that the thermoplastic polymer material extends into or infiltrates crevices or cavities formed in another element (e.g., polymer foam or sheet, plate, structural device) to secure the elements together when cooled. Heatbonding may occur when only one element includes a thermoplastic polymer material or when both elements include thermoplastic polymer materials. Additionally, heatbonding does not generally involve the use of stitching or adhesives, but involves directly bonding elements to each other with heat. In some situations, however, stitching or adhesives may be utilized to supplement the heatbond or the joining of elements through heat bonding. A needle punching process may also be utilized to join the elements or supplement the heatbond. As known to a person having ordinary skill in the art, needle punching is a process by which some of the fibers or filaments in a nonwoven textile are pushed through the nonwoven textile. In another aspect, the heatbonded thermoplastic element formed may be secured to another elements with further heat bonding, adhesives, stitching, and needle punching processes, or the like.

[102] Although a heatbonding process may be utilized to form a heatbond that joins nonwoven textile 100 and component 120, the configuration of the heatbond at least partially depends upon the materials and structure of component 120. As a first example, if component 120 is at least partially formed from a thermoplastic polymer material, then the thermoplastic polymer materials of nonwoven textile 100 and component 120 may intermingle with each other to secure nonwoven textile 100 and component 120 together when cooled. If, however, the thermoplastic polymer material of component 120 has a melting point that is significantly higher than the thermoplastic polymer material of nonwoven textile 100, then the thermoplastic polymer material of nonwoven textile 100 may extend into the structure, crevices, or cavities of component 120 to secure the elements together when cooled. As a second example, component 120 may be formed from a textile that does not include a thermoplastic polymer material, and the thermoplastic polymer material of nonwoven textile 100 may extend around or bond with filaments in component 120 to secure the textile elements together when cooled. As a third example, component 120 may be a polymer foam material, polymer sheet, or plate that includes a thermoplastic polymer material, and the thermoplastic polymer materials of nonwoven textile 100 and component 120 may intermingle with each other to secure nonwoven textile 100 and component 120 together when cooled. As a fourth example, component 120 may be a polymer foam material, polymer sheet, or plate that does not include a thermoplastic polymer material, and the thermoplastic polymer material of nonwoven textile 100 may extend into or infiltrate crevices or cavities within component 120 to secure the elements together when cooled. Referring to Figure 11, a plurality of heatbond elements 105 (e.g., the thermoplastic polymer material from one or both of nonwoven textile 100 and component 120) are depicted as extending between nonwoven textile 100 and component 120 to join the elements together. Accordingly, a heatbond may be utilized to join nonwoven textile 100 and component 120 even when component 120 is formed from a diverse range of materials or has one of a variety of structures.

[103] A first general manufacturing process for forming a composite element will now be discussed with reference to Figures 12A-12C. Initially, nonwoven textile 100 and component 120 are located between first plate 111 and second plate 112, as depicted in Figure 12A. Plates 111 and 112 then translate or otherwise move toward each other in order to compress or induce contact between nonwoven textile 100 and component 120, as depicted in Figure 12B. In order to form the heatbond and join nonwoven textile 100 and component 120, heat is applied to nonwoven textile 100 and component 120. That is, the temperatures of nonwoven textile 100 and component 120 are elevated to cause softening or melting of the thermoplastic polymer material at the interface between nonwoven textile 100 and component 120. Depending upon the materials of both nonwoven textile 100 and component 120, as well as the overall configuration of component 120, only first plate 111 may be heated, only second plate 112 may be heated, or both plates 111 and 112 may be heated so as to elevate the temperatures of nonwoven textile 100 and component 120 through conduction. Upon separating plates 111 and 112, as depicted in Figure 12C, the composite element formed from both nonwoven textile 100 and component 120 may be removed and permitted to cool.

[104] The manufacturing process discussed relative to Figures 12A-12C generally involves (a) forming nonwoven textile 100 and component 120 separately and (b) subsequently joining nonwoven textile 100 and component 120 to form the composite element. Referring to Figure 13, a process wherein filaments 103 are deposited directly onto component 120 during the manufacture of nonwoven textile 100 is depicted. Initially, component 120 is placed upon plate 112, which may also be a moving conveyor. An extrusion nozzle 121 then extrudes or otherwise forms a plurality of filaments 103 from a thermoplastic polymer material. As filaments 103 fall upon component 120, filaments 103 collect, lie, or otherwise deposit upon a surface of component 120, thereby forming nonwoven textile 100. Once cooled, nonwoven textile 100 is effectively joined to component 120, thereby forming the composite element. Accordingly, filaments 103 may be deposited directly upon component 120 during the manufacture of nonwoven textile 100. As a similar manufacturing process, material (e.g., foam, molten polymer, a coating) may be sprayed, deposited, or otherwise applied to a surface of nonwoven textile 100 to form the composite element. Moreover, a composite element that includes two or more layers of nonwoven textile 100 may be formed by repeatedly depositing layers of filaments 103. When each of the layers of filaments 103 have different properties or are formed from different polymer materials, the resulting composite element may have the combined properties of the various layers.

[105] Although the general processes discussed above may be utilized to form a composite element from nonwoven textile 100 and component 120, other methods may also be utilized. Rather than heating nonwoven textile 100 and component 120 through conduction, other methods that include radio frequency heating or chemical heating may be utilized. In some processes, second surface 102 and a surface of component 120 may be heated through radiant heating prior to being compressed between plates 111 and 112. An advantage of utilizing radiant heating to elevate the temperature of only the surfaces forming the heatbond is that the thermoplastic polymer material within other portions of nonwoven textile 100 and component 120 are not heated significantly. In some processes, stitching or adhesives may also be utilized between nonwoven textile 100 and component 120 to supplement the heatbond.

[106] Nonwoven textile 100 is depicted in Figures 10-12C as having a configuration that does not include fused regions 104. In order to impart varying properties to a composite element, fused regions 104 may be formed in nonwoven textile 100. In some processes fused regions 104 may be formed prior to joining nonwoven textile 100 with another component (e.g., component 120). In other processes, however, fused regions 104 may be formed during the heatbonding process or following the heatbonding process. Accordingly, fused regions 104 may be formed at any stage of the various manufacturing process for composite elements.

[107] VI - Composite Element Configurations

[108] Concepts relating to the general structure of composite elements and processes for forming the composite elements were presented above. As more specific examples, the following discussion discloses various composite element configurations, wherein nonwoven textile 100 is joined with each of a mechanically-manipulated textile 130, a sheet 140, a foam layer 150, and a plurality of strands 160.

[109] An example of a composite element that includes nonwoven textile 100 and mechanically-manipulated textile 130 is depicted in Figures 14 and 15. Whereas nonwoven textile 100 is formed from randomly-distributed filaments 103, textile 130 is formed by mechanically-manipulating one or more yarns 131 to form a woven or interlooped structure. When manufactured with an interlooped structure, textile 130 may be formed through a variety of knitting processes, including flat knitting, wide tube circular knitting, narrow tube circular knit jacquard, single knit circular knit jacquard, double knit circular knit jacquard, warp knit jacquard, and double needle bar raschel knitting, for example. Accordingly, textile 130 may have a variety of configurations, and various weft-knitting and warp-knitting techniques may be utilized to manufacture textile 130. Although yarns 131 of textile 130 may be at least partially formed from a thermoplastic polymer material, many mechanically-manipulated textiles are formed from natural filaments (e.g., cotton, silk) or thermoset polymer materials. In order to form a heatbond between nonwoven textile 100 and textile 130, the thermoplastic polymer material from nonwoven textile 100 extends around or bonds with yarns 131 or extends into the structure of yarns 131 to secure nonwoven textile 100 and textile 130 together when cooled. More particularly, various heatbond elements 105 are depicted in Figure 15 as extending around or into yarns 131 to form the heatbond. A process similar to the process discussed above relative to Figures 12A-12C may be utilized to form the heatbond between nonwoven textile 100 and textile 130. That is, the heatbond between nonwoven textile 100 and textile 130 may be formed, for example, by compressing and heating the elements between plates 111 and 112.

[110] The combination of nonwoven textile 100 and textile 130 may impart some advantages over either of nonwoven textile 100 and textile 130 alone. For example, textile 130 may exhibit one-directional stretch, wherein the configuration of yarns 131 allows textile 130 to stretch in one direction, but limits stretch in a perpendicular direction. When nonwoven textile 100 and textile 130 are joined, the composite element may also exhibit a corresponding one-directional stretch. As another example, the composite element may also be incorporated into various articles of apparel, with textile 130 being positioned to contact the skin of an individual wearing the apparel, and the materials selected for textile 130 and the structure of textile 130 may impart more comfort than nonwoven textile 100 alone. In addition to these advantages, various fused regions 104 may be formed in nonwoven textile 100 to impart different degrees of permeability, durability, and stretch-resistance to specific areas of the composite element. Accordingly, the composite element may have a configuration that imparts a combination of properties that neither nonwoven textile 100 nor textile 130 may impart alone.

[111] Another example of a composite element, which includes nonwoven textile 100 and sheet 140, is depicted in Figures 16 and 17. Sheet 140 may be formed from a sheet or plate of a polymer, suede, synthetic suede, metal, or wood material, for example, and may be either flexible or inflexible. In order to form a heatbond between nonwoven textile 100 and sheet 140, the thermoplastic polymer material of nonwoven textile 100 may extend into or infiltrate crevices or cavities within sheet 140 to secure the elements together when cooled. In circumstances where sheet 140 is formed from a thermoplastic polymer material, then the thermoplastic polymer materials of nonwoven textile 100 and sheet 140 may intermingle with each other (e.g., diffuse across a boundary layer between the thermoplastic polymer materials) to secure nonwoven textile 100 and sheet 140 together when cooled. A process similar to the process discussed above relative

to Figures 12A-12C may be utilized to form the heatbond between nonwoven textile 100 and sheet 140. As an alternative, stitching or adhesives may be utilized, as well as a needle punching process to push filaments 103 into or through sheet 140 to join nonwoven textile 100 and sheet 140 or to supplement the heatbond.

[112] The combination of nonwoven textile 100 and sheet 140 may be suitable for articles of apparel that impart protection from acute impacts, for example. A lack of stitching, rivets, or other elements joining nonwoven textile 100 and sheet 140 forms a relatively smooth interface. When incorporated into an article of apparel, the lack of discontinuities in the area joining nonwoven textile 100 and sheet 140 may impart comfort to the individual wearing the apparel. As another example, edges of sheet 140 are depicted as being spaced inward from edges of nonwoven textile 100. When incorporating the composite element into a product, such as apparel, the edges of nonwoven textile 100 may be utilized to join the composite element to other textile elements or portions of the apparel. In addition to these advantages, various fused regions 104 may be formed in nonwoven textile 100 to impart different degrees of permeability, durability, and stretch-resistance to areas of the composite element.

[113] Although sheet 140 is depicted as having a solid or otherwise continuous configuration, sheet 140 may also be absent in various areas of the composite element. Referring to Figure 18A, sheet 140 has the configuration of various strips of material that extend across nonwoven textile 100. A similar configuration is depicted in Figure 18B, wherein sheet 140 has the configuration of a grid. In addition to imparting strength and tear-resistance to the composite element, the strip and grid configurations of sheet 140 expose portions of nonwoven textile 100, thereby allowing permeability in the exposed areas. In each of Figures 16-18B, sheet 140 is depicted as having a thickness that is comparable to the thickness of nonwoven textile 100. In Figure 18C, however, sheet 140 is depicted as having a thickness that is substantially less than the thickness of nonwoven textile 100. Even with a reduced thickness, sheet 140 may impart strength and tear-resistance, while allowing permeability.

[114] A further example of a composite element that includes two layers of nonwoven textile 100 and foam layer 150 is depicted in Figures 19 and 20. Foam layer 150 may be formed from a foamed polymer material that is either thermoset or thermoplastic. In configurations where foam layer 150 is formed from a thermoset polymer material, the thermoplastic polymer material from the two layers of nonwoven textile 100 may extend into or infiltrate crevices or cavities on opposite sides of foam layer 150 to form heatbonds and secure the elements together. In configurations where foam layer 150 is formed from a thermoplastic polymer material, the thermoplastic polymer materials of the two layers of nonwoven textile 100 and foam layer 150 may intermingle with each other to form heatbonds and secure the elements together.

[115] A process similar to the process discussed above relative to Figures 12A-12C may be utilized to form the heatbonds between the two layer of nonwoven textile 100 and foam layer 150. More particularly, foam layer 150 may be placed between the two layers of nonwoven textile 100, and these three elements may be located between plates 111 and 112. Upon compressing and heating, heatbonds may form between the two layers of nonwoven textile 100 and the opposite sides of foam layer 150. Additionally, the two layers of nonwoven textile 100 may be heatbonded to each other around the perimeter of foam layer 150. That is, heatbonds may also be utilized to join the two layers of nonwoven textile 100 to each other. In addition to foam layer 150, other intermediate elements (e.g., textile 130 or sheet 140) may be bonded between the two layers of nonwoven textile 100. A needle punching process may also be utilized to push filaments 103 into or through foam layer 150 to join nonwoven textile 100 and foam layer 150 or to supplement the heatbond, as well as stitching or adhesives.

[116] The combination of the two layers of nonwoven textile 100 and foam layer 150 may be suitable for articles of apparel where cushioning (i.e., attenuation of impact forces) is advantageous, such as padding for athletic activities that may involve contact or impact with other athletes or equipment. The lack of discontinuities in the area joining the layers of nonwoven textile 100 and foam layer 150 may impart comfort to the individual wearing the apparel. The edges of the two layers of nonwoven textile 100 may also be utilized to join the composite element to other textile elements or portions of the apparel. In addition to these advantages, various fused regions 104 may be formed in nonwoven textile 100 to impart different degrees of permeability, durability, and stretch-resistance to the composite element.

[117] An example of a composite element that includes nonwoven textile 100 and a plurality of strands 160 is depicted in Figures 21 and 22. Strands 160 are secured to nonwoven textile 100 and extend in a direction that is substantially parallel to either of surfaces 101 and 102. Referring to the cross-section of Figure 22, the positions of strands 160 relative to surfaces 101 and 102 may vary significantly. More particularly, strands 160 may be located upon first surface 101, strands 160 may be partially embedded within first surface 101, strands 160 may be recessed under and adjacent to first surface 101, strands 160 may be spaced inward from first surface 101 and located between surfaces 101 and 102, or strands 160 may be adjacent to second surface 102. A heatbonding process may be utilized to secure strands 160 to nonwoven textile 100. That is, thermoplastic polymer material of nonwoven textile 100 may be softened or melted to form a heatbond that joins strands 160 to nonwoven textile 100. Depending upon the degree to which the thermoplastic polymer material of nonwoven textile 100 is softened or melted, strands 160 may be positioned upon first surface 101 or located inward from first surface 101.

[118] Strands 160 may be formed from any generally one-dimensional material exhibiting a length that is substantially greater than a width and a thickness. Depending upon the material utilized and the desired properties, strands 160 may be individual filaments, yarns that include a plurality of filaments, or threads that include a plurality of yarns. As discussed in greater detail below, suitable materials for strands 160 include rayon, nylon, polyester, polyacrylic, silk, cotton, carbon, glass, aramids (e.g., para-aramid fibers and meta-aramid fibers), ultra high molecular weight polyethylene, and liquid crystal polymer, for example. In some configurations, strands 160 may also be metal wires or cables.

[119] In comparison with the thermoplastic polymer material forming nonwoven textile 100, many of the materials noted above for strands 160 exhibit greater tensile strength and stretch-resistance. That is, strands 160 may be stronger than nonwoven textile 100 and may exhibit less stretch than nonwoven textile 100 when subjected to a tensile force. The combination of nonwoven textile 100 and strands 160 imparts a structure wherein the composite element may stretch in one direction and is substantially stretch-resistant and has more strength in another direction. Referring to Figure 21, two perpendicular directions are identified with arrows 161 and 162. When the composite element is subjected to a tensile force (i.e., stretched) in the direction of arrow 161, nonwoven textile 100 may stretch significantly. When the composite element is subjected to a tensile force (i.e., stretched) in the direction of arrow 162, however, strands 160 resist the force and are more stretch-resistant than nonwoven textile 100. Accordingly, strands 160 may be oriented to impart strength and stretch-resistance to the composite element in particular directions. Although strands 160 are discussed herein as imparting stretch-resistance, strands 160 may be formed from materials that stretch significantly. Strands 160 may also be utilized to impart other properties to the composite element. For example, strands 160 may be electrically-conductive to allow the transmission of power or data, or strands 160 may be located within nonwoven textile 100 to impart a particular aesthetic.

[120] Strands 160 are depicted as being substantially parallel to each other in Figure 21, and ends of strands 160 are depicted as being spaced inward from edges of nonwoven textile 100. In other composite element configurations, strands 160 may be arranged in other orientations and may extend entirely or only partially across nonwoven textile 100. Referring to Figure 23A, strands 160 are depicted as crossing each other. Given the angle that strands 160 are oriented relative to each other, strands 160 may only partially limit the stretch in the direction of arrow 161, but the composite element may be substantially stretch-resistant in the direction of arrow 162. A similar configuration is depicted in Figure 23B, wherein strands 160 cross each other at right angles. In this configuration, strands 160 may impart stretch-resistance in the directions of both arrows 161 and 162. That is, the composite element may be stretch-resistant in all directions due to the orientation of strands 160. As another matter, whereas ends of strands 160 are spaced inward from edges of nonwoven textile 100 in Figure 23A, the ends of strands 160 extend to the edges of nonwoven textile 100 in Figure 23B. Strands 160 are depicted as having a wave-like or non-linear configuration in Figure 23C. In this configuration, strands 160 may permit some stretch in the direction of arrow 162. Once strands 160 straighten due to the stretch, however, then strands 160 may substantially resist stretch and provide strength in the direction of arrow 162. Another configuration is depicted in Figure 23D, wherein strands 160 are arranged in a non-parallel configuration to radiate outward.

[121] In some configurations of the composite element, fused regions 104 may be added to further affect the properties of the composite element. Referring to Figure 23E, a single fused region 104 extends across nonwoven textile 100 in the direction of arrow 161. Given that fused regions 104 may exhibit more stretch-resistance than other areas of nonwoven textile 100, the fused region in Figure 23E may impart some stretch-resistance in the direction of arrow 161, and strands 160 may impart stretch-resistance to the direction of arrow 162. In some configurations, fused regions may extend along strands 160 and in the direction of arrow 162, as depicted in Figure 23F. Accordingly, fused regions 104 may be utilized with strands 160 to impart specific properties to a composite element.

[122] The material properties of strands 160 relate to the specific materials that are utilized within strands 160. Examples of material properties that may be relevant in selecting specific materials for strands 160 include tensile strength, tensile modulus, density, flexibility, tenacity, and durability. Each of the materials noted above as being suitable for strands 160 exhibit different combinations of material properties. Accordingly, the material properties for each of these materials may be compared in selecting particular materials for strands 160. Tensile strength is a measure of resistance to breaking when subjected to tensile (i.e., stretching) forces. That is, a material with a high tensile strength is less likely to break when subjected to tensile forces than a material with a low tensile strength. Tensile modulus is a measure of resistance to stretching when subjected to tensile forces. That is, a material with a high tensile modulus is less likely to stretch when subjected to tensile forces than a material with a low tensile modulus. Density is a measure of mass per unit volume. That is, a particular volume of a material with a high density has more weight than the same volume of a material with a low density.

[123] Nylon has a relatively low tensile strength, a relatively low tensile modulus, and an average density when compared to each of the other materials. Steel has an average tensile strength, a moderately high tensile modulus, and a relatively high density when compared to the other materials. While nylon is less dense than steel (i.e., lighter than steel), nylon has a lesser strength and a greater propensity to stretch than steel. Conversely, while steel is stronger and exhibits less stretch, steel is significantly more dense (i.e., heavier than nylon). Each of the engineering fibers (e.g., carbon fibers, aramid fibers, ultra high molecular weight polyethylene, and liquid crystal polymer) exhibit tensile strengths and tensile moduli that are comparable to steel. In addition, the engineering fibers exhibit densities that are comparable to nylon. That is, the engineering fibers have relatively high tensile strengths and tensile moduli, but also have relatively low densities. In general, each of the engineering fibers have a tensile strength greater than 0.60 gigapascals, a tensile modulus greater than 50 gigapascals, and a density less than 2.0 grams per centimeter cubed.

[124] In addition to material properties, the structural properties of various configurations of strands 160 may be considered when selecting a particular configuration for a composite element. The structural properties of strands 160 relate to the specific structure that is utilized to form strands 160. Examples of structural properties that may be relevant in selecting specific configurations for strands 160 include denier, number of plies, breaking force, twist, and number of individual filaments, for example.

[125] Based upon the above discussion, nonwoven textile 100 may be heatbonded or otherwise joined (e.g., through stitching or adhesive bonding) to a variety of other components to form composite elements. An advantage of joining nonwoven textile 100 to the other components is that the composite elements generally include combined properties from both nonwoven textile 100 and the other components. As examples, composite elements may be formed by joining nonwoven textile 100 to any of textile 130, sheet 140, foam layer 150, and strands 160.

[126] VII - Seam Formation

[127] In order to incorporate nonwoven textile 100 into a product, nonwoven textile 100 is often joined with other elements of the product to form a seam. For example, nonwoven textile 100 may be joined with other nonwoven textile elements, various mechanically-manipulated textile elements, or polymer sheets. Although stitching and adhesive bonding may be utilized to join nonwoven textile 100 to the other elements of the product, the seam may also be formed through a heatbonding process.

[128] As an example of the manner in which nonwoven textile 100 may be joined to another element, Figures 24 and 25 depict a pair of elements of nonwoven textile 100 that are joined to form a seam 106. That is, an edge area of one nonwoven textile 100 is joined with an edge area of the other nonwoven textile 100 at seam 106. More particularly, seam 106 is formed by heatbonding first surface 101 of one nonwoven textile 100 with first surface 101 of the other nonwoven textile 100. As with some conventional stitched seams, first surfaces 101 from each nonwoven textile 100 are turned inward at seam 106 to face each other, and first surfaces 101 are joined to each other. In contrast with some conventional stitched seams, a heatbond is utilized to join first surfaces 101 from each nonwoven textile 100 to each other. In some configurations, however, stitching or adhesive bonding may also be utilized to reinforce seam 106.

[129] A general manufacturing process for forming seam 106 will now be discussed with reference to Figures 26A-26D. Initially, the pair of elements of nonwoven textile 100 are located between a first seam-forming die 117 and a second seam-forming die 118, as depicted in Figure 26A. Seam-forming dies 117 and 118 then translate or otherwise move toward each other in order to compress or induce contact between edge areas of the pair of elements of nonwoven textile 100, as depicted in Figure 26B. In order to form the heatbond and join the edge areas of the elements of nonwoven textile 100, seam-forming dies 117 and 118 apply heat to the edge areas. That is, seam-forming dies 117 and 118 elevate the temperatures of the edge areas of the pair of elements of nonwoven textile 100 to cause softening or melting of the thermoplastic polymer material at the interface between the edge areas. Upon separating seam-forming dies 117 and 118, as depicted in Figure 26C, seam 106 is formed between the edge areas of the pair of elements of nonwoven textile 100. After being permitted to cool, the pair of elements of nonwoven textile 100 may be unfolded, as depicted in Figure 26D. After forming, seam 106 may also be trimmed to limit the degree to which the end areas of the pair of elements of nonwoven textile 100 extend downward at seam 106.

[130] Although the general process discussed above may be utilized to form seam 106, other methods may also be utilized. Rather than heating the edge areas of elements of nonwoven textile 100 through conduction, other methods that include radio frequency heating, chemical heating, or radiant heating may be utilized. In some processes, stitching or adhesives may also be utilized between the pair of elements of nonwoven textile 100 to supplement the heatbond. As an alternate method, the pair of elements of nonwoven textile 100 may be placed upon a surface, such as second plate 112, and a heated roller 119 may form seam 106, as depicted in Figure 27.

[131] As with the formation of fused regions 104, the formation of seam 106 involves softening or melting the thermoplastic polymer material in various filaments 103 that are located in the area of seam 106. Depending upon the degree to which filaments 103 change state, the various filaments 103 in the area of seam 106 may (a) remain in a filamentous configuration, (b) melt entirely into a liquid that cools into a non-filamentous configuration, or (c) take an intermediate configuration wherein some filaments 103 or portions of individual filaments 103 remain filamentous and other filaments 103 or portions of individual filaments 103 become non-filamentous. Referring to Figure 25, filaments 103 are depicted as remaining in the filamentous configuration in the area of seam 106, but may be melted into a non-filamentous configuration or may take the intermediate configuration. Accordingly, although filaments 103 in the area of seam 106 are generally fused to a greater degree than filaments 103 in other areas of nonwoven textile 100, the degree of fusing may vary significantly.

[132] In forming seam 106 between the pair of elements of nonwoven textile 100, the thermoplastic polymer materials from the various filaments 103 intermingle with each other and are secured together when cooled. Nonwoven textile 100 may also be joined with other types of elements to form a similar seam 106. As a first example, nonwoven textile 100 is depicted as being joined with mechanically-manipulated textile 130 at seam 106 in Figure 28A. Although yarns 131 of textile 130 may be at least partially formed from a thermoplastic polymer material, many mechanically-manipulated textiles are formed from natural filaments (e.g., cotton, silk) or thermoset polymer materials. In order to form a heatbond between nonwoven textile 100 and textile 130 at seam 106, the thermoplastic polymer material from nonwoven textile 100 extends around or bonds with yarns 131 or extends into the structure of yarns 131 to secure the nonwoven textile 100 and textile 130 together at seam 106 when cooled. As a second example, nonwoven textile 100 is depicted as being joined with sheet 140 at seam 106 in Figure 28B. In some configurations, sheet 140 may be a flexible polymer sheet. In order to form a heatbond between nonwoven textile 100 and sheet 140 at seam 106, the thermoplastic polymer material of nonwoven textile 100 may extend into or infiltrate crevices or cavities within sheet 140 to secure the elements together when cooled. In circumstances where sheet 140 is formed from a thermoplastic polymer material, then the thermoplastic polymer materials of nonwoven textile 100 and sheet 140 may intermingle with each other to secure nonwoven textile 100 and sheet 140 together at seam 106 when cooled.

[133] The thicknesses of elements of nonwoven textile 100 are depicted as being substantially uniform, even in the areas of seam 106. Depending upon the temperature and pressure used to form seam 106, the configuration of seam 106 may vary to include a variety of other configurations. Referring to Figure 29A, elements of nonwoven textile 100 exhibit reduced thicknesses in the areas of seam 106, and the thermoplastic polymer material of filaments 103 is depicted as being in a non-filamentous configuration. Seam 106 may also exhibit a pointed configuration, as depicted in Figure 29B. The temperature and pressure used to form seam 106 may also impart a stepped structure, as depicted in Figure 29C. Accordingly, the configuration of the pair of elements of nonwoven textile 100 at seam 106 may vary significantly. Moreover, similar configurations for seam 106 may result when nonwoven textile 100 is joined with other elements, such as textile 130 or sheet 140.

[134] As another example of the manner in which nonwoven textile 100 may be joined to another element, Figures 30 and 31 depict a pair of elements of nonwoven textile 100 that are joined to form a seam 107. In this configuration, an edge area of one nonwoven textile 100 overlaps and is joined with an edge of the other nonwoven textile 100 at seam 107. Although a heatbond is utilized to join the pair of elements of nonwoven textile 100 to each other, stitching or adhesive bonding may also be utilized to reinforce seam 107. Moreover, a single nonwoven textile 100 may also be joined with other types of elements, including textile 130 and sheet 140, to form a similar seam 107.

[135] A general manufacturing process for forming seam 107 will now be discussed with reference to Figures 32A-32C. Initially, the pair of elements of nonwoven textile 100 are positioned in an overlapping configuration between first seam-forming die 117 and second seam-forming die 118, as depicted in Figure 32A. Seam-forming dies 117 and 118 then translate or otherwise move toward each other in order to compress or induce contact between edge areas of the pair of nonwoven textile elements 100, as depicted in Figure 32B. In order to form the heatbond and join the edge areas of the elements of nonwoven textile 100, seam-forming dies 117 and 118 apply heat to the edge areas. That is, seam-forming dies 117 and 118 elevate the temperatures of the edge areas of the pair of elements of nonwoven textile 100 to cause softening or melting of the thermoplastic polymer material at the interface between the edge areas. Upon separating seam-forming dies 117 and 118, as depicted in Figure 32C, seam 107 is formed between the edge areas of the pair of elements of nonwoven textile 100.

[136] Although the general process discussed above may be utilized to form seam 107, other methods may also be utilized. Rather than heating the edge areas of elements of nonwoven textile 100 through conduction, other methods that include radio frequency heating, chemical heating, or radiant heating may be utilized. In some processes, stitching or adhesives may also be utilized between the pair of elements of nonwoven textile 100 to supplement the heatbond. As an alternate method, the pair of elements of nonwoven textile 100 may be placed upon a surface, such as second plate 112, and heated roller 119 may form seam 107, as depicted in Figure 33. Referring to Figure 31, filaments 103 are depicted as remaining in the filamentous configuration in the area of seam 107, but may be melted into a non-filamentous configuration or may take the intermediate configuration. Accordingly, although filaments 103 in the area of seam 107 are generally fused to a greater degree than filaments 103 in other areas of nonwoven textile 100, the degree of fusing may vary significantly.

[137] First surfaces 101 of the pair of elements of nonwoven textile 100 are depicted as being co-planar or flush with each other in Figures 30 and 31. Similarly, second surfaces 102 of the pair of elements of nonwoven textile 100 are also depicted as being coplanar or flush with each other. Depending upon the temperature and pressure used to form seam 107, the configuration of seam 107 may vary to include a variety of other configurations. Referring to Figure 34A, surfaces 101 and 102 bow inward at seam 107, and the thermoplastic polymer material is depicted as having a non-filamentous configuration. Surfaces 101 and 102 angle inward more-abruptly in Figure 34B, which may be caused from pressure exerted by seam-forming dies 117 and 118. As another configuration, Figure 34C depicts the pair of elements of nonwoven textile 100 as being joined at 107 in a non-coplanar configuration. Accordingly, the configuration of the pair of elements of nonwoven textile 100 at seam 107 may vary significantly. Moreover, similar configurations for seam 107 may result when nonwoven textile 100 is joined with other elements, such as textile 130 or sheet 140.

[138] VIII - General Product Configurations

[139] Nonwoven textile 100, multiple elements of nonwoven textile 100, or various composite element configurations may be utilized in articles of apparel (e.g., shirts, jackets and other outerwear, pants, footwear), containers, and upholstery for furniture. Various configurations of nonwoven textile 100 may also be utilized in bed coverings, table coverings, towels, flags, tents, sails, and parachutes, as well as industrial purposes that include automotive and aerospace applications, filter materials, medical textiles, geotextiles, agrotextiles, and industrial apparel. Accordingly, nonwoven textile 100 may be utilized in a variety of products for both personal and industrial purposes.

[140] Although nonwoven textile 100 may be utilized in a variety of products, the following discussion provides examples of articles of apparel that incorporate nonwoven textile 100. That is, the following discussion demonstrates various ways in which nonwoven textile 100 may be incorporated into a shirt 200, a pair of pants 300, and an article of footwear 400. Moreover, examples of various configurations of shirt 200, pants 300, and footwear 400 are provided in order to demonstrate various concepts associated with utilizing nonwoven textile 100 in products. Accordingly, while the concepts outlined below are specifically applied to various articles of apparel, the concepts may be applied to a variety of other products.

[141] IX - Shirt Configurations

[142] Various configurations of shirt 200 are depicted in Figures 35A-35H as including a torso region 201 and a pair of arm regions 202 that extend outward from torso region 201. Torso region 201 corresponds with a torso of a wearer and covers at least a portion of the torso when worn. An upper area of torso region 201 defines a neck opening 203 through which the neck and head of the wearer protrude when shirt 200 is worn. Similarly, a lower area of torso region 201 defines a waist opening 204 through which the waist or pelvic area of the wearer protrudes when shirt 200 is worn. Arm regions 202 respectively correspond with a right arm and a left arm of the wearer and cover at least a portion of the right arm and the left arm when shirt 200 is worn. Each of arm regions 202 define an arm opening 205 through which the hands, wrists, or arms of the wearer protrude when shirt 200 is worn. Shirt 200 has the configuration of a shirt-type garment, particularly a long-sleeved shirt. In general, shirt-type garments cover a portion of a torso of the wearer and may extend over arms of the wearer. In further examples, apparel having the general structure of shirt 200 may have the configuration of other shirt-type garments, including short-sleeved shirts, tank tops, undershirts, jackets, or coats.

[143] A first configuration of shirt 200 is depicted in Figures 35A and 36A. A majority of shirt 200 is formed from nonwoven textile 100. More particularly, torso region 201 and each of arm regions 202 are primarily formed from nonwoven textile 100. Although shirt 200 may be formed from a single element of nonwoven textile 100, shirt 200 is generally formed from multiple joined elements of nonwoven textile 100. As depicted, for example, at least a front area of torso region 201 is formed one element of nonwoven textile 100, and each of arm regions 202 are formed from different elements of nonwoven textile 100. A pair of seams 206 extends between torso region 201 and arm regions 202 in order to join the various elements of nonwoven textile 100 together. In general, seams 206 define regions where edge areas of the elements of nonwoven textile 100 are heatbonded with each other. Referring to Figure 36A, one of seams 206 is depicted as having the general configuration of seam 106, but may also have the configuration of seam 107 or another type of seam. Stitching and adhesive bonding may also be utilized to form or supplement seams 206.

[144] A second configuration of shirt 200 is depicted in Figures 35B and 36B. As with the configuration of Figure 35A, a majority of shirt 200 is formed from nonwoven textile 100. In order to impart different properties to specific areas of shirt 200, various fused regions 104 are formed in nonwoven textile 100. More particularly, fused regions 104 are formed around neck opening 203, waist opening 204, and each of arm openings 205. Given that each of openings 203-205 may be stretched as shirt 200 is put on an individual and taken off the individual, fused regions 104 are located around openings 203-205 in order to impart greater stretch-resistance to these areas. Filaments 103 in fused regions 104 of shirt 200 are generally fused to a greater degree than filaments 103 in other areas of shirt 200 and may exhibit a non-filamentous configuration, as depicted in Figure 36B. Filaments 103 in fused regions 104 of shirt 200 may also exhibit a filamentous configuration or the intermediate configuration. In addition to providing greater stretch-resistance, fused regions 104 impart enhanced durability to the areas around openings 203-205.

[145] A third configuration of shirt 200 is depicted in Figures 35C and 36C as including further fused regions 104. Given that elbow areas of shirt 200 may be subjected to relatively high abrasion as shirt 200 is worn, some of fused regions 104 may be located in the elbow areas to impart greater durability. Also, backpack straps that extend over shoulder areas of shirt 200 may abrade and stretch the shoulder areas. Additional fused regions 200 are, therefore, located in the shoulder areas of shirt 200 to impart both durability and stretch-resistance. The areas of nonwoven textile 100 that are located in the shoulder areas and around seams 206 effectively form both seams 206 and the fused regions 104 in the shoulder areas, as depicted in Figure 36C. Two separate processes may be utilized to form these areas. That is, a first heatbonding process may form seams 206, and a second heating process may form the fused regions 104 in the shoulder areas. As an alternative, however, seams 206 and the fused regions 104 in the shoulder areas may be formed through a single heatbonding/heating process.

[146] Although the size of fused regions 104 in shirt 200 may vary significantly, some of fused regions 104 generally have a continuous area of at least one square centimeter. As noted above, various embossing or calendaring processes may be utilized during the manufacturing process for nonwoven textile 100. Some embossing or calendaring processes may form a plurality of relatively small areas (i.e., one to ten square millimeters) where filaments 103 are somewhat fused to each other. In contrast with the areas formed by embossing or calendaring, some of fused regions 104 have a continuous area of at least one square centimeter. As utilized herein, "continuous area" or variants thereof is defined as a relatively unbroken or uninterrupted region. As examples, and with reference to Figure 35C, the fused region 104 around neck opening 203 individually forms a continuous area, each of the fused regions 104 in the elbow areas of shirt 200 individually form a continuous area, and each of the fused regions 104 in the shoulder areas of shirt 200 individually form a continuous area. All of fused regions 104 (i.e., around neck openings 203-205 and in the shoulder and elbow areas) are not collectively one continuous area because portions of nonwoven textile 100 without significant fusing extend between these fused regions 104.

[147] A fourth configuration of shirt 200 is depicted in Figures 35D and 36D. Referring to Figures 35B and 36B, fused regions 104 are utilized to provide stretch-resistance to the areas around openings 203-205. Another structure that may be utilized to provide stretch-resistance, as well as a different aesthetic, involves folding nonwoven textile 100 and heatbonding or otherwise securing nonwoven textile 100 to itself at various bond areas 207, as generally depicted in Figure 36D. Although this structure may be utilized for any of openings 203-205, bond areas 207 where textile 100 is heatbonded to itself are depicted as extending around waist opening 204 and arm openings 205.

[148] A fifth configuration of shirt 200 is depicted in Figures 35E and 36E. Whereas the configurations of shirt 200 depicted in Figures 35A-35D are primarily formed from nonwoven textile 100, arm regions 202 in this configuration of shirt 200 are formed from textile 130, which is a mechanically-manipulated textile. As discussed above, seams having the configuration of seams 106 and 107 may join nonwoven textile 100 with a variety of other materials, including textile 130. Seams 206 join, therefore, nonwoven textile from torso region 201 with elements of textile 130 from arm regions 202. Utilizing various types of textile materials within shirt 200 may, for example, enhance the comfort, durability, or aesthetic qualities of shirt 200. Although arm regions 202 are depicted as being formed from textile 130, other areas may additionally or alternatively be formed form textile 130 or other materials. For example, a lower portion of torso region 201 may be formed from textile 130, only an area around neck opening 203 may be formed from textile 130, or the configuration of Figure 35E may be reversed such that torso region 201 is formed from textile 130 and each of arm regions 202 are formed from nonwoven textile 100. Although textile 130 is utilized as an example, elements formed from the materials of sheet 140 or foam layer 150 may also be incorporated into shirt 200 and joined with nonwoven textile 100. Accordingly, an article of apparel, such as shirt 200, may incorporate both nonwoven textile 100 and various other textiles or materials. Various fused regions 104 are also formed in the nonwoven textile 100 of torso region 201 in order to impart different properties to specific areas of shirt 200 that incorporate nonwoven textile 100.

[149] A sixth configuration of shirt 200 is depicted in Figures 35F and 36F, in which a majority of shirt 200 is formed from a composite element of nonwoven textile 100 and textile 130. More particularly, the material forming shirt 200 has a layered structure including an outer layer of nonwoven textile 100 and an inner layer of textile 130. The combination of nonwoven textile 100 and textile 130 may impart some advantages over either of nonwoven textile 100 and textile 130 alone. For example, textile 130 may exhibit one-directional stretch that imparts one-directional stretch to the composite element. Textile 130 may also be positioned to contact the skin of an individual wearing shirt 200, and the materials selected for textile 130 and the structure of textile 130 may impart more comfort than nonwoven textile 100 alone. As an additional matter, the presence of nonwoven textile 100 permits elements to be joined through heatbonding. Referring to Figure 36F, surfaces of the composite material that include nonwoven textile 100 are heatbonded to each other to join elements from torso region 201 and one of arm regions 202. Various fused regions 104 are also formed in regions 201 and 202 in order to impart different properties to specific areas of shirt 200.

[150] A seventh configuration of shirt 200 is depicted in Figures 35G and 36G. In order to provide protection to a wearer, various sheets 140 and foam layers 150 are heatbonded to an interior surface of nonwoven textile 100. More particularly, two sheets 140 are located in the shoulder areas of shirt 200, two sheets 140 are located in arm regions 202, and two foam layers 150 are located on sides of torso region 201. Various fused regions 104 are also formed in nonwoven textile 100. More particularly, a pair of fused regions 104 extend around the areas where foam layers 150 are located in torso region 201, and a pair of fused regions 104 extend over the areas where sheets 140 are located in arm regions 202. These fused regions 104 may be utilized to reinforce or add stretch-resistance to areas surrounding foam layers 150 or provide greater durability to areas over sheets 140, for example.

[151] An eighth configuration of shirt 200 is depicted in Figures 35H and 36H. In addition to various fused regions 104 that are formed in nonwoven textile 100, a plurality of strands 160 are also embedded within nonwoven textile 100 to, for example, impart stretch-resistance or additional strength to specific areas of shirt 200. More particularly, seven strands 160 radiate outward and downward from a point in an upper portion of torso region 201, two strands 160 extend in parallel along each of arm regions 202, and at least one strand 160 extends across seams 206 in shoulder areas of shirt 200. Some of strands 160 extend through various fused regions 104 that may impart additional stretch-resistance or durability, for example, to the areas surrounding strands 160. In torso region 201, each of strands 160 pass through one of fused regions 104, while two of strands 160 extend along a pair of fused regions 104. In the shoulder areas of shirt 200, a pair of strands 160 are located entirely within fused regions 104. Accordingly, strands 160 may be utilized alone or coupled with fused regions 104.

[152] Based upon the above discussion, nonwoven textile 100 may be utilized in an article of apparel, such as shirt 200. In some configurations, seams 206 having the configuration of either of seams 106 or 107 may be used to join textile elements, including elements of nonwoven textile 100. In order to impart different properties to areas of shirt 200, various fused regions 104 may be formed, different types of textiles may be incorporated into shirt 200, and composite elements may be formed by joining one or more of textile 130, sheet 140, foam layer 150, strands 160, or various other components to nonwoven textile 100. By forming fused regions 104 in nonwoven textile 100 and combining nonwoven textile 100 with other components to form composite elements, various properties and combinations of properties may be imparted to different areas of shirt 200. That is, the various concepts disclosed herein may be utilized individually or in combination to engineer the properties of shirt 200 and tailor shirt 200 to a specific purpose. Given that nonwoven textile 100 incorporates a thermoplastic polymer material, seams 206 and the composite elements may be formed through heatbonding.

[153] X - Pants Configurations

[154] Various configurations of pants 300 are depicted in Figures 37A-37C as including a pelvic region 301 and a pair of leg regions 302 that extend downward from pelvic region 301. Pelvic region 301 corresponds with a lower torso and pelvis bone of a wearer and covers at least a portion of the lower torso when worn. An upper area of pelvic region 301 defines a waist opening 303 through which the torso extends when pants 300 are worn. Leg regions 302 respectively correspond with a right leg and a left leg of the wearer and cover at least a portion of the right leg and the left leg when pants 300 are worn. Each of leg regions 302 define an ankle opening 304 through which the ankle and feet of the wearer protrude when pants 300 are worn. Pants 300 have the configuration of a pants-type garment, particularly a pair of athletic pants. In general, pants-type garments cover the lower torso of the wearer and may extend over legs of the wearer. In further examples, apparel having the general structure of pants 300 may have the configuration of other pants-type garments, including shorts, jeans, briefs, swimsuits, and undergarments.

[155] A first configuration of pants 300 is depicted in Figure 37A. A majority of pants 300 is formed from nonwoven textile 100. More particularly, pelvic region 301 and each of leg regions 302 are primarily formed from nonwoven textile 100. Although pants 300 may be formed from a single element of nonwoven textile 100, pants 300 is generally formed from multiple joined elements of nonwoven textile 100. Although not depicted, seams similar to seams 106, 107, or 206 may be utilized to join the various elements of nonwoven textile 100 together. Stitching and adhesive bonding may also be utilized to form or supplement the seams.

[156] A pocket 305 is formed in pants 300 and may be utilized to hold or otherwise contain relatively small objects (e.g., keys, wallet, identification card, mobile phone, portable music player). Two overlapping layers of nonwoven textile 100 are utilized to form pocket 305, as depicted in Figure 38. More particularly, a bond area 306 is utilized to heatbond the layers of nonwoven textile 100 to each other. A central area of one of the layers of nonwoven textile 100 remains unbonded, however, to form the areas within pocket 305 for containing the objects. A pocket similar to pocket 305 may also be formed in other products and articles of apparel, including shirt 200.

[157] A second configuration of pants 300 is depicted in Figure 37B. As with the configuration of Figure 37A, a majority of pants 300 is formed from nonwoven textile 100. In order to impart different properties to specific areas of pants 300, various fused regions 104 are formed in nonwoven textile 100. More particularly, fused regions 104 are formed around waist opening 303 and each of leg openings 304. Another fused region 104 is formed at an opening for pocket 305. Given that each of openings 303 and 304, as well as the opening to pocket 305, may be stretched, fused regions 104 may be utilized to impart greater stretch-resistance to these areas. That is, filaments 103 in fused regions 104 of pants 300 are generally fused to a greater degree than filaments 103 in other areas of pants 300 and may have any of the filamentous, non-filamentous, or intermediate configurations discussed above. In addition to providing greater stretch-resistance, fused regions 104 impart enhanced durability. Given that knee areas of pants 300 may be subjected to relatively high abrasion as pants 300 are worn, additional fused regions 104 may be located in the knee areas to impart greater durability.

[158] A third configuration of pants 300 is depicted in Figure 37C. As with shirt 200, fused regions 104, textile 130, sheet 140, foam layer 150, and strands 160 may be utilized to impart properties to various areas of pants 300. In leg regions 302, for example, textile 130 is heatbonded to an interior surface of nonwoven textile 100. A pair of sheets 140 are heatbonded to pants 300 in side areas of pelvic region 301, and portions of the fused region 104 around waist opening 303 extend under sheets 140. A pair of foam layers 150 are also located in the knee areas of pants 300, and strands 160 that extend along leg regions 302 extend under foam layers 150 (e.g., between nonwoven textile 100 and foam layers 150). End areas of strands 160 also extend into fused regions 104 in lower areas of leg regions 302. Accordingly, fused regions 104, textile 130, sheet 140, foam layer 150, and strands 160 may be utilized or combined in a variety of ways to impart properties to different various areas of pants 300. Whereas various elements of sheet 140 and foam layer 150 are heatbonded with an interior surface of shirt 200 in Figure 35G, various elements of sheet 140 and foam layer 150 are heatbonded with an exterior surface of pants 300 in Figure 37C. Depending upon various structural and aesthetic factors, composite elements and apparel including the composite elements may be formed with components (e.g., textile 130, sheet 140, foam layer 150, strands 160) located on an exterior or an interior of nonwoven textile 100.

[159] Based upon the above discussion, nonwoven textile 100 may be utilized in an article of apparel, such as pants 300. Seams of various types may be used to join textile elements, including elements of nonwoven textile 100. In order to impart different properties to areas of pants 300, various fused regions 104 may be formed, different types of textiles may be incorporated into shirt 200, and composite elements may be formed by joining one or more of textile 130, sheet 140, foam layer 150, strands 160, or various other components to nonwoven textile 100. By forming fused regions 104 in nonwoven textile 100 and combining nonwoven textile 100 with other components to form composite elements, various properties and combinations of properties may be imparted to different areas of pants 300. That is, the various concepts disclosed herein may be utilized individually or in combination to engineer the properties of pants 300 and tailor pants 300 to a specific purpose. Given that nonwoven textile 100 incorporates a thermoplastic polymer material, the seams and composite elements may be formed through heatbonding.

[160] XI - Footwear Configurations

[161] Various configurations of footwear 400 are depicted in Figures 39A-39G as including a sole structure 410 and an upper 420. Sole structure 410 is secured to upper 420 and extends between the foot of a wearer and the ground when footwear 400 is placed upon the foot. In addition to providing traction, sole structure 410 may attenuate ground reaction forces when compressed between the foot and the ground during walking, running, or other ambulatory activities. As depicted, sole structure 410 includes a fluid-filled chamber 411, a reinforcing structure 412 that is bonded to and extends around an exterior of chamber 411, and an outsole 413 that is secured to a lower surface of chamber 411, which is similar to a sole structure that is disclosed in U.S. Patent Number 7,086,179 to Dojan, et al., which is incorporated by reference herein. The configuration of sole structure 410 may vary significantly to include a variety of other conventional or nonconventional structures. As an example, sole structure 410 may incorporate a polymer foam element in place of chamber 411 and reinforcing structure 412, and the polymer foam element may at least partially encapsulate a fluid-filled chamber, as disclosed in either of U.S. Patent Numbers 7,000,335 to Swigart, et al. and 7,386,946 to Goodwin, which are incorporated by reference herein. As another example, sole structure 410 may incorporate a fluid-filled chamber with an internal foam tensile member, as disclosed in U.S. Patent Number 7,131,218 to Schindler, which is incorporated by reference herein. Accordingly, sole structure 410 may have a variety of configurations.

[162] Upper 420 defines a void within footwear 400 for receiving and securing the foot relative to sole structure 410. More particularly, upper 420 is structured to extend along a lateral side of the foot, along a medial side of the foot, over the foot, and under the foot, such that the void within upper 420 is shaped to accommodate the foot. Access to the void is provided by an ankle opening 421 located in at least a heel region of footwear 400. A lace 422 extends through various lace apertures 423 in upper 420 and permits the wearer to modify dimensions of upper 420 to accommodate the proportions of the foot. Lace 422 also permits the wearer to loosen upper 420 to facilitate entry and removal of the foot from the void. Although not depicted, upper 420 may include a tongue that extends under lace 422 to enhance the comfort or adjustability of footwear 400.

[163] A first configuration of footwear 400 is depicted in Figures 39A and 40A. Portions of upper 420 that extend along sides of the foot, over the foot, and under the foot may be formed from various elements of nonwoven textile 100. Although not depicted, seams similar to seams 106 and 107 may be used to join the elements of nonwoven textile 100. In many articles of footwear, stitching or adhesives are utilized to join the upper and sole structure. Sole structure 410, however, may be at least partially formed from a thermoplastic polymer material. More particularly, chamber 411 and reinforcing structure 412 may be at least partially formed from a thermoplastic polymer material that joins to upper 420 with a heatbond. That is, a heatbonding process may be utilized to join sole structure 410 and upper 420. In some configurations, stitching or adhesives may be utilized to join sole structure 410 and upper 420, or the heatbond may be supplemented with stitching or adhesives.

[164] A relatively large percentage of footwear 400 may be formed from thermoplastic polymer materials. As discussed above, nonwoven textile 100, chamber 411, and reinforcing structure 412 may be at least partially formed from thermoplastic polymer materials. Although lace 422 is not generally joined to upper 420 through bonding or stitching, lace 422 may also be formed from a thermoplastic polymer material. Similarly, outsole 413 may also be formed from a thermoplastic polymer material. Depending upon the number of elements of footwear 400 that incorporate thermoplastic polymer materials or are entirely formed from thermoplastic polymer materials, the percentage by mass of footwear 400 that is formed from the thermoplastic polymer materials may range from thirty percent to one-hundred percent. In some configurations, at least sixty percent of a combined mass of upper 420 and sole structure 410 may be from the thermoplastic polymer material of nonwoven textile 100 and thermoplastic polymer materials of at least one of (a) other elements of upper 420 (i.e., lace 422) and (b) the elements of sole structure 410 (i.e., chamber 411, reinforcing structure 412, outsole 413). In further configurations, at least eighty percent or even at least ninety percent of a combined mass of upper 420 and sole structure 410 may be from the thermoplastic polymer material of nonwoven textile 100 and thermoplastic polymer materials of at least one of (a) other elements of upper 420 and (b) the elements of sole structure 410. Accordingly, a majority or even all of footwear 400 may be formed from one or more thermoplastic polymer materials.

[165] A second configuration of footwear 400 is depicted in Figures 39B and 40B, in which three generally linear fused regions 104 extend from a heel area to a forefoot area of footwear 400. As discussed in detail above, the thermoplastic polymer material forming filaments 103 of nonwoven textile 100 is fused to a greater degree in fused regions 104 than in other areas of nonwoven textile 100. The thermoplastic polymer material from filaments 103 may also be fused to form a non-filamentous portion of nonwoven textile 100. The three fused regions 104 form, therefore, areas where filaments 103 are fused to a greater degree than in other areas of upper 420. Fused regions 104 have generally greater stretch-resistance than other areas of nonwoven textile 100. Given that fused regions 104 extend longitudinally between the heel area and the forefoot area of footwear 400, fused regions 104 may reduce the amount of longitudinal stretch in footwear 400. That is, fused regions 104 may impart greater stretch-resistance to footwear 400 in the direction between the heel area and the forefoot area. Fused regions 104 may also increase the durability of upper 420 and decrease the permeability of upper 420.

[166] A third configuration of footwear 400 is depicted in Figures 39C and 40C. Various fused regions 104 are formed in nonwoven textile 100. One of fused regions 104 extends around and is proximal to ankle opening 421, which may add greater stretch-resistance to the area around ankle opening 421 and assists with securely-retaining the foot within upper 420. Another fused region 104 is located in the heel region and extends around a rear area of the footwear to form a heel counter that resists movement of the heel within upper 420. A further fused region 104 is located in the forefoot area and adjacent to the sole structure, which adds greater durability to the forefoot area. More particularly, the forefoot area of upper 420 may experience greater abrasive-wear than other portions of upper 420, and the addition to fused region 104 in the forefoot area may enhance the abrasion-resistance of footwear 400 in the forefoot area. Additional fused regions 104 extend around some of lace apertures 423, which may enhance the durability and stretch-resistance of areas that receive lace 422. Fused regions 104 also extend downward from an area that is proximal to lace apertures 423 to an area that is proximal to sole structure 410 in order to enhance the stretch-resistance along the sides of footwear 400. More particularly, tension in lace 422 may place tension in the sides of upper 420. By forming fused regions 104 that extend downward along the sides of upper 420, the stretch in upper 420 may be reduced.

[167] The size of fused regions 104 in footwear 400 may vary significantly, but fused regions 104 generally have a continuous area of at least one square centimeter. As noted above, various embossing or calendaring processes may be utilized during the manufacturing process for nonwoven textile 100. Some embossing or calendaring processes may form a plurality of relatively small areas (i.e., one to ten square millimeters) where filaments 103 are somewhat fused to each other. In contrast with the areas formed by embossing or calendaring, fused regions 104 have a continuous area, as defined above, of at least one square centimeter.

[168] Although a majority of upper 420 may be formed from a single layer of nonwoven textile 100, multiple layers may also be utilized. Referring to Figure 40C, upper 420 includes an intermediate foam layer 150 between two layers of nonwoven textile 100. An advantage to this configuration is that foam layer imparts additional cushioning to the sides of upper 420, thereby protecting and imparting greater comfort to the foot. In general, the portions of upper 420 that incorporate foam layer 150 may be formed to have the general configuration of the composite element discussed above relative to Figures 19 and 20. Moreover, a heatbonding process similar to the process discussed above relative to Figures 12A-12C may be utilized to form the portions of upper 420 that incorporate foam layer 150. As an alternative to foam layer 150, textile 130 or sheet 140 may also be heatbonded to nonwoven textile 100 in footwear 400. Accordingly, incorporating various composite elements into footwear 400 may impart a layered configuration with different properties.

[169] A fourth configuration of footwear 400 is depicted in Figures 39D and 40D, in which various strands 160 are embedded within nonwoven textile 100. In comparison with the thermoplastic polymer material forming nonwoven textile 100, many of the materials noted above for strands 160 exhibit greater tensile strength and stretch-resistance. That is, strands 160 may be stronger than nonwoven textile 100 and may exhibit less stretch than nonwoven textile 100 when subjected to a tensile force. When utilized within footwear 400, therefore, strands 160 may be utilized to impart greater strength and stretch-resistance than nonwoven textile 100.

[170] Strands 160 are embedded within nonwoven textile 100 or otherwise bonded to nonwoven textile 100. Many of strands 160 extend in a direction that is substantially parallel to a surface of nonwoven textile 100 for a distance of at least five centimeters. An advantage to forming at least some of strands 160 to extend through the distance of at least five centimeters is that tensile forces upon one area of footwear 400 may be transferred along strands 160 to another area of footwear 400. One group of strands 160 extends from the heel area to the forefoot area of footwear 400 to increase strength and reduce the amount of longitudinal stretch in footwear 400. That is, these strands 160 may impart greater strength and stretch-resistance to footwear 400 in the direction between the heel area and the forefoot area. Another group of strands 160 extends downward from an area that is proximal to lace apertures 423 to an area that is proximal to sole structure 410 in order to enhance the strength and stretch-resistance along the sides of footwear 400. More particularly, tension in lace 422 may place tension in the sides of upper 420. By positioning strands 160 to extend downward along the sides of upper 420, the stretch in upper 420 may be reduced, while increasing the strength. A further group of strands 160 is also located in the heel region to effectively form a heel counter that enhances the stability of footwear 400. Additional details concerning footwear having a configuration that includes strands similar to strands 160 are disclosed in U.S. Patent Application Publication US2007/0271821 to Meschter, which is incorporated by reference herein.

[171] A fifth configuration of footwear 400 is depicted in Figures 39E. In contrast with the configuration of Figures 39D and 40D, various fused regions 104 are formed in nonwoven textile 100. More particularly, fused regions 104 are located in the areas of the groups of strands 160 that (a) extend downward from an area that is proximal to lace apertures 423 to an area that is proximal to sole structure 410 and (b) are located in the heel region. At least a portion of strands 160 extend through the fused regions 104, which imparts additional stretch-resistance and greater durability to the areas of upper 420 that incorporate strands 160, thereby providing greater protection to strands 160. Fused regions 104 may have a continuous area of at least one square centimeter, and the thermoplastic polymer material from filaments 103 within fused regions 104 may be either, filamentous, non-filamentous, or a combination of filamentous and non-filamentous.

[172] A sixth configuration of footwear 400 is depicted in Figure 39F. Three fused regions 104 in the side of footwear 400 have the shapes of the letters "A," "B," and "C." As discussed above, fused regions 104 may be utilized to modify various properties of nonwoven textile 100, including the properties of permeability, durability, and stretch-resistance. In general, various aesthetic properties may also be modified by forming fused regions 104, including the transparency and the darkness of a color of nonwoven textile 100. That is, the color of fused regions 104 may be darker than the color of other portions of nonwoven textile 100. Utilizing this change in aesthetic properties, fused regions 104 may be utilized to form indicia in areas of footwear 400. That is, fused regions 104 may be utilized to form a name or logo of a team or company, the name or initials of an individual, or an esthetic pattern, drawing, or element in nonwoven textile 100. Similarly, fused regions 104 may be utilized to form indicia in shirt 200, pants 300, or any other product incorporating nonwoven textile 100.

[173] Fused regions 104 may be utilized to form indicia in the side of footwear 400, as depicted in Figure 39F, and also in shirt 200, pants 300, or a variety of other products incorporating nonwoven textile 100. As a related matter, elements of nonwoven textile 100 may be heatbonded or otherwise joined to various products to form indicia. For example, elements of nonwoven textile 100 having the shapes of the letters "A," "B," and "C" may be heatbonded to the sides of an article of footwear where the upper is primarily formed from synthetic leather. Given that nonwoven textile 100 may be heatbonded to a variety of other materials, elements of nonwoven textile 100 may be heatbonded to products in order to form indicia.

[174] Seams similar to seams 106 and 107 may be used to join the elements of nonwoven textile 100 in any configuration of footwear 400. Referring to Figure 39F, a pair of seams 424 extend in a generally diagonal direction through upper 420 to join different elements of nonwoven textile 100. Although heatbonding may be utilized to form seams 424, stitching or adhesives may also be utilized. As noted above, sole structure 410 may also have various structures, in addition to the structure that includes chamber 411 and reinforcing structure 412. Referring again to Figure 39F, a thermoplastic polymer foam material 425 is utilized in place of chamber 411 and reinforcing structure 412, and upper 420 may be heatbonded to foam material 425 to join sole structure 410 to upper 420. Heatbonds may also be utilized when a thermoset polymer foam material is utilized within sole structure 410.

[175] A seventh configuration of footwear 400 is depicted in Figure 39G, wherein nonwoven textile 100 is utilized to form a pair of straps 426 that replace or supplement lace 422. In general, straps 426 permit the wearer to modify dimensions of upper 420 to accommodate the proportions of the foot. Straps 426 also permit the wearer to loosen upper 420 to facilitate entry and removal of the foot from the void. One end of straps 426 may be permanently secured to upper 420, whereas a remainder of straps 426 may be joined with a hook-and-loop fastener, for example. This configuration allows straps to be adjusted by the wearer. As discussed above, nonwoven textile 100 may stretch and return to an original configuration after being stretched. Utilizing this property, the wearer may stretch straps 426 to impart tension, thereby tightening upper 420 around the foot. By lifting straps, the tension may be released to allow entry and removal of the foot.

[176] In addition to forming the portion of upper 420 that extends along and around the foot to form the void for receiving the foot, nonwoven textile 100 may also form structural elements of footwear 400. As an example, a lace loop 427 is depicted in Figure 41. Lace loop 427 may be incorporated into upper 420 as a replacement or alternative for one or more of the various lace apertures 423. Whereas lace apertures 423 are openings through upper 420 that receive lace 422, lace loop 427 is a folded or overlapped area of nonwoven textile 100 that defines a channel through which lace 422 extends. In forming lace loop 427, nonwoven textile 100 is heatbonded to itself at a bond area 428 to form the channel.

[177] Based upon the above discussion, nonwoven textile 100 may be utilized in apparel having the configuration of an article of footwear, such as footwear 400. In order to impart different properties to areas of footwear 400, various fused regions 104 may be formed, different types of textiles may be incorporated into footwear 400, and composite elements may be formed by joining one or more of textile 130, sheet 140, foam layer 150, strands 160, or various other components to nonwoven textile 100. Given that nonwoven textile 100 incorporates a thermoplastic polymer material, a heatbonding process may be utilized to join upper 420 to sole structure 410.

[178] XII - Forming, Texturing, and Coloring The Nonwoven Textile

[179] The configuration of nonwoven textile 100 depicted in Figure 1 has a generally planar configuration. Nonwoven textile 100 may also exhibit a variety of three-dimensional configurations. As an example, nonwoven textile 100 is depicted as having a wavy or undulating configuration in Figure 42A. A similar configuration with squared waves is depicted in Figure 42B. As another example, nonwoven textile may have waves that extend in two directions to impart an egg crate configuration, as depicted in Figure 42C. Accordingly, nonwoven textile 100 may be formed to have a variety of non-planar or three-dimensional configurations.

[180] A variety of processes may be utilized to form a three-dimensional configuration in nonwoven textile 100. Referring to Figures 43A-43C, an example of a method is depicted as involving first plate 111 and second plate 112, which each have surfaces that correspond with the resulting three-dimensional aspects of nonwoven textile 100. Initially, nonwoven textile 100 is located between plates 111 and 112, as depicted in Figure 43A. Plates 111 and 112 then translate or otherwise move toward each other in order to contact and compress nonwoven textile 100, as depicted in Figure 43B. In order to form the three-dimensional configuration in nonwoven textile 100, heat from one or both of plates 111 and 112 is applied to nonwoven textile 100 so as to soften or melt the thermoplastic polymer material within filaments 103. Upon separating plates 111 and 112, as depicted in Figure 43C, nonwoven textile 100 exhibits the three-dimensional configuration from the surfaces of plates 111 and 112. Although heat may be applied through conduction, radio frequency or radiant heating may also be used. As another example of a process that may be utilized to form a three-dimensional configuration in nonwoven textile 100, filaments 103 may be directly deposited upon a three-dimensional surface in the process for manufacturing nonwoven textile 100.

[181] In addition to forming nonwoven textile 100 to have three-dimensional aspects, a texture may be imparted to one or both of surfaces 101 and 102. Referring to Figure 44A, nonwoven textile 100 has a configuration wherein first surface 101 is textured to include a plurality of wave-like features. Another configuration is depicted in Figure 44B, wherein first surface 101 is textured to include a plurality of x-shaped features. Textures may also be utilized to convey information, as in the series of alpha-numeric characters that are formed in first surface 101 in Figure 44C. Additionally, textures may be utilized to impart the appearance of other materials, such as the synthetic leather texture in Figure 44D.

[182] A variety of processes may be utilized to impart a texture to nonwoven textile 100. Referring to Figures 45A-45C, an example of a method is depicted as involving first plate 111 and second plate 112, which each have textured surfaces. Initially, nonwoven textile 100 is located between plates 111 and 112, as depicted in Figure 45A. Plates 111 and 112 then translate or otherwise move toward each other in order to contact and compress nonwoven textile 100, as depicted in Figure 45B. In order to impart the textured configuration in nonwoven textile 100, heat from one or both of plates 111 and 112 is applied to nonwoven textile 100 so as to soften or melt the thermoplastic polymer material within filaments 103. Upon separating plates 111 and 112, as depicted in Figure 45C, nonwoven textile 100 exhibits the texture from the surfaces of plates 111 and 112. Although heat may be applied through conduction, radio frequency or radiant heating may also be used. As another example of a process that may be utilized to form textured surfaces in nonwoven textile 100, a textured release paper may be placed adjacent to nonwoven textile 100. Upon compressing and heating, the texture from the release paper may be transferred to nonwoven textile 100.

[183] Depending upon the type of polymer material utilized for nonwoven textile 100, a variety of coloring processes may be utilized to impart color to nonwoven textile 100. Digital printing, for example, may be utilized to deposit dye or a colorant onto either if surfaces 101 and 102 to form indicia, graphics, logos, or other aesthetic features. Instructions, size identifiers, or other information may also be printed onto nonwoven textile 100. Moreover, coloring processes may be utilized before or after nonwoven textile 100 is incorporated into a product. Other coloring processes, including screen printing and laser printing, may be used to impart colors or change the overall color of portions of nonwoven textile 100.

[184] Based upon the above discussion, three-dimensional, textured, and colored configurations of nonwoven textile 100 may be formed. When incorporated into products (e.g., shirt 200, pants 300, footwear 400), these features may provide both structural and aesthetic enhancements to the products. For example, the three-dimensional configurations may provide enhanced impact force attenuation and greater permeability by increasing surface area. Texturing may increase slip-resistance, as well as providing a range of aesthetic possibilities. Moreover, coloring nonwoven textile 100 may be utilized to convey information and increase the visibility of the products.

[185] XIII - Stitchbonding Configurations

[186] The process of stitchbonding may also be utilized to join an element of nonwoven textile 100 to other elements of nonwoven textile 100, other textiles, or a variety of other materials, to form a textile article. Referring to figures 12D through 12G, stitchbonding may be used to secure the element of nonwoven textile 100 to another component 120. In some aspects, nonwoven textile 100 may be secured to component 120 in a way that permits some movement of nonwoven textile 100 relative to component 120.

[187] Stitchbonding is a mechanical bonding technique based on warp knitting principles. The process of stitchbonding involves bonding yarn layers, webs, fibrous batts, or flat substrates by means of a system of stitches. For purposes of this detailed description, stitchbonding includes the interlooping of fibers and yarns. For example, interlooped stitches 268 may be used for knitted-stitched components involving yarn. In the process, rows of needles move together to pierce the substrate being processed to form stitches. While conventional sewing-based stitching is generally directed to the piercing of fabric or textiles in a pattern by thread, the stitches utlitized in stitchbonding are either made from the material in the substrate itself or by using yarns that are separately fed-in.

Thus, stitchbonding may provide a structure with more flexibility, as well as a texture closer to that of the original materials, than other methods used in the production of nonwoven fabrics.

[188] Component 120 to which nonwoven textile 100 may be stitchbonded may be selected to provide properties desirable for the ultimate use of the stitchbonded product. Component 120 was discussed above with respect to the composite element shown in Figures 12A through 12C. Suitable materials for component 120 include a layer of woven-textile, another layer of nonwoven textile, a natural material such as leather or the like, polymer foam, a breathable gas-permeable but liquid impermeable material, and other composite materials that are sturdy enough to receive and hold a stitch. A plurality of the same or different components 120 may also be stitchbonded to the nonwoven textile.

[189] In some aspects, a web 252 is initially fed to a needle puncher for tacking before being passed to a stitchbonding machine 250. Tacking provides temporary stitches that may be readily removed in order to hold the pieces in place until they can be permanently secured. Tacking may improve the mechanical interlocking between the fibers of nonwoven textile 100 and component 120, and prevent loss of fibers from the structure.

[190] As shown in the example of Fig. 12D, nonwoven textile 100 is positioned adjacent to component 120 such that nonwoven textile 100 and component 120 are coplanar. That is, nonwoven textile 100 and component 120 are aligned such that they abut each other, and are in contact with each other. The nonwoven textile 100 and component 120 may be aligned on stitchbonding machine 250, between a first supporting bar 260 and a second supporting bar 264. Generally, nonwoven textile 100 and component 120 are at least partially coextensive with each other. In the example of Fig. 12D, nonwoven textile 100 and component 120 are disposed in cross-laid web 252 of fibers. Nonwoven textile 100 and component 120, prepared as web 252, are fed into a stitchbonding machine 250. Stitchbonding machine 250 bonds fabric of web 252 by knitting columns of interlooped stitches 268 down the length of web 252. This process can hold web 252 in place.

[191] Web 252 comprising nonwoven textile 100 and component 120 may be fed into a stitchbonding machine. In FIG. 12D a row of specially strengthened needles 256 are shown adjacent to web 252. In the example in FIG. 12D, a needle 256 penetrates web 252 and emerges through web 252. Alternatively, more than one needle 256 may penetrate web 252. After needle 256 passes through web 252, a guide bar 254 laps fibers into the hooks of needle 256. Guide bar 254 is a mechanism in the stitchbonding machine that guides the movement of the yarns so that they are threaded into the appropriate needle hooks, and are restrained and/or controlled against outward movements. Guide bar 254 can move in a circular or winding motion to generate a loop. As needles 256 withdraw again the hooks close, and a new loop forms. A stitching yarn 163 can be seen as it travels through web 252. This can also be seen in Figs. 12E and 12F. In a subsequent step, needles 256 may reverse direction and withdraw the hook end of needles 256 from web 252. Needles 256 may draw the loops through the previous courses and bind the yarn to web 252. Thus, needles 256 move back and forth through the fibrous layers of web 252, which may result in an interlocking of the fiber layers of nonwoven textile 100 and component 120.

[192] As described above, needles 256 may penetrate web 252 with stitching yarn 163. In one alternative, stitching yarn 163 used during stitchbonding may be the same as strands 160 discussed above. Generally, stitching yarn 163 may be formed from any material exhibiting a length that is substantially greater than the material's width and the material's thickness. Depending upon the material utilized and the desired properties, stitching yarn 163 may be individual fibers, or yarns that include a plurality of fibers. Suitable materials for stitching yarn 163 include rayon, nylon, polyester, polyacrylic, silk, cotton, carbon, glass, aramids (e.g., para-aramid fibers and meta-aramid fibers), ultra high molecular weight polyethylene, and liquid crystal polymer, for example.

[193] As shown in Fig. 12D-12G, stitching yarn 163 is stitched into nonwoven textile 100 and component 120 to form a stitch pattern 903. Stitch pattern 903 includes an individual stitch line 901. Stitch pattern 903 extends through component 120 and across nonwoven textile 100, as shown in Figs. 12E and 12F. That is, in the example shown, stitch pattern 903 is in the form of a single line that extends back-and-forth across the surface plane of nonwoven textile 100. Stitch pattern 903 therefore extends in both a latitudinal direction 540 and a longitudinal direction 542. It should be understood to one of ordinary skill in the art that latitudinal direction 540 and longitudinal direction 542 are merely relative directions on the plane of nonwoven textile 100, where latitudinal direction 540 is at a substantially right angle to longitudinal direction 542, and do not designate any absolute orientation. Stitch pattern 903 extends across the surface of the composite textile article in at least two directions.

[194] Figs. 12F and 12G show a cross-sectional view of stitch line 901. Stitch pattern 903 includes stitch line 901 that extends through a cross section of the composite textile article. Stitch line 901 extends vertically through a cross section of nonwoven textile 100 and through a cross section of component 120. Stitching yarn 163 is stitched back and forth in an interlooping manner through the entire cross section in a reciprocating manner, for example as seen in interlooped stitches 268. During the stitching, stitching yarn 163 pierces nonwoven textile 100 and component 120 so that a first vertical segment of stitching yarn 163 extends through both layers of material. A horizontal segment of stitching yarn 163 then extends across a surface of component 120. Next, a second vertical segment of stitching yarn 163, which is spaced apart from the first vertical segment of stitching yarn 163, extends through both of nonwoven textile 100 and component 120 to form a complete stitch. Finally, a second horizontal segment extends across a surface of nonwoven textile 100 to begin a repeating pattern of horizontal segments on opposite surfaces joined by vertical segments through the material.

[195] The above-described stitching steps are repeated linearly to form stitch line 901, and may be repeated until a pattern is formed on a surface area to form overall stitch pattern 903. Stitch pattern 903 therefore holds nonwoven textile 100 and component 120 together at a large number of points. In other aspects, a plurality of stitching lines may be used, so that stitch pattern 903 includes multiple stitch lines.

[196] A variety of stitchbonding machines and processes may be utilized. In the examples shown in FIGS. 12D-12G, a conventional stitchbonding technique is used. Such techniques can include but are not limited to the stitchbonding processing techniques, such as Maliwatt, Malivilies, Malipol, Voltex, or Kunit, or other stitchbonding techniques. The Malliwatt technique typically operates with one or two guide bars and includes a needle and closing wire system that can penetrate through a cross-laid web substrate. Malivlies stitchbonding allows manufacture of threadless textile without additional binding. The loops are made from the fibers of the fabric substrate itself, and connect the fabric together. The Malimo technique includes plain overstitching of loose yarn sheets that are laid on top of one another. In Malipol stitchbonding, needles penetrate the ground fabric, and the interlooped stitching is overlapped in the needle hook. Voltex stitchbonding can be used with high pile or high plush fabrics, and continuously introduces a ground fabric and a web. No stitching yarn or yarn preparation is required. The Kunit technique uses a brushing bar to feed fibers to the stitchbonding machine in the form of a thin web batt, forming a distinctive folded pile. Thus, substrates of various materials within a wide range of thicknesses and weights may be interlooped by a stitchbonding technique.

[197] In FIGS. 12D-12G, stitchbonding is accomplished with the use of a stitching yarn 163. Alternatively, stitchbonding may be utilized without a stitching yarn 163. For example, interlooped stitches 268 may be formed by the yarns present in web 252 itself. The stitching process may be similar to that shown in FIGS. 12D-12F, but guide bar 254 is not used. Needles 256 may move back and forth, pushing needles 256 through web 252, and the timing of the movement may be delayed so that the hook of the needles 256 pick up some fiber from web 252. In some processes, these fibers are formed into a loop on the first cycle, and on subsequent cycles the newly formed loops may be pulled through the previous loops, as in warp knitting, producing a structure that may be felt-like on one side and like a knitted fabric on the other side.

[198] Stitchbonding nonwoven textile 100 and component 120 together to form a textile article offers several benefits depending on the materials and stitches selected. For example, stitch materials and patterns can be selected so as to increase tear and tensile strengths of the combined components. The use of stitchbonding may increase the tensile strength above a threshold necessary for the textile article to be used in a particular application. For example, stitchbonding may enable the tensile strength of the textile article to increase by approximately 5-20%. In other examples, stitchbonding may enable the tensile strength of the textile article to increase by more than about 25%, more than about 30% or more than about 40%. Increasing the tensile strength by more than 30% in particular may be useful when the textile article is incorporated into an article of footwear, to form an upper from the textile article.

[199] Additionally, stitchbonding may be useful to limit stretching movement in one or more directions while facilitating stretching movement in other directions, as described below with respect to Figs. 46M and 46O. In addition, stitchbonding can provide aesthetic benefits, such as a preferred texture. In some cases, stitchbonding can produce textile articles with greater softness than other processes. In addition, the mechanical bonding that occurs in stitchbonding is possible in a single process without the use of chemicals.

[200] Nonwoven textile 100 can be substantially smooth and planar as shown in figure 12E, or nonwoven textile 100 can have a desirable surface texture when formed. Exemplar texturing systems include forming nonwoven textile 100 in a mold as shown in figures 43A to 43C or using one of the other texturing systems disclosed herein. In addition, texture can be applied by pressing nonwoven textile 100 in a press during formation as disclosed in U.S. Patent Application Serial Number 12/579,838, which was filed in the U.S. Patent and Trademark Office on 15 October 2009 and titled “Textured Thermoplastic Non-Woven Elements” and in U.S Patent Application Serial Number 13/482,182, which was filed in the U.S. Patent and Trademark Office on 29 May 2012 and titled “Textured Elements Incorporating Non-Woven Textile Materials And Methods For Manufacturing The Textured Elements,” the disclosures of which are hereby incorporated by reference in their entirety.

[201] Stitchbonding may be utilized alone, or in combination with heatbonding or adhesives to join nonwoven textile 100 to component 120. For example, the stitchbonding process, shown in Figs. 12D-12G, may be used in conjunction with the heatbonding shown in Figs. 12A-12C. This combination of stitchbonding and heatbonding may be particularly useful when component 120 is another nonwoven textile formed from polymer filaments that incorporate a thermoplastic polyurethane material, in order to increase tensile strength of both nonwoven textiles and ensure good bonding between them. Thus, nonwoven textile 100 may be a first nonwoven textile formed from a plurality of polymer filaments that incorporate a thermoplastic polyurethane material, and component 120 may be a second nonwoven textile formed from a plurality of polymer filaments that incorporate a thermoplastic polyurethane material. The first nonwoven textile may have a first melting temperature, while the second nonwoven textile may have a second melting temperature that is different from the first melting temperature. As a result of the difference in melting temperatures, the heatbonding process may be controlled so as to most effectively bond the two nonwoven textiles. Exemplar combinations of two layer nonwoven textile combinations can be found in U.S. Patent Application Serial Number 13/045,168, which was filed in the U.S. Patent and Trademark Office on 10 March 2011 and titled “Layered Thermoplastic Non-Woven Textile Elements;” the disclosure of which is hereby incorporated by reference in its entirety.

[202] Nonwoven textile 100 may also be reinforced by embroidery that does not secure nonwoven textile 100 to another component, but merely threads though nonwoven textile 100 repeatedly. The term embroidery as used herein refers to repeated threading with a thread that extends from one surface 101 of nonwoven textile 100 through or at least partially through to opposite surface 102. Embroidery does not join nonwoven textile 100 to anything else, in contrast with stitchbonding. Such embroidery may, for example, increase the tensile strength and/or abrasion resistance of nonwoven textile 100 independent of the stitchbonding. For example, referring to Figure 46A, a thread 263 is stitched into nonwoven textile 100 to form a plurality of parallel lines that extend across nonwoven textile 100. Thread 263 repeatedly extends between first outer surface 101 and opposing second outer surface 102 (i.e., through nonwoven textile 100) to form an embroidered configuration. Thread 263 may impart stretch-resistance and enhance the overall strength of nonwoven textile 100.

Thread 263 may also enhance the overall aesthetics of nonwoven textile 100. When incorporated into products having nonwoven textile 100 (e.g., shirt 200, pants 300, footwear 400), thread 263 may provide both structural and aesthetic enhancements to the products.

[203] A thread may be embroidered to provide a variety of embroidered patterns as variously shown in Figs. 46A through 46F. As an example, thread 363 has the configuration of a zigzag embroidery in Figure 46B and thread 463 has the configuration of a chain stitch embroidery in Figure 46C. Whereas thread 263 and thread 363 form generally parallel lines of embroidery in Figures 46A and 46B respectively, the embroidery formed by thread 463 are non-parallel and cross each other in Figure 46C. Thread 563 may also be embroidered to form various configurations, as depicted in Figure 46D. Embroidery may also be utilized to form more complicated configurations with thread 663, as depicted in Figure 46E. Nonwoven textile 100 may also include various fused regions 104, with the embroidery formed by thread 163 extending through both fused and non-fused areas of nonwoven textile 100, as depicted in Figure 46F. Accordingly, thread 163, 263, 363, 463, 563, and 663 may be utilized to form a variety of embroidery types that may impart stretch-resistance, enhance strength, or enhance the overall aesthetics of nonwoven textile 100. Moreover, fused regions 104 shown in Fig. 46F may also be formed in nonwoven textile 100 to modify other properties.

[204] Whereas Figs. 46A through 46F show embroidery that does not secure nonwoven textile 100 to another component, Figs. 46G through 46R show stitching that constitutes stitchbonding between nonwoven textile 100 and component 120. Generally, each stitch line may have different shaped stitch patterns as may be desired for the particular application of the article in which it will be used. As known to a person having ordinary skill in the art, industrial stitching machines may be programmed to achieve a wide variety of stitch patterns.

[205] For example, Fig. 46G shows a stitch pattern 905 that includes a plurality of stitch lines 907 stitched from a fiber 763. In the example of Fig. 46G, as well as the examples shown in Figs. 46H through 46R, each stitch pattern may extend through the entire cross section the textile article as shown in Fig. 12F in order to secure nonwoven textile 100 to component 120. Figure 46G shows a specific stitch pattern 905 that includes overlapping stitch lines 907 with curved portions 500 and straight portions 502 creating an aesthetically pleasing geometric pattern that also allows the level of stretch and tensile strength of the article formed to be optimized for a particular application. Specifically, stitch pattern 905 may partially restrict the ability of textile article shown in Fig. 46G to stretch in direction 540, while preserving the ability to stretch in direction 542. The large number of overlapping stitch lines 907 may also dramatically increase the tensile strength of the textile article.

[206] Figures 46H and 46J show various stitch patterns formed of a plurality of generally non-overlapping stitch lines. Fig. 46H shows how each stitch line includes alternating concave portions 504 and convex portions 506 therealong. Namely, Fig. 46H shows stitch pattern 909 that includes multiple stitch lines 911. In this example, stitch lines 911 are non-overlapping but adjacent to each other where the concave portion 504 of one stitch line 911 meets the convex portion 506 of an adjacent stitch line. Each stitch line 911 is flipped relative to its immediate adjacent stitch line, so that two adjacent stitch lines form a mirror image pattern therealong. These configurations of stitch patterns 909 and 917 may securely attach nonwoven textile 100 to component 120 while also providing a desired texture and aesthetic appearance. Also, stitch patterns 909 and 917 may partially restrict stretching in direction 540, although the restriction may be to a less degree than in the example shown in Fig. 46G. Similarly, Fig, 46J shows stitch pattern 917 having stitch lines 919 with alternating concave portions 504 and convex portions 506 therealong. Adjacent stitch lines 919 may then intersect each other at points 516.

[207] In the example shown in figure 46I, stitch pattern 913 includes multiple stitch lines 915. In this example, two adjacent stitch lines 915 overlap each other at two points 508, 510 in each of the overlapping concave portions 504 and two points 512, 514 in each of the overlapping convex portions 506. In figure 46J, the stitch lines 919 are positioned with respect to each other so that the mirrored concave portions 504 of adjacent lines 919 intersect each other at one location 516 as shown.

[208] Figures 46K to 46R show additional stitch patterns that may be used to stitchbond nonwoven textile 100 to component 120. For example, Fig. 46K shows a “single bar” stitch having overall stitch pattern 921. A bar may be referred to as the horizontal distance the yarn extends across the surface of nonwoven textile 100 between each vertical segment that extends through nonwoven textile 100 and component 120 or from one needle puncture point to another, adjacent needle puncture point. Stitch pattern 921 may be referred to as a chevron pattern, because it forms a series of “V” shapes. The multiple “V” shapes in stitch pattern 921 is formed by a series of ninety degree angles 1000, 1002, and 1004 that face in alternate directions along a single stitch line 923. Other chevron patterns not shown may have a “V” shape with an angle of other than ninety degrees. Each stitch 516 in a stitch line 923 pierces and extends through nonwoven textile 100 and component 120 at uniform spaced apart locations 520 with the distance between each angle in the stitching defining a bar 522. In the particular example shown in FIG. 46K, a single bar 522 stitch pattern 921 is disclosed. This pattern allows the textile article to stretch in two directions, both direction 540 and direction 542. In other words, stitch pattern 921 does not inhibit stretching of the textile article in any direction.

[209] Figure 46L provides a two bar 522 chevron stitch pattern 925 that is similar to stitch pattern 921 shown in Fig. 46K. In Fig. 46L, two bars are adjoining and parallel for each leg of the “V” shape. That is, two bars with two through stitching holes are present between each angle 1006, 1008, 1010 in stitch pattern 925. Each repeating “V” shape is therefore defined by four through stitch holes. Stitch pattern 925 also allows two-way stretching of the textile article in the directions of arrow 540 and arrow 542. That is, stitch pattern 925 also does not inhibit stretching of the textile article in any direction. Instead, it merely provides increased tensile strength without limiting the ability of the textile article to stretch in any way. This may be advantageous when, for example, the textile article is incorporated into an article of clothing that should stretch uniformly in all directions.

[210] Figure 46M shows the same two bar chevron stitch pattern 929 as stitch pattern 925 of figure 46L, along with a plurality of parallel-aligned single bar 522 straight stitch lines 933 running along the longitudinal length of each chevron as shown. Namely, stitch pattern 929 includes first set of stitches 931 in the chevron shape and a second set of stitches 933 that are each straights lines. Each of the stitches 933 are parallel to each other. The chevron pattern forms ninety degree angles 1012, 1014, and 1016 within each “V” shape, as discussed above. The intersection between each stitch line 931 and each stitch line 933 forms a forty-five degree angle, such as angles 1018 and 1020.

[211] In the example shown in Fig. 46M, stitches 933 may limit the ability of the textile article to stretch. Namely, stitches 933 are aligned in a direction along the length of each straight line stitch, and the multiple stitches 933 repeat in a regular pattern such that each stitch 933 is parallel to each other stitch 933. As a result, the textile article will have reduced ability to stretch in longitudinal direction 542, as compared to a textile article without stitches 933. The ability of the textile article to stretch in latitudinal direction 540 will be unchanged. This type of configuration may be useful in applications where reduced ability to stretch in one direction may be helpful. For example, this configuration of a textile article with stitch pattern 929 may be useful in an article of footwear, where the textile article should be snug against a wearer's foot. Additionally, the tensile strength of the example shown in Fig. 46M may be increased relative to the tensile strength of the example shown in Fig. 46L with the chevron stitch pattern alone.

[212] Figure 46N shows an example of a textile article with stitch pattern 935. Stitch pattern 935 includes first set of stitches 937 and second set of stitches 939. Each set of stitches is in the chevron shape, and accordingly forms ninety degree angles 1022, 1024, 1026, 1028, 1030, 1032 with itself. In this example, the two chevron patterns are arranged to be mirror images of each other, overlapping at each angle. Therefore, first set of stitches 937 and second set of stitches 939 form a ninety degree angle between each stitch, as shown. The configuration of stitch pattern 935 may achieve a high tensile strength, because of the presence of the two sets of stitches, while also allowing for full undiminished stretching in both direction 540 and direction 542. This configuration may therefore be particularly useful in applications such as athletic wear, where a garment may undergo high levels of stretching and strain. This configuration may also exhibit additional abrasion resistance as a result of first set of stitch 937 being combined with second set of stitches 939, such abrasion resistance may also be useful in athletic garments.

[213] Figure 46O shows another example of a textile article having stitch pattern 941. The example shown in Fig. 46O includes a first set of stitches 943 arranged in the chevron pattern as shown in Fig. 46K and discussed above. The chevron stitch pattern of stitches 943 includes ninety degree angles 1034, 1036, and 1038 alternately facing opposite directions. Stitch pattern 941 also includes a second set of stitches 945. Second set of stitches 945 is arranged in a repeating pattern of parallel straight lines, as was discussed with respect to stitch lines 933 in stitch pattern 929 of Fig. 46M. First set of stitches 943 and second set of stitches 945 intersect at points 522. Each intersection 522 forms an angle 1040, 1042, 1044, 1046, etc. between each stitch 943 and each stitch 945 that is forty-five degrees. As was discussed with respect to the example of Fig. 46M, stitch pattern 941 limits the ability of the textile article to stretch along direction 542. This configuration may therefore also be useful in applications where the textile article should only stretch in one direction, direction 540, as discussed above.

[214] Referring to FIG. 46P, it can be appreciated that stitch pattern 947 can include ornamental features. For example, nonwoven textile 100 can include surface ornamentation such as the look of a natural material such as leather. Stitch pattern 947 can mimic those found on conventional leather stitching, such as cross-stitching or tunnel stitching, to more accurately give the nonwoven textile the look of a natural material secured in place with stitching.

[215] Alternatively, the nonwoven textile 100 can include raised or molded features, as shown in Figs. 46Q and 46R. Component 120 can be stitched to the nonwoven textile 100 with a desirable stitch pattern, such as stitch pattern 951 or stitch pattern 957.

[216] XIV - Adhesive Tape

[217] An element of tape 170 is depicted in Figures 47 and 48 as having the configuration of a composite element that includes nonwoven textile 100 and an adhesive layer 171. Tape 170 may be utilized for a variety of purposes, including as packing tape, as painting tape, or as medical or therapeutic tape. An advantage to utilizing tape 170 as medical or therapeutic tape, for example, is that the permeability and stretch-resistance, among other properties, may be controlled. With regard to permeability, when tape 170 to be adhered to the skin of an individual (i.e., with adhesive layer 171), air and water may pass through tape 170 to impart breathability and allow the underlying skin to be washed or otherwise cleansed. Tape 170 may also resist stretch when adhered to the skin of the individual to provide support for surrounding soft tissue. Examples of suitable materials for adhesive layer 171 include any of the conventional adhesives utilized in tape-type products, including medical-grade acrylic adhesive.

[218] A variety of structures may be utilized to impart specific degrees of stretch-resistance to tape 170. As an example, the stretch-resistance to tape 170 may be controlled though the thickness of nonwoven textile 100 or the materials forming filaments 103 in nonwoven textile 100. Referring to Figure 49A, fused regions 104 may also be formed in tape 170 to control stretch-resistance. Strands 160 may also be incorporated into tape 170 to impart a higher level of stretch-resistance, as depicted in Figure 49B. Additionally, some configurations of tape 170 may include both fused regions 104 and strands 160, as depicted in Figure 49C.

[219] XV - Recycling The Nonwoven Textile

[220] Filaments 103 of nonwoven textile 100 include a thermoplastic polymer material. In some configurations of nonwoven textile 100, a majority or substantially all of filaments 103 are formed from the thermoplastic polymer material. Given that many configurations of shirt 200 and pants 300 are primarily formed from nonwoven textile 100, then a majority or substantially all of shirt 200 and pants 300 are formed from the thermoplastic polymer material. Similarly, a relatively large percentage of footwear 400 may also be formed from thermoplastic polymer materials. Unlike many articles of apparel, the materials of shirt 200, pants 300, and footwear 400 may be recycled following their useful lives.

[221] Utilizing shirt 200 as an example, the thermoplastic polymer material from shirt 200 may be extracted, recycled, and incorporated into another product (e.g., apparel, container, upholstery) as a nonwoven textile, a polymer foam, or a polymer sheet. This process is generally shown in Figure 50, in which shirt 200 is recycled in a recycling center 180, and thermoplastic polymer material from shirt 200 is incorporated into one or more of another shirt 200, pants 300, or footwear 400. Moreover, given that a majority or substantially all of shirt 200 is formed from the thermoplastic polymer material, then a majority or substantially all of the thermoplastic polymer material may be utilized in another product following recycling. Although the thermoplastic polymer material from shirt 200 was initially utilized within nonwoven textile 100, for example, the thermoplastic polymer material from shirt 200 may be subsequently utilized in another element of nonwoven textile 100, another textile that includes a thermoplastic polymer material, a polymer foam, or a polymer sheet. Pants 300, footwear 400, and other products incorporating nonwoven textile 100 may be recycled through a similar process. Accordingly, an advantage of forming shirt 200, pants 300, footwear 400, or other products with the various configurations discussed above relates to recyclability.

[222] XVI - Conclusion

[223] Nonwoven textile 100 includes a plurality of filaments 103 that are at least partially formed from a thermoplastic polymer material. Various fused regions 104 may be formed in nonwoven textile 100 to modify properties that include permeability, durability, and stretch-resistance. Various components (textiles, polymer sheets, foam layers, strands) may also be secured to or combined with nonwoven textile 100 (e.g., through heatbonding) to impart additional properties or advantages to nonwoven textile 100. Moreover, fused regions 104 and the components may be combined to impart various configurations to nonwoven textile 100.

[224] The following references include information that may be relevant to the present application: U.S. Patent Application Serial Number 12/367,275, which was filed in the U.S. Patent and Trademark Office on 6 February 2009 and entitled “Thermoplastic Non-Woven Textile Elements;” U.S. Patent Application Serial Number 12/579,838, which was filed in the U.S. Patent and Trademark Office on 15 October 2009 and titled “Textured Thermoplastic Non-Woven Elements;” U.S. Patent Application Serial Number 13/045,168, which was filed in the U.S. Patent and Trademark Office on 10 March 2011 and titled “Layered Thermoplastic Non-Woven Textile Elements;” and U.S Patent Application Serial Number 13/482,182, which was filed in the U.S. Patent and Trademark Office on 29 May 2012 and titled “Textured Elements Incorporating Non-Woven Textile Materials And Methods For Manufacturing The Textured Elements,” all of the disclosures of which are hereby incorporated by reference.

[225] Unless this disclosure indicates to the contrary, any feature of any one example or configuration discussed herein may be combined with any other feature(s) of another example or configuration discussed herein. The features of any example may be combined with the features of any other example in any combination or subcombination.

[226] The invention is disclosed above and in the accompanying figures with reference to a variety of configurations. The purpose served by the disclosure, however, is to provide an example of the various features and concepts related to the invention, not to limit the scope of the invention. One skilled in the relevant art will recognize that numerous variations and modifications may be made to the configurations described above without departing from the scope of the present invention, as defined by the appended claims.

CLAIMS

1. A textile article, the textile article comprising:

a first component, the first component comprising a nonwoven textile formed from a plurality of polymer filaments, wherein at least some of the polymer filaments are fused together, wherein each polymer filament incorporates a thermoplastic polyurethane material; and

a second component,

wherein the second component is joined to the first component, the second component being joined to the first component by stitchbonding.

2. The textile article of claim 1, wherein the stitchbonding joins the first component and the second component such that the first component and the second component are coplanar with each other.

3. The textile article of claim 1 or claim 2, wherein the stitchbonding is arranged in a pattern, and the pattern extends longitudinally and latitudinally across a plane defined by a surface of the first component and the second component.

4. The textile article of any of claims 1-3, wherein the stitchbonding extends through a cross section of the first component and extends through a cross section of the second component.

5. The textile article of any of claims 1-4, wherein

the stitchbonding is arranged in a repeating chevron pattern, the repeating chevron pattern being comprised of a series of stitches;

each stitch in the series of stitches extending across the first component and the second component in a configuration that includes a series of ninety degree angles facing in alternate directions.

6. The textile article of any of claims 1-5, wherein the stitchbonding includes:

a first stitch line comprising a first set of stitches, wherein each stitch in the first stitch line is configured in a straight line that is parallel to every stitch in the first stitch line, and each stitch is spaced apart from and does not overlap any adjacent stitch in the first set of stitches;

a second stitch line comprising a second set of stitches, wherein the second stitch line is arranged in a repeating chevron pattern;

wherein the first stitch line and the second stitch line intersect at multiple points at a forty-five degree angle therebetween.

7. The textile article of claim 6, wherein the first set of stitches is aligned in a first direction along a length of each straight line stitch in the first set of stitches; and

the first set of stitches and the second set of stitches are arranged in a pattern such that the first set of stitches limits stretching of the textile article in the first direction as compared to a similar textile article without the first set of stitches.

8. The textile article of any of claims 1-5, wherein the stitchbonding includes:

a first set of stitches, each stitch in the first set of stitches being configured in a first repeating chevron pattern;

a second set of stitches, each stitch in the second set of stitches being arranged in a second repeating chevron pattern;

wherein the first repeating chevron pattern and the second repeating chevron pattern are arranged so as to be overlapping mirror images of each other.

9. A textile article, the textile article comprising:

a first component, the first component comprising a nonwoven textile formed from a plurality of polymer filaments that incorporate a thermoplastic polyurethane material, wherein the thermoplastic polymer filaments stretch at least one-hundred percent prior to tensile failure; and

a second component,

wherein the second component is joined to the first component by a pattern of stitchbonding, the pattern being a repeating pattern of stitches that extends across the first component and the second component in two dimensions;

10. The textile article of claim 9, wherein

the first component comprises a first nonwoven textile formed from a plurality of polymer filaments, wherein a portion of the polymer filaments are fused together, wherein each polymer filament incorporates a thermoplastic polyurethane material;

and the second component comprising a second nonwoven textile formed from a plurality of polymer filaments fused together, wherein each polymer filament incorporates a thermoplastic polyurethane material.

11. The textile article of claim 9, wherein:

the first component comprises a first nonwoven textile formed from a plurality of polymer filaments that incorporate a thermoplastic polyurethane material;

the second component comprises a second nonwoven textile formed from a plurality of polymer filaments that incorporate a thermoplastic polyurethane material; and

the first component is joined to the second component by the pattern of stitching and by heatbonding.

12. The textile article of claim 9, wherein the second component comprises a material selected from the group consisting of: a woven textile, a second nonwoven textile, a natural material, a polymer foam, and a breathable gas-permeable but liquid impermeable material.

13. The textile article of any of claims 9-12, wherein the first component has a first water permeability; the second component has a second water permeability; and the first water permeability is lower than the second water permeability.

14. The textile article of any of claims 9-13, wherein the textile article is incorporated into an article of clothing.

15. The textile article of any of claims 9-13, wherein the textile article is incorporated into an article of footwear.

16. A textile article, the textile article comprising:

a first component, the first component comprising a nonwoven textile formed from a plurality of polymer filaments that incorporate a thermoplastic polyurethane material; and

a second component,

wherein the second component is joined to the first component by a pattern of stitchbonding, the pattern being a repeating pattern that extends across the first component and the second component in multiple directions, and the stitchbonding extends through a cross section of the first component and extends through a cross section of the second component, and

wherein the second component is also joined to the first component by heatbonding.

17. The textile article of claim 16, wherein the second component is a nonwoven textile formed from a plurality of polymer filaments that incorporate a thermoplastic polyurethane material.

18. The textile article of claim 16, wherein

the second component comprises a thermoplastic material;

the thermoplastic polyurethane material of the first component has a first melting temperature;

the thermoplastic material of the second component has a second melting temperature; and

the first melting temperature is different from the second melting temperature.

19. A method of forming a textile article, the method comprising:

aligning a first component adjacent to a second component, such that the first component and the second component abut and are in direct contact;

the first component comprising a nonwoven textile formed from a plurality of polymer filaments, wherein at least a portion of the polymer filaments are fused together, wherein each polymer filament incorporates a thermoplastic polyurethane material;

stitchbonding the first component to the second component, the stitchbonding including passing a fiber through a cross section of the first component and a cross section of the second component in a repeating pattern,

wherein the step of stitchbonding produces a stitch pattern, and the stitch pattern extends in two dimensions across a coplanar surface of the first component and the second component in a repeating pattern.

20. The method of claim 19, wherein the second component comprises a thermoplastic material; and

the method further includes a step of heatbonding the first component to the second component.

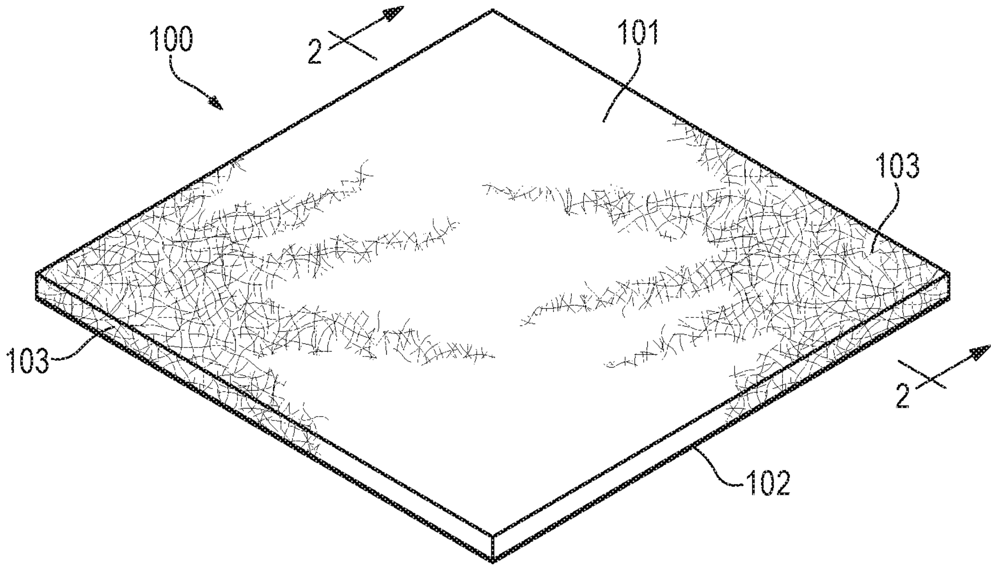


Figure 1

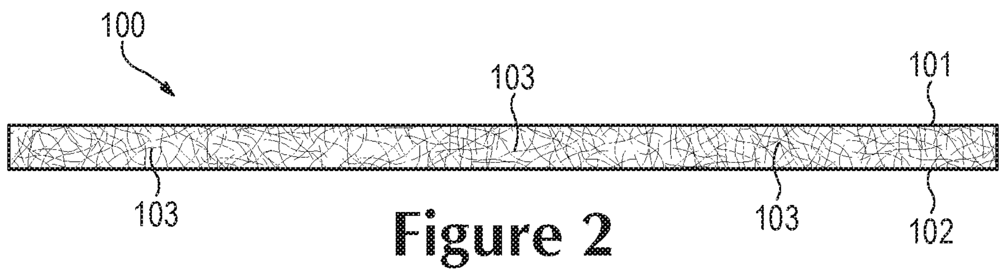


Figure 2

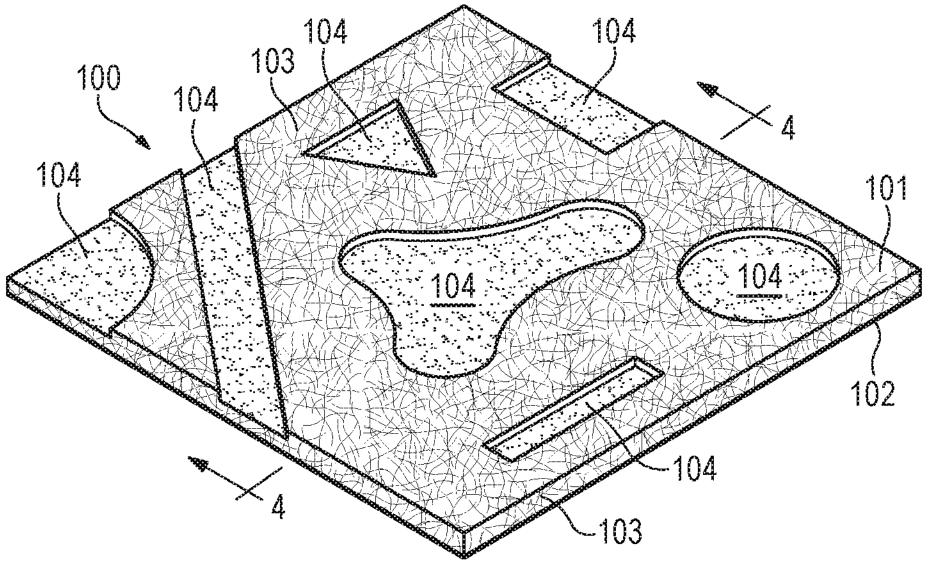


Figure 3

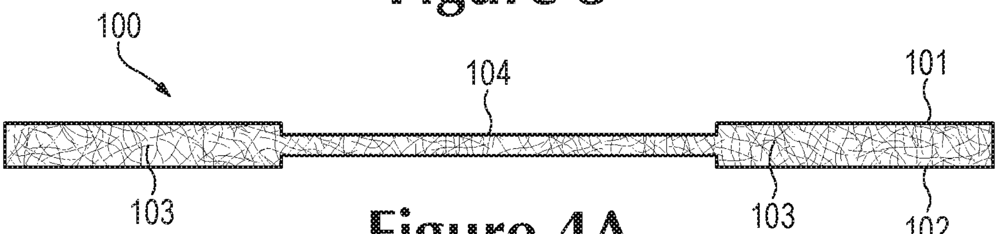


Figure 4A

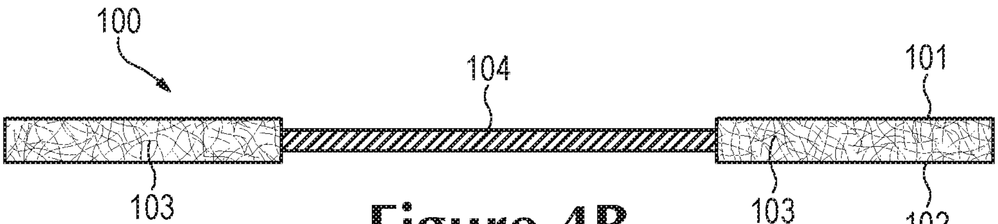


Figure 4B

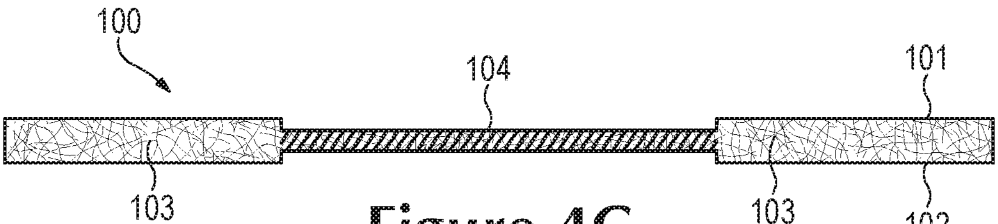


Figure 4C

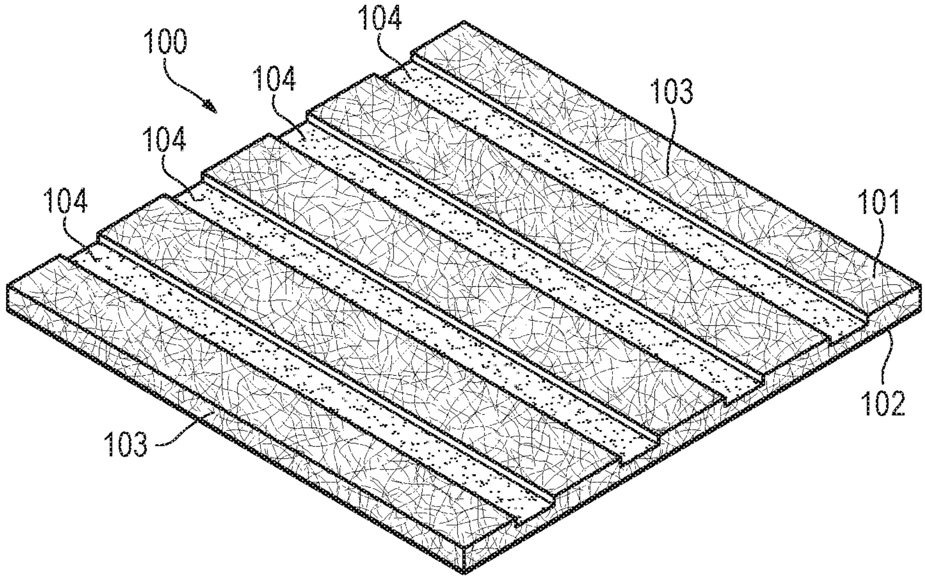


Figure 5A

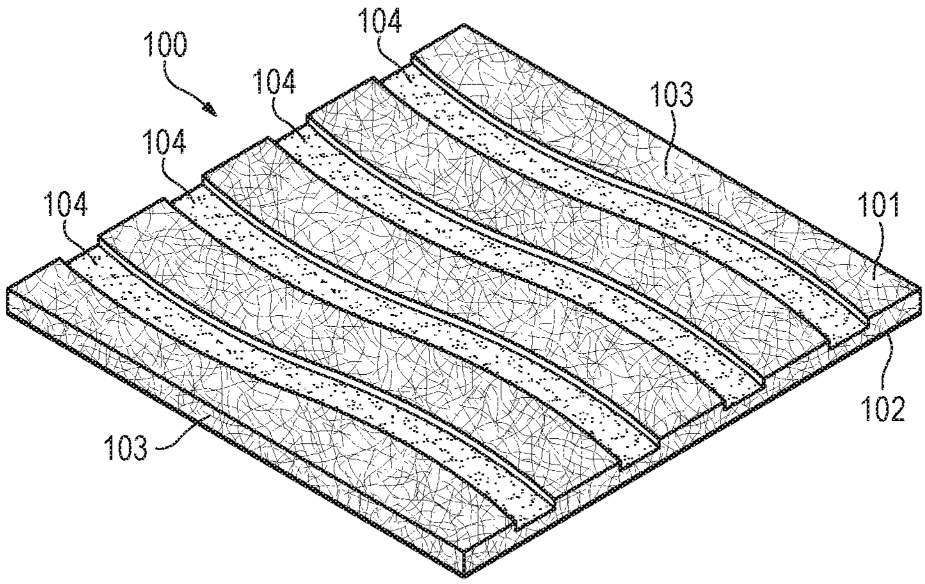


Figure 5B

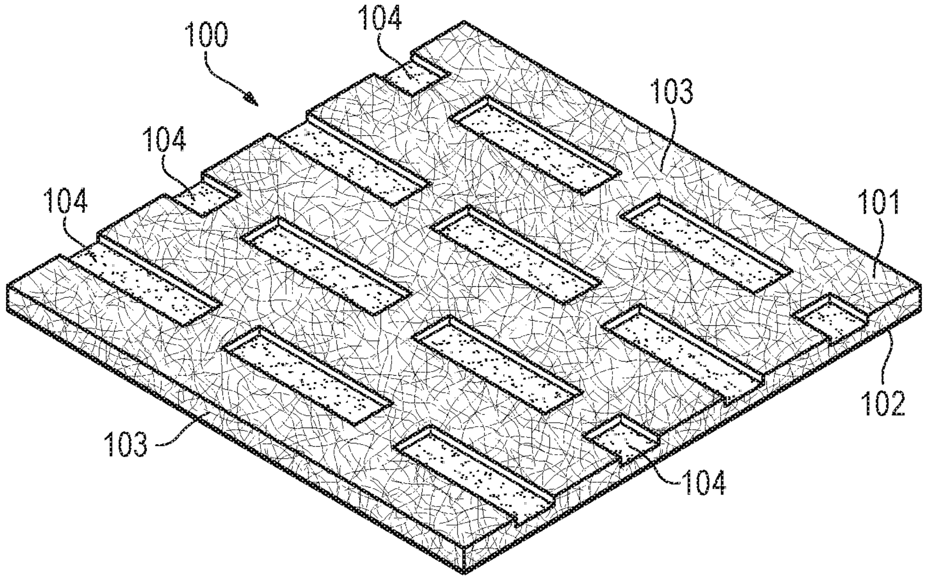


Figure 5C

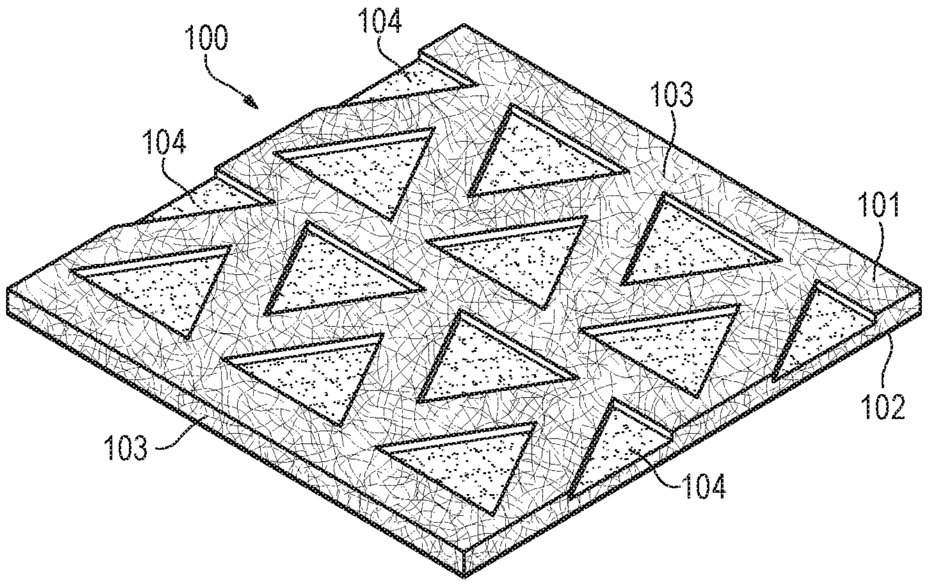


Figure 5D

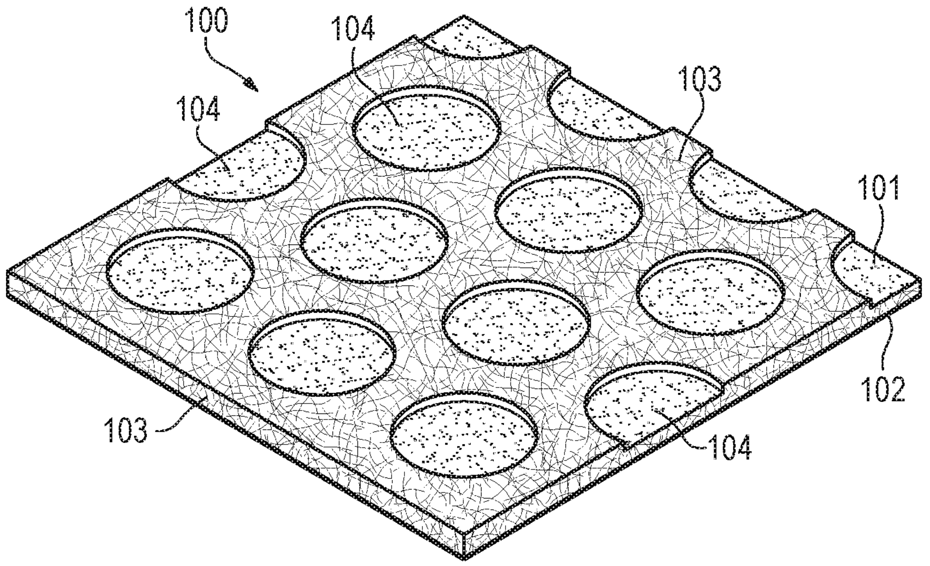


Figure 5E

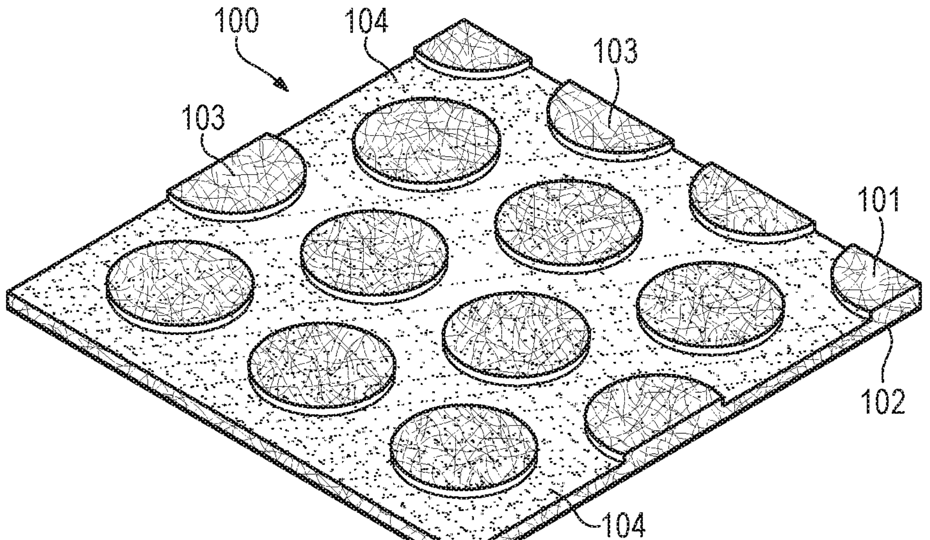


Figure 5F

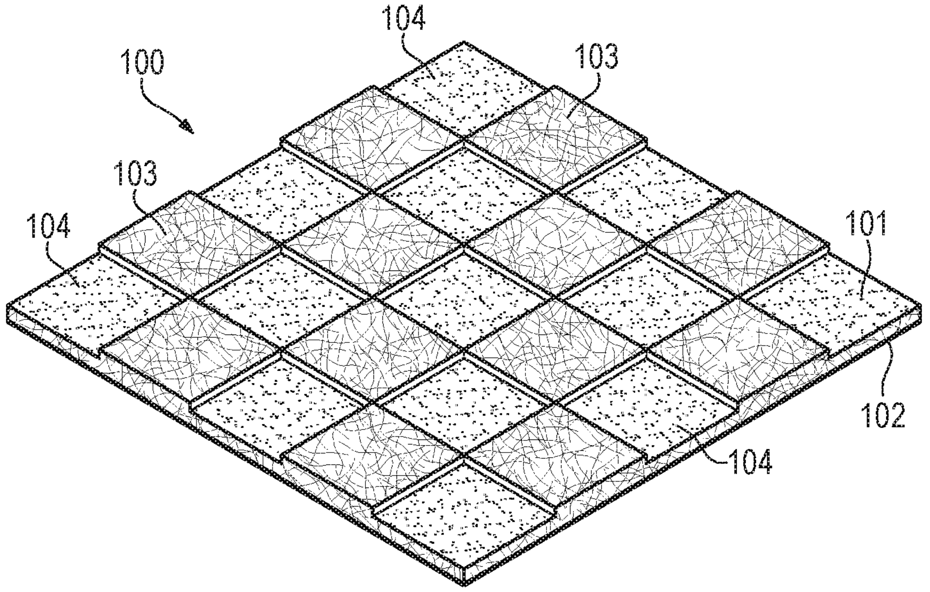


Figure 5G

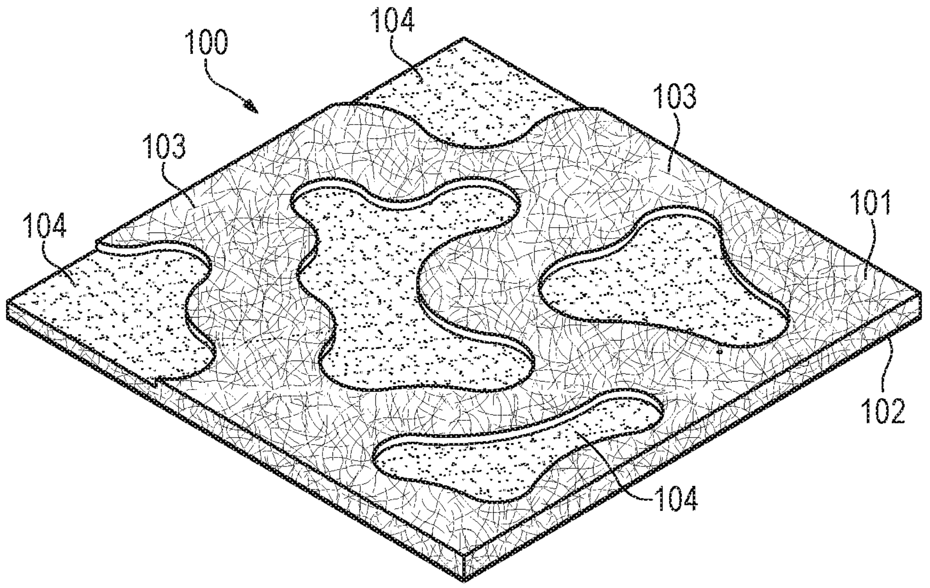


Figure 5H

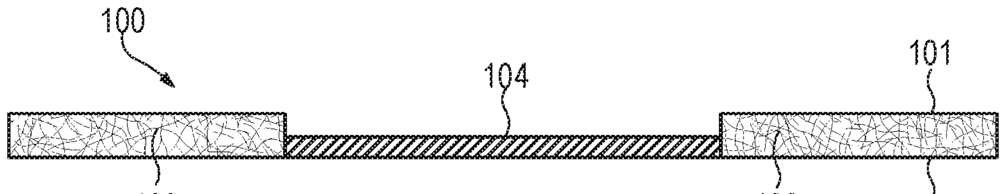


Figure 6A

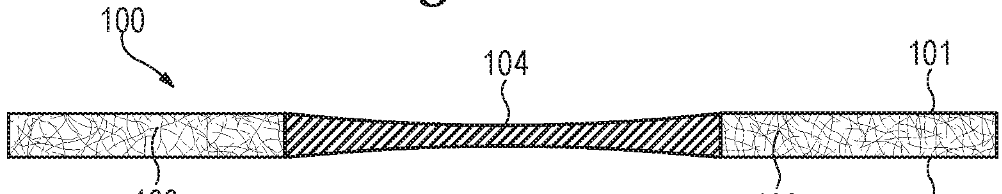


Figure 6B

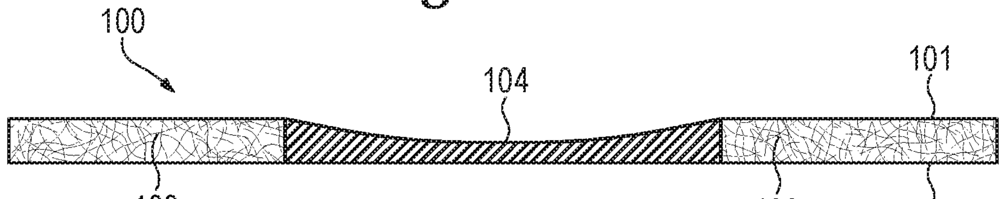


Figure 6C

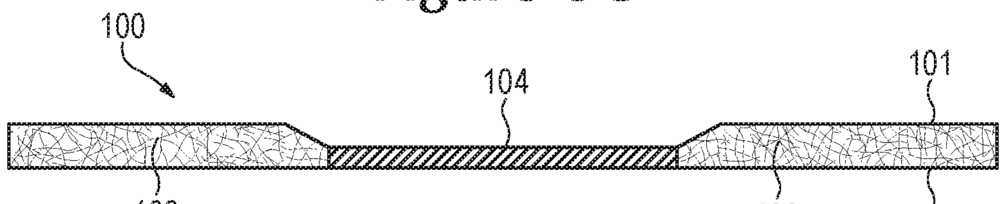


Figure 6D

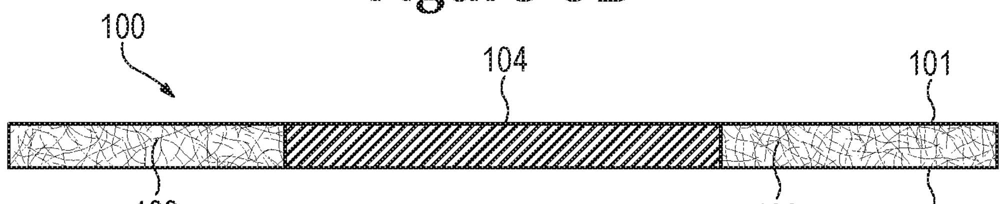


Figure 6E

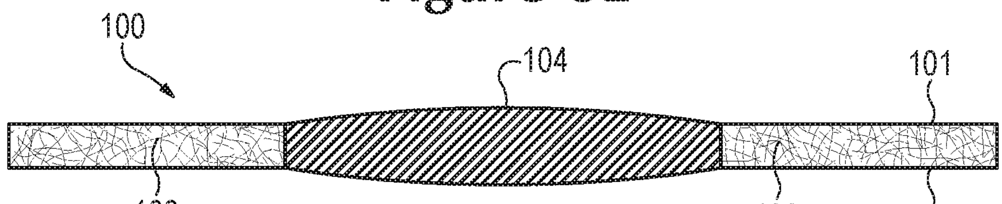
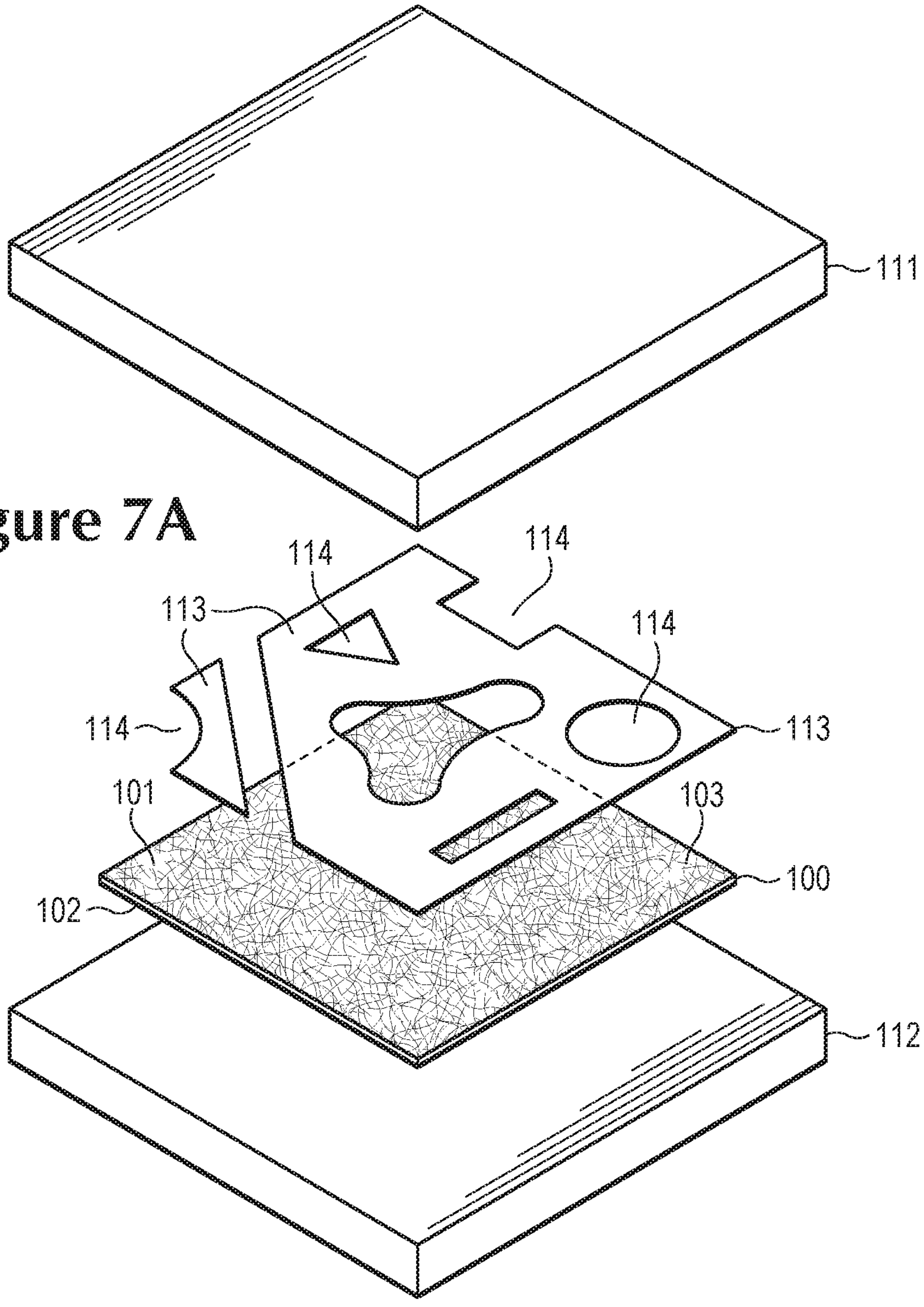


Figure 6F

Figure 7A



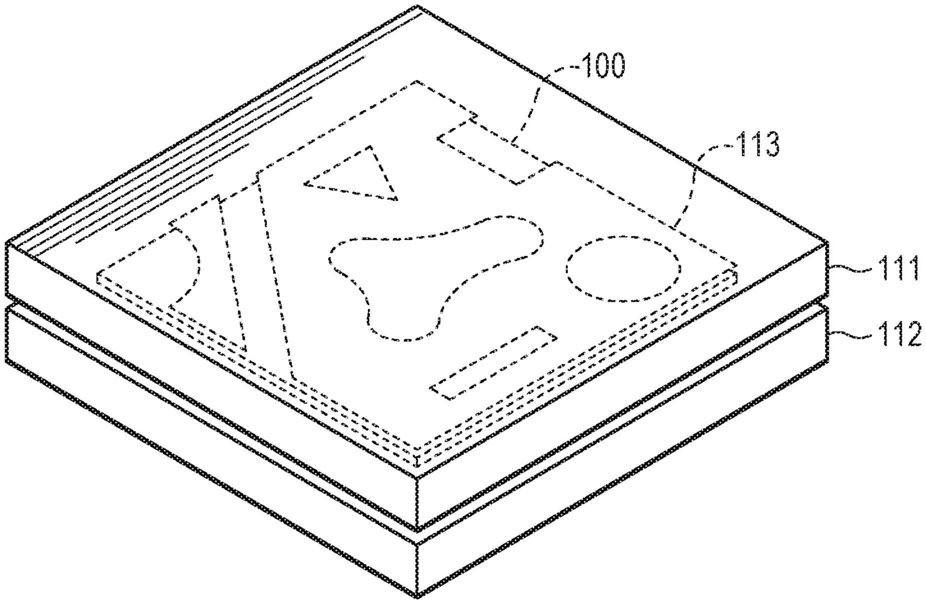
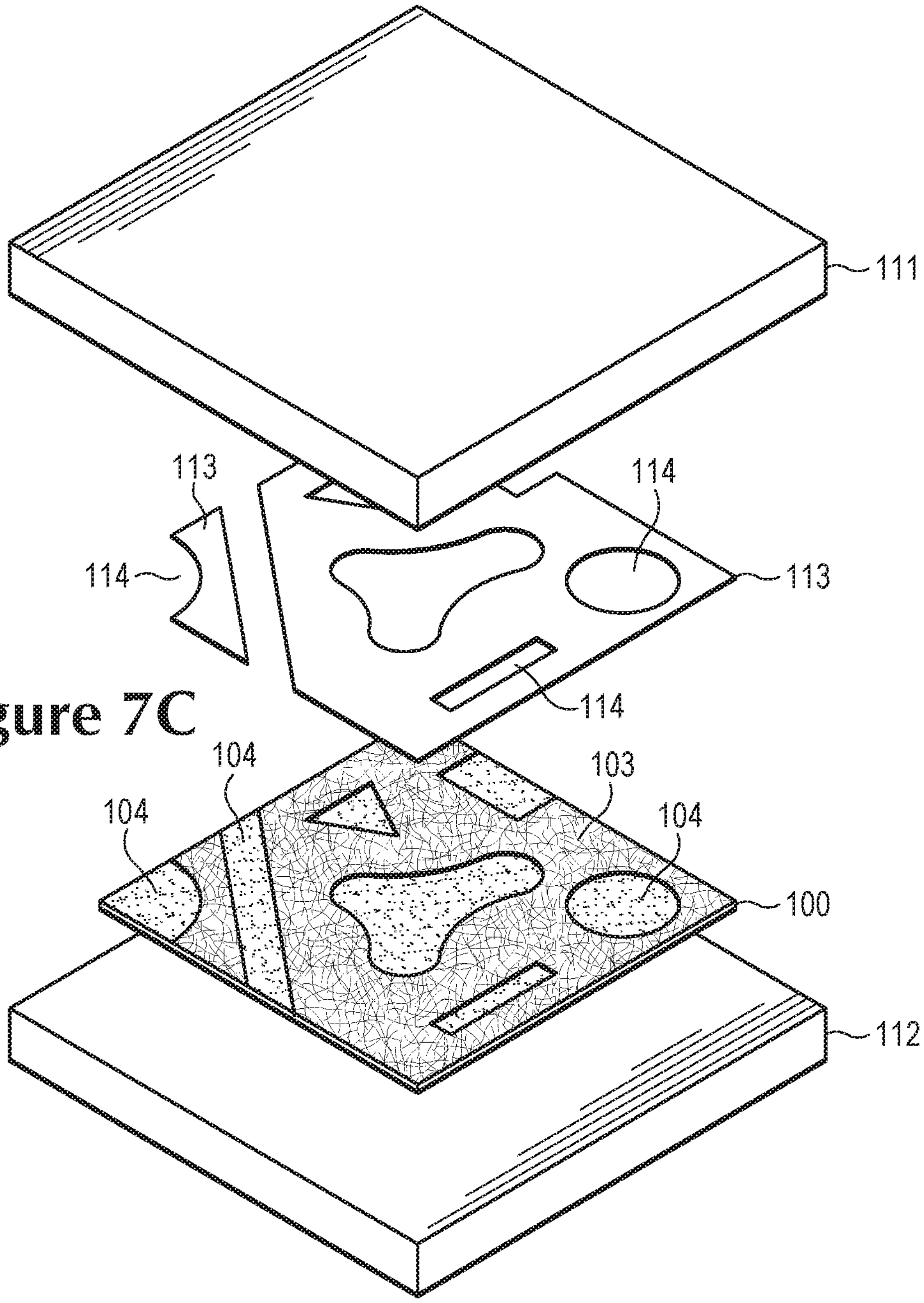


Figure 7B

Figure 7C



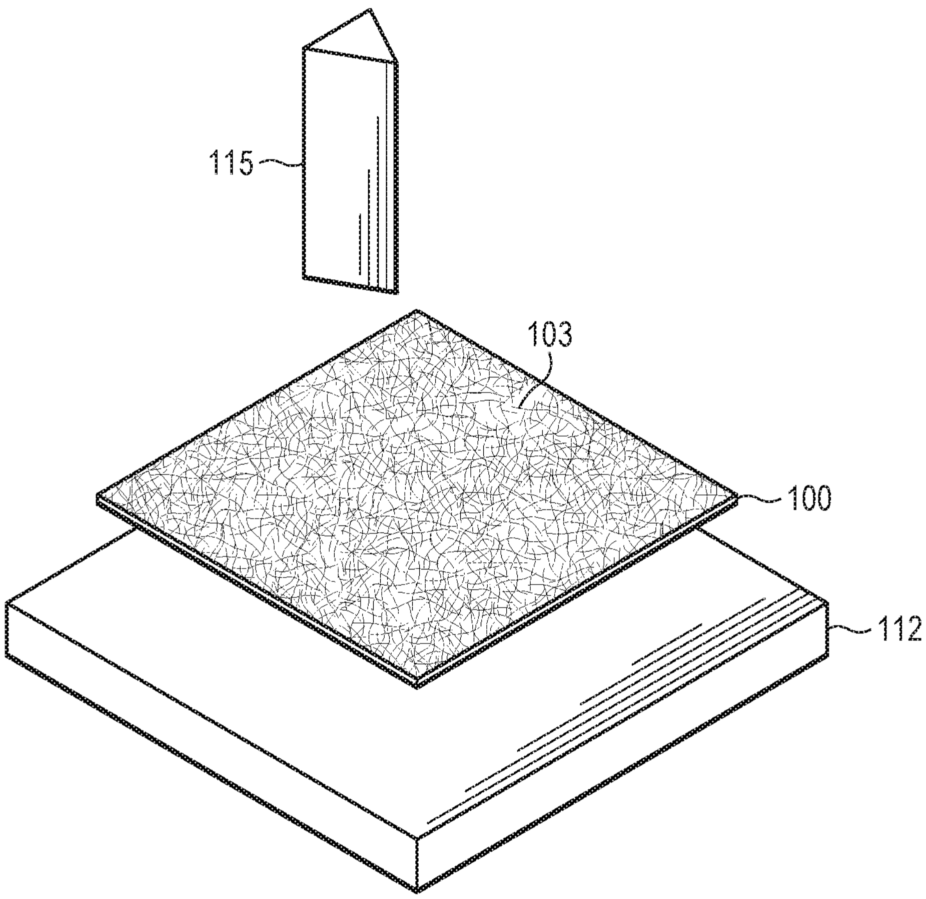
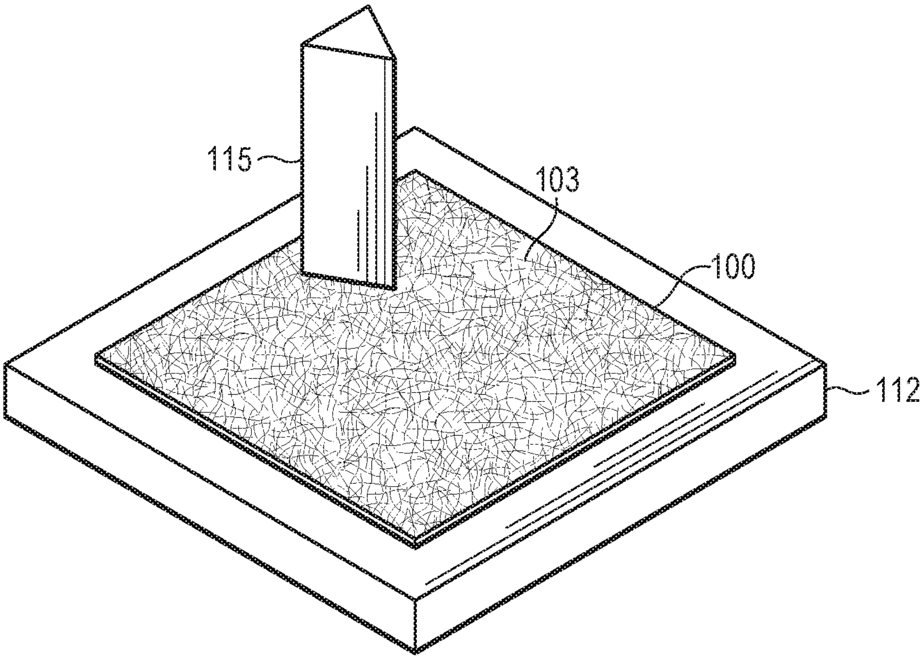


Figure 8A



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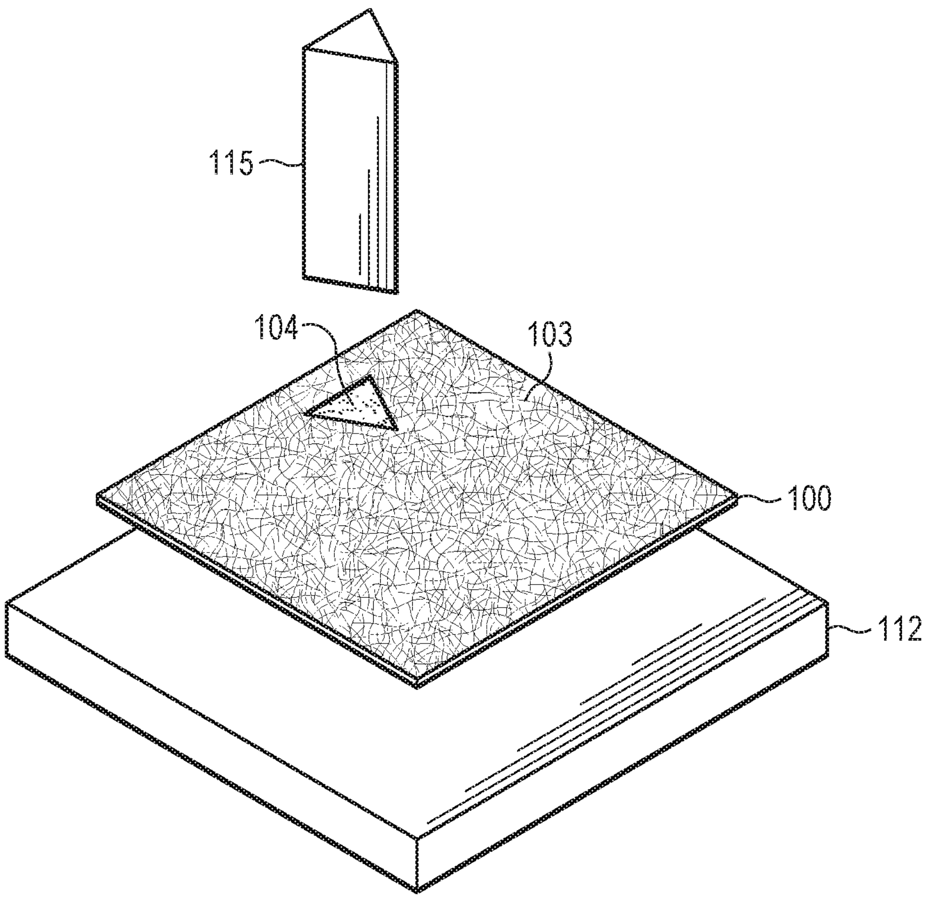

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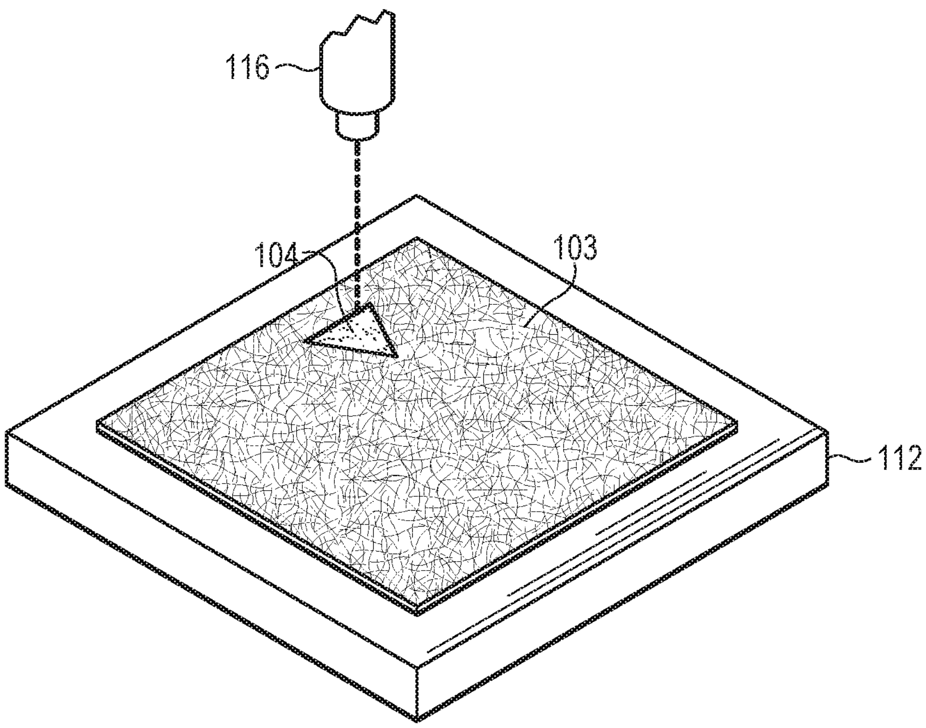

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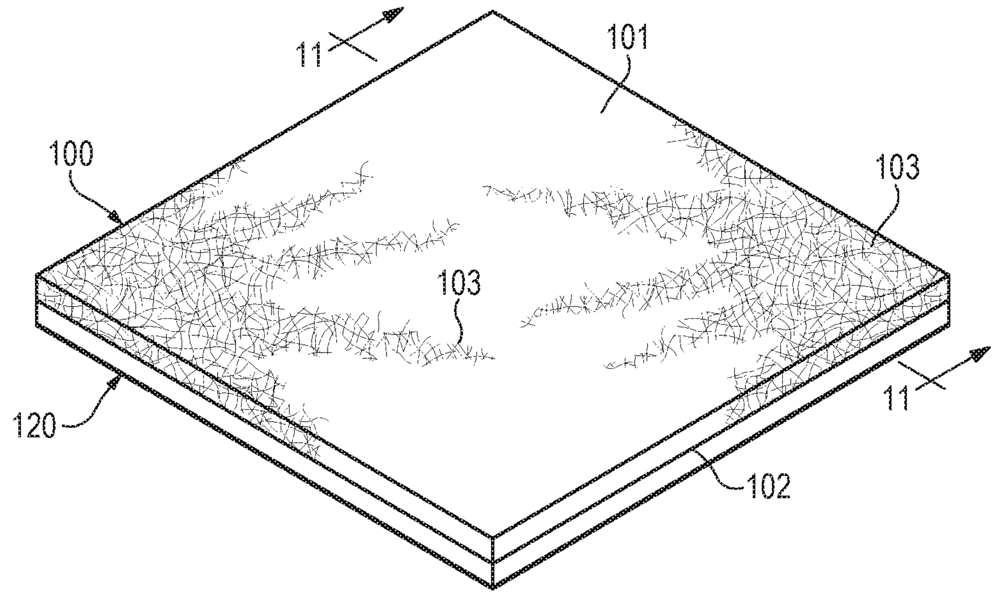


Figure 10

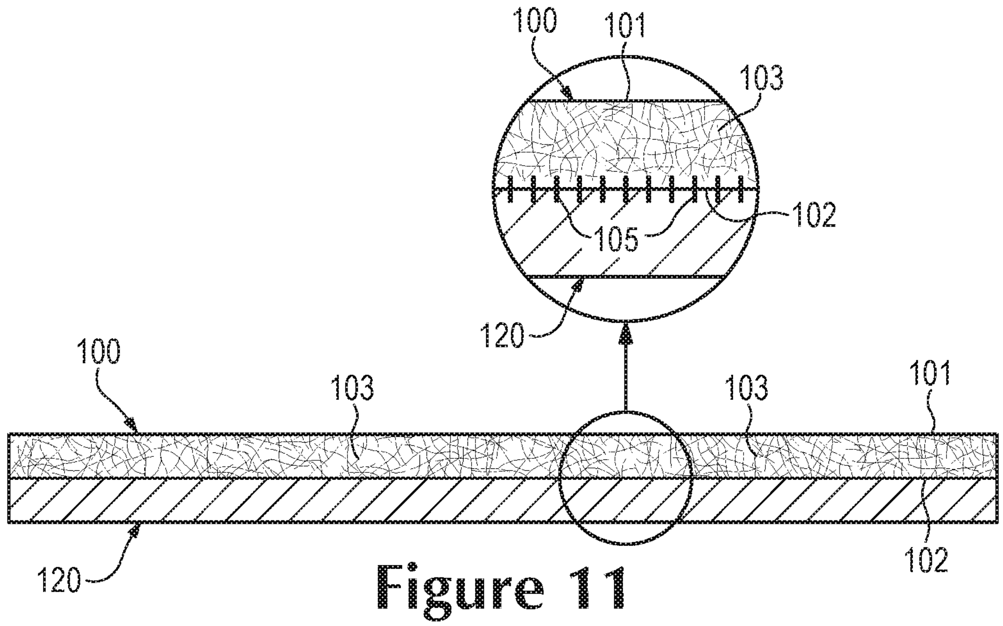


Figure 11

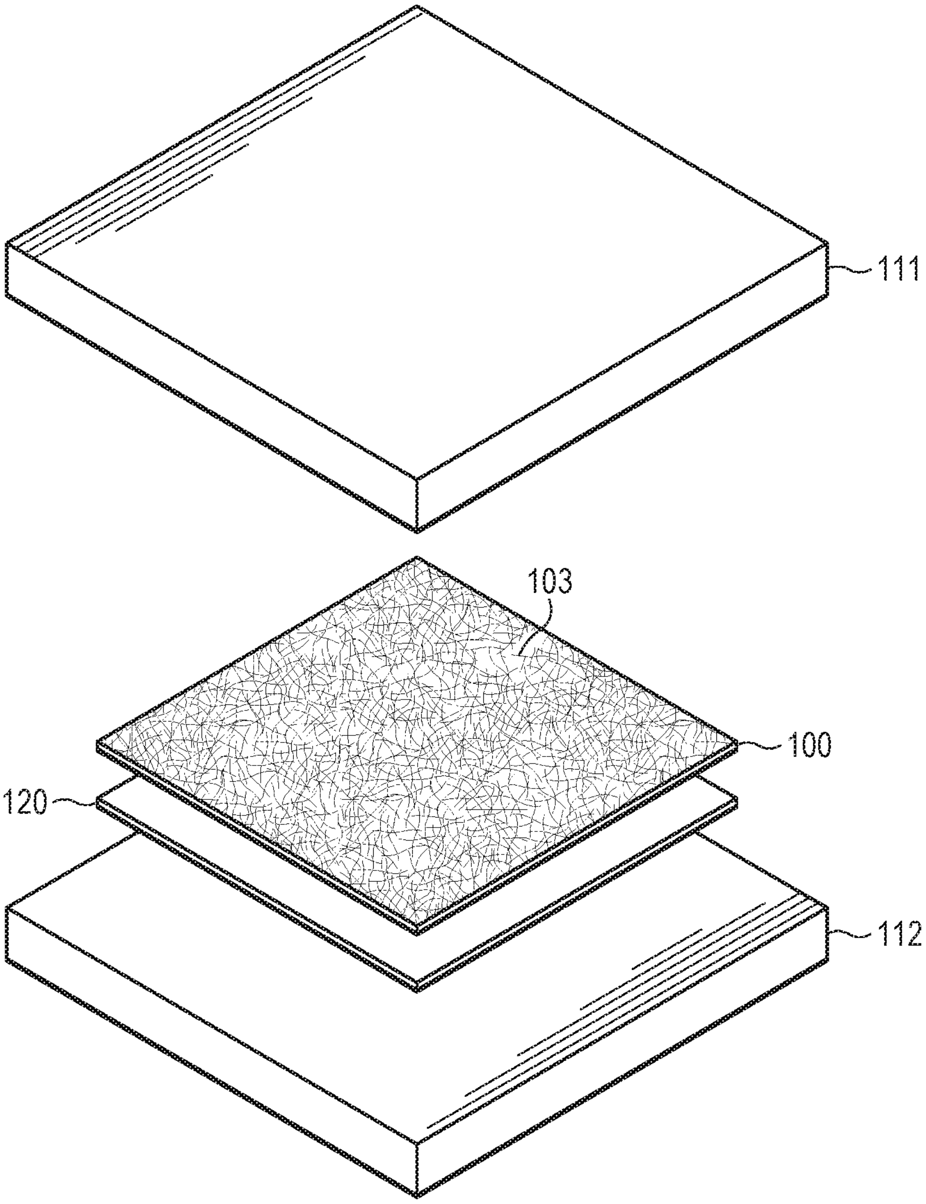


Figure 12A

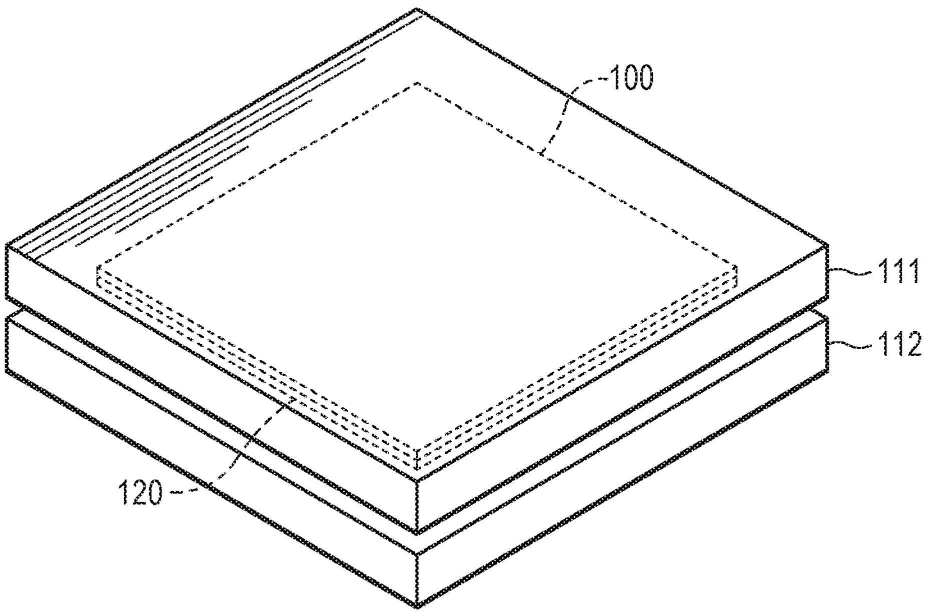


Figure 12B

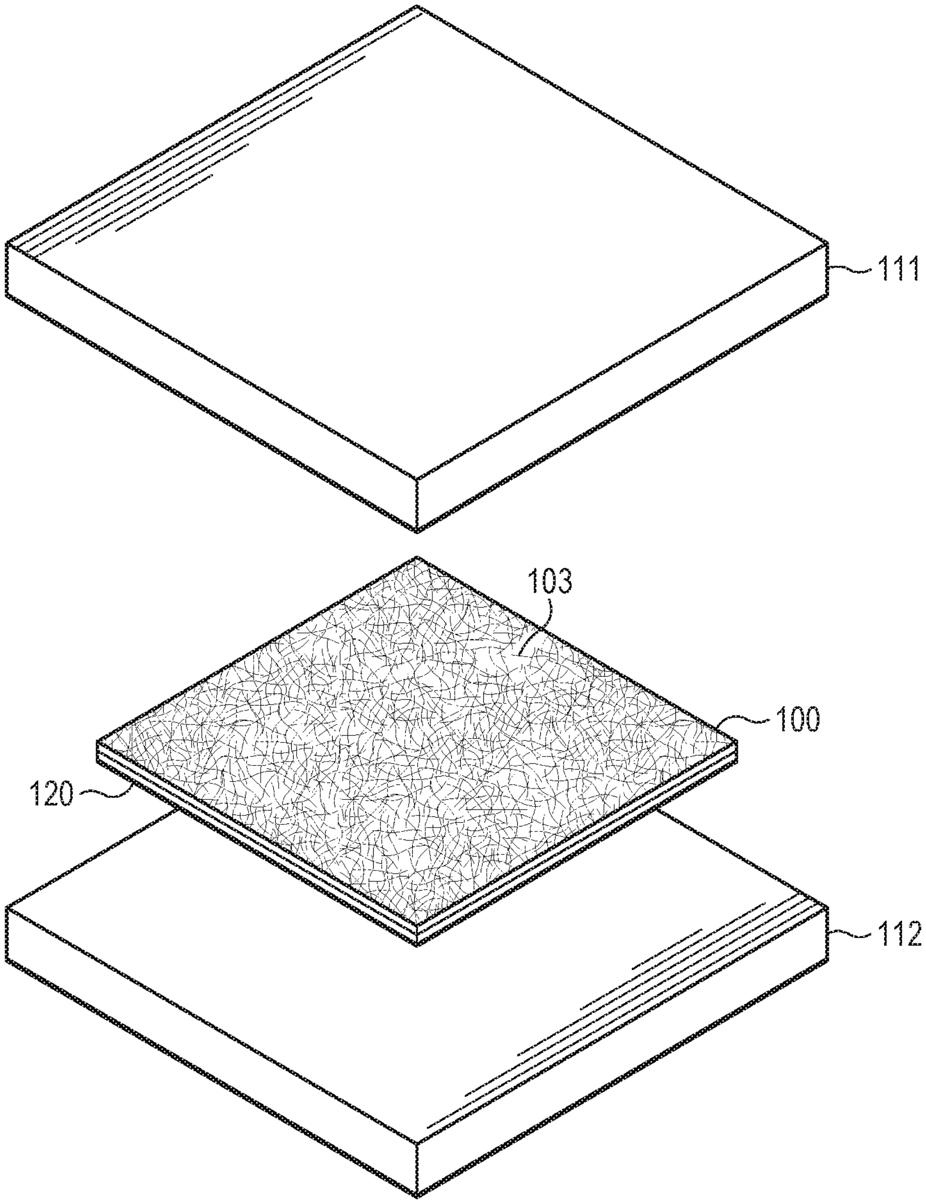


Figure 12C

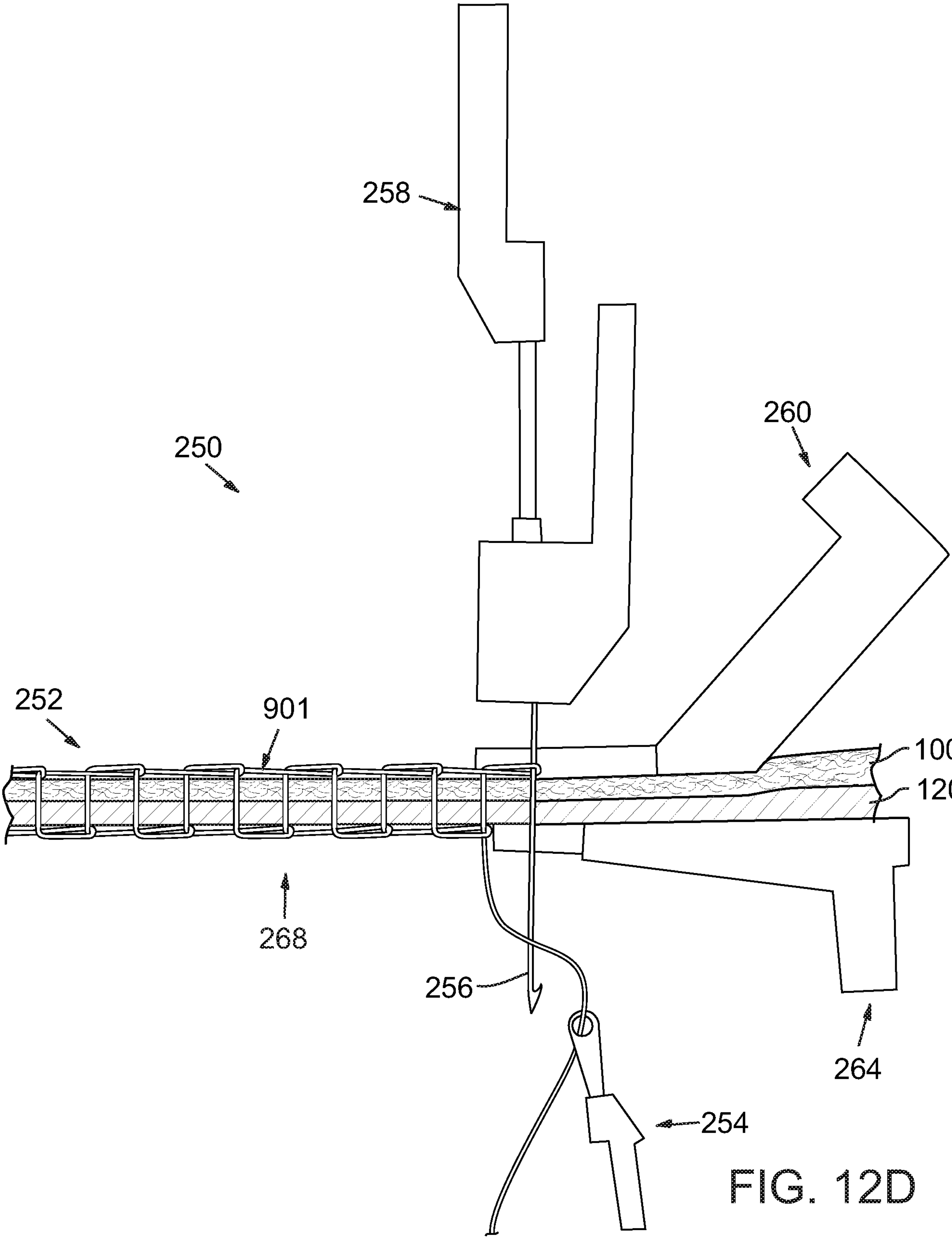


FIG. 12D

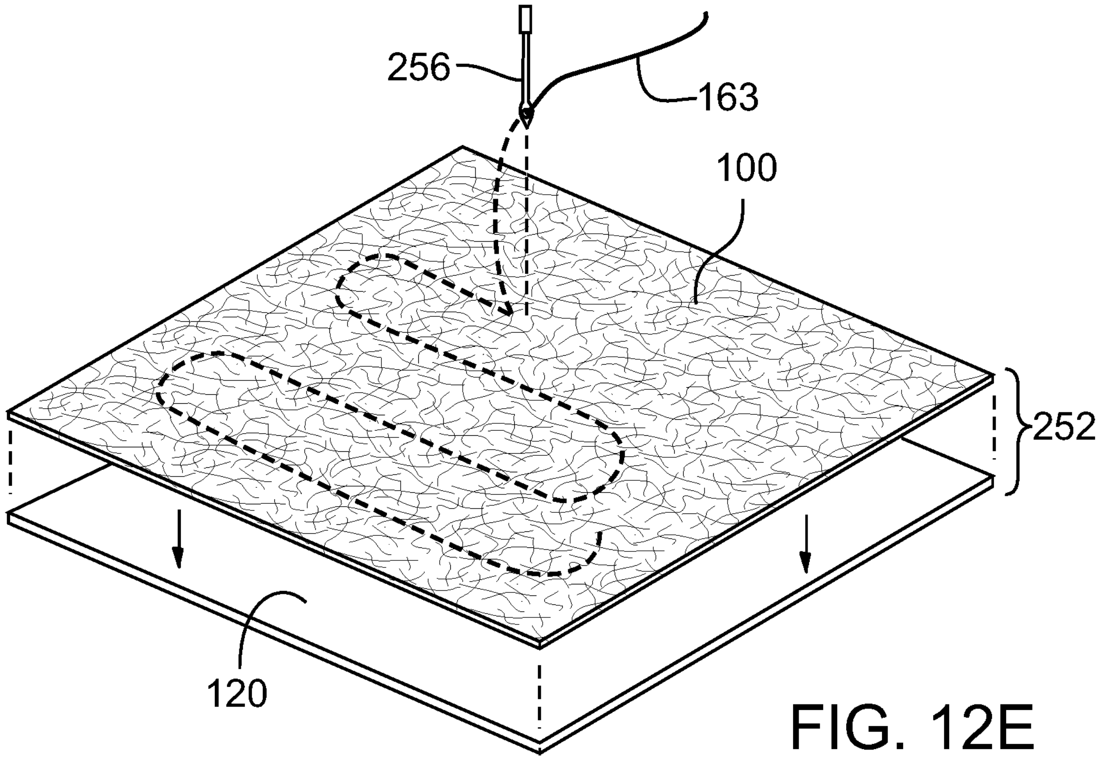


FIG. 12E

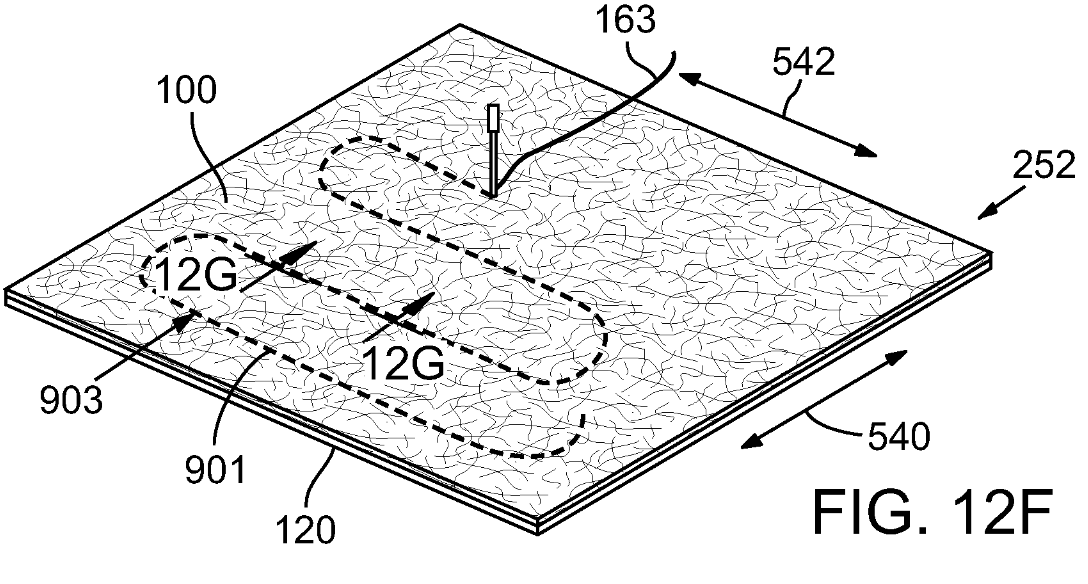


FIG. 12F

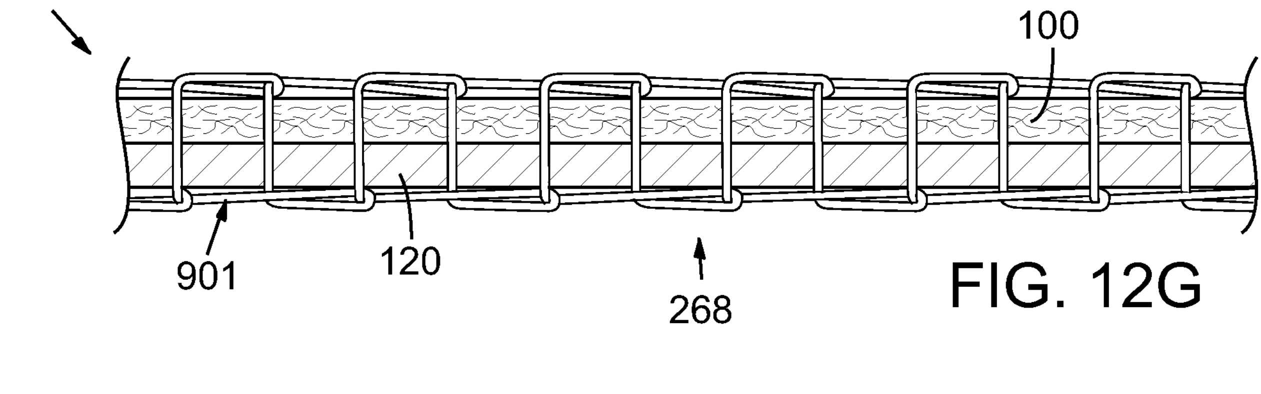


FIG. 12G

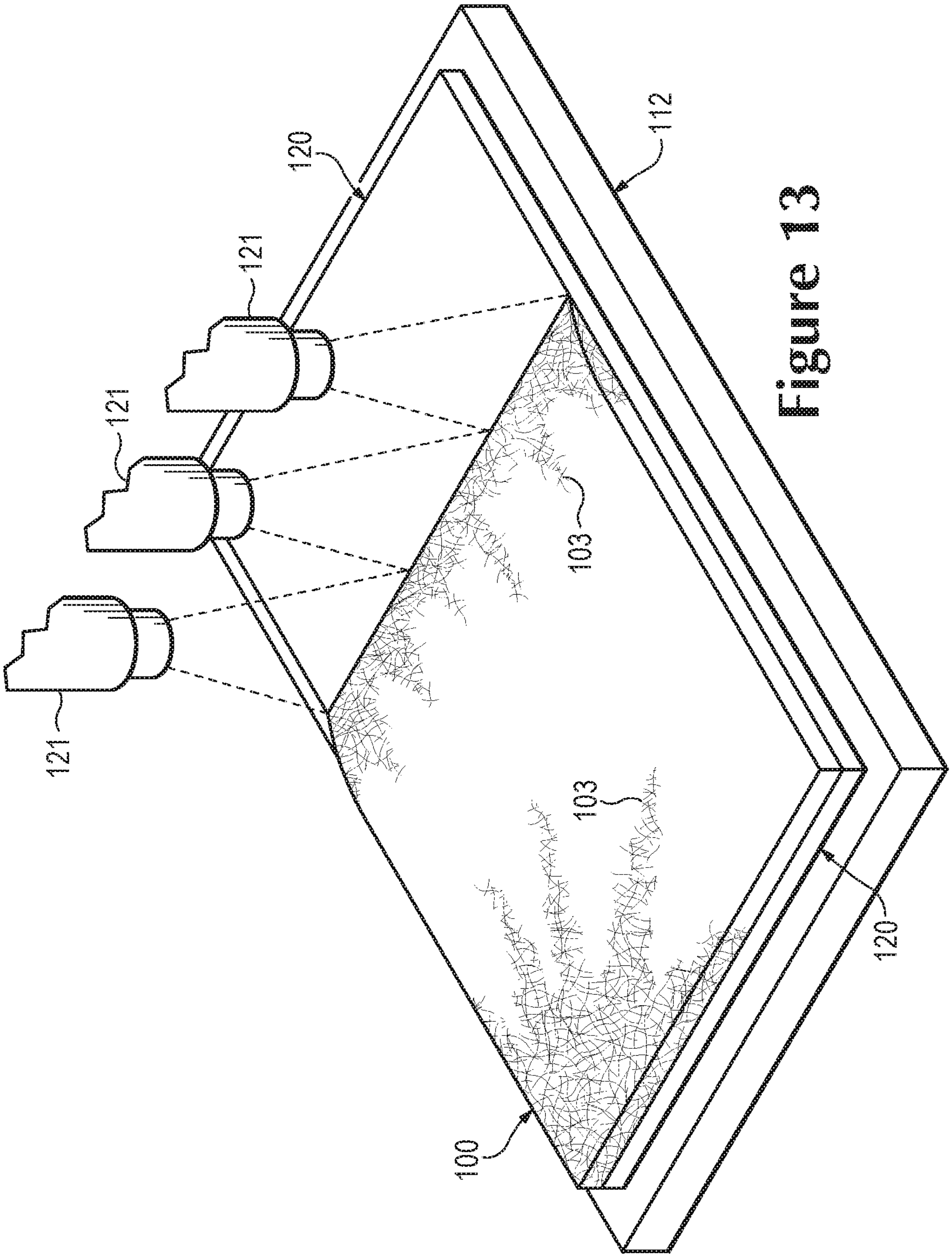


Figure 13

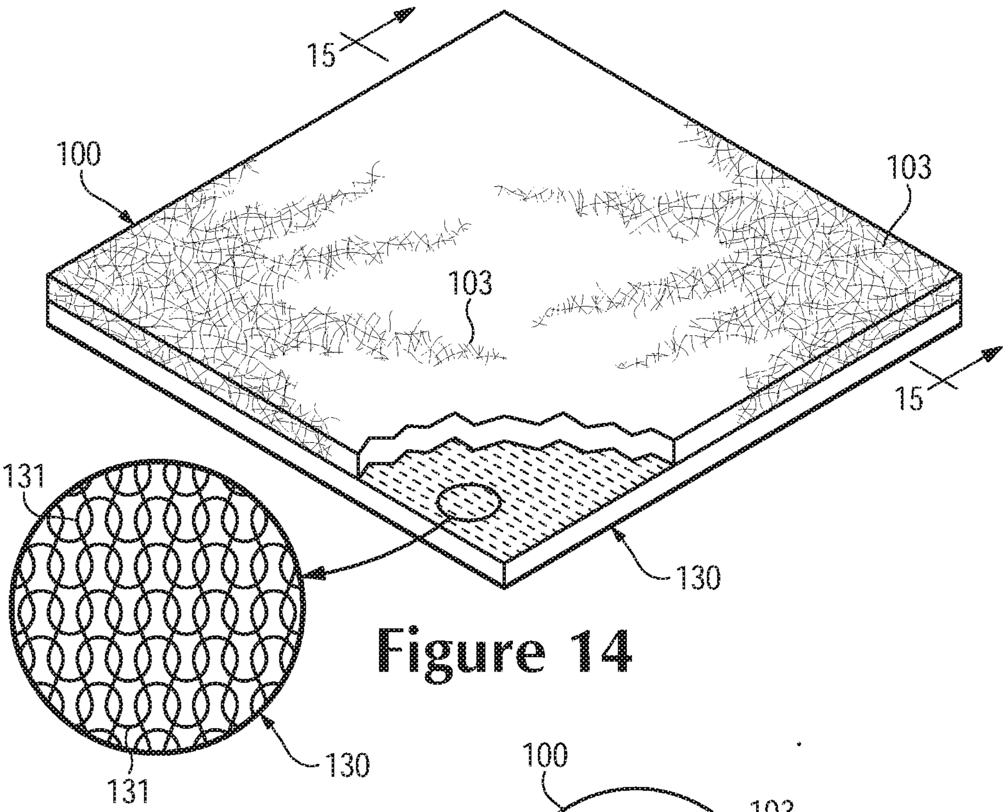


Figure 14

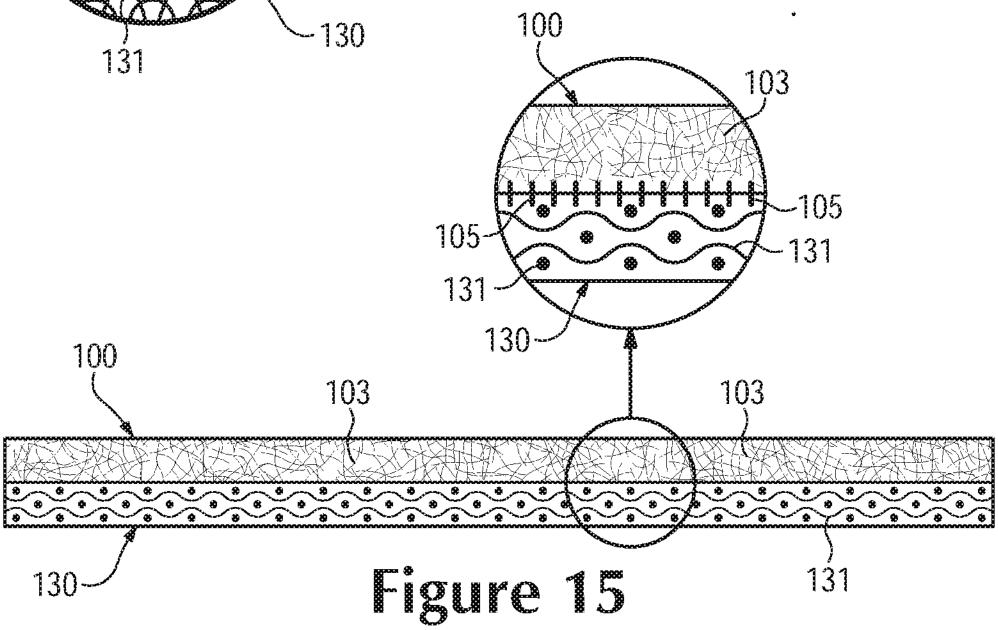


Figure 15

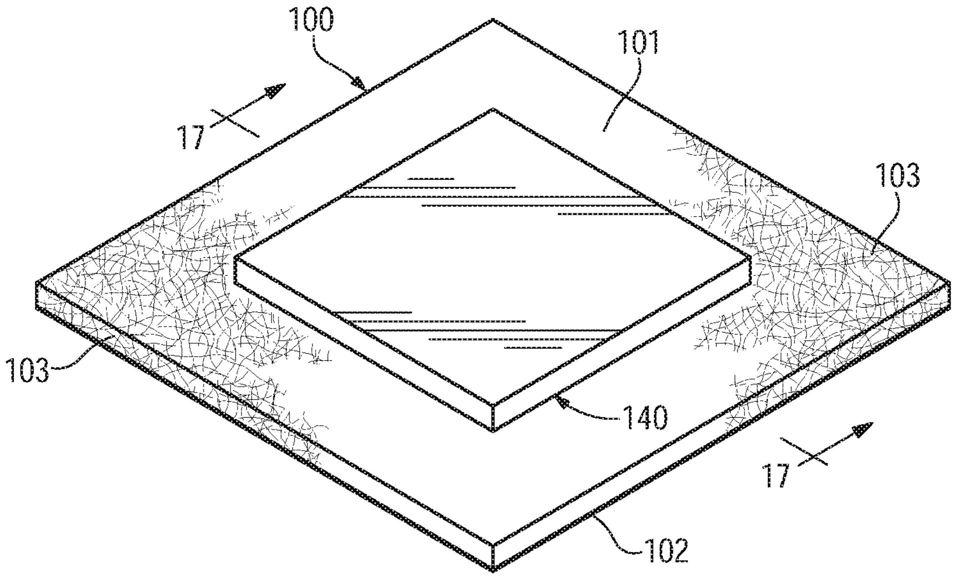


Figure 16

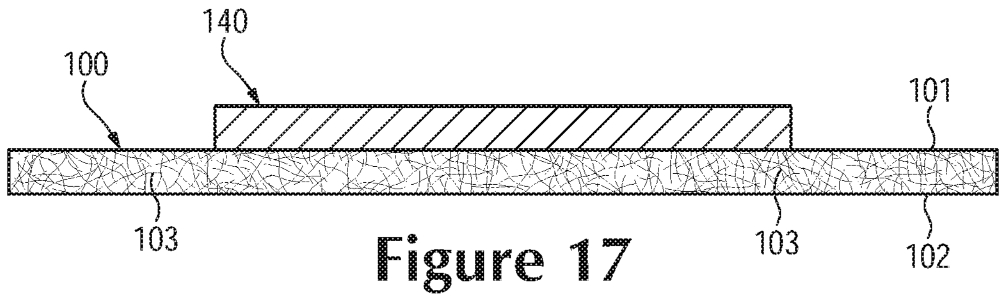


Figure 17

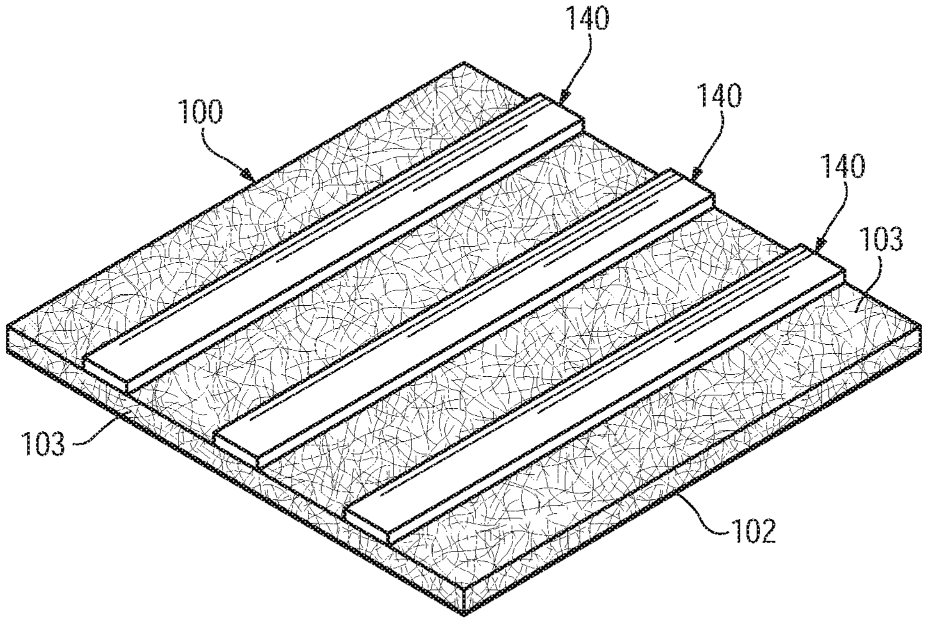


Figure 18A

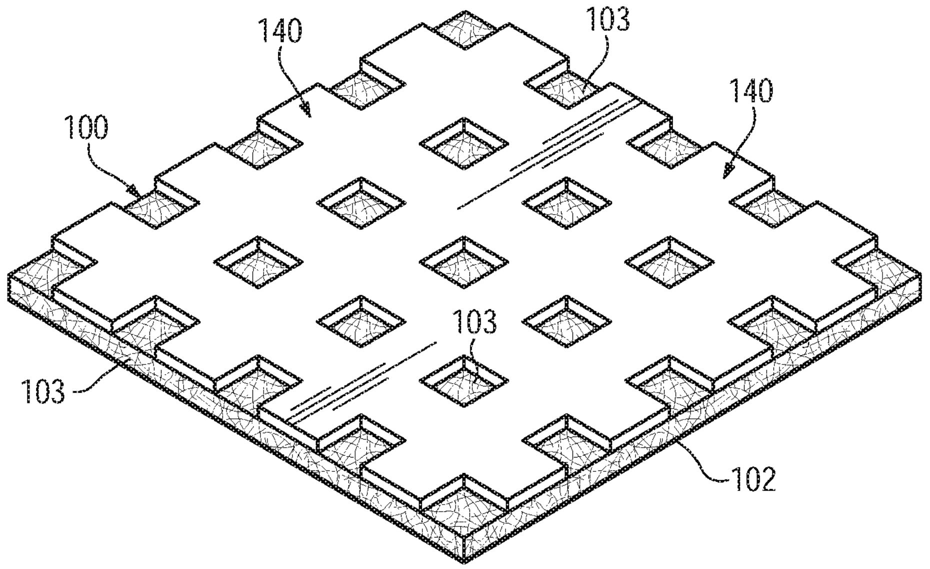


Figure 18B

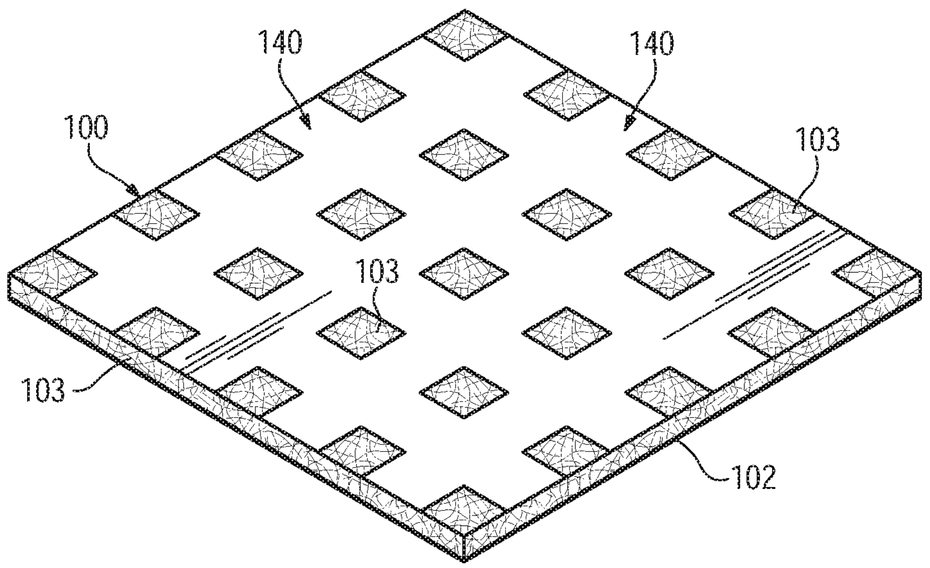


Figure 18C

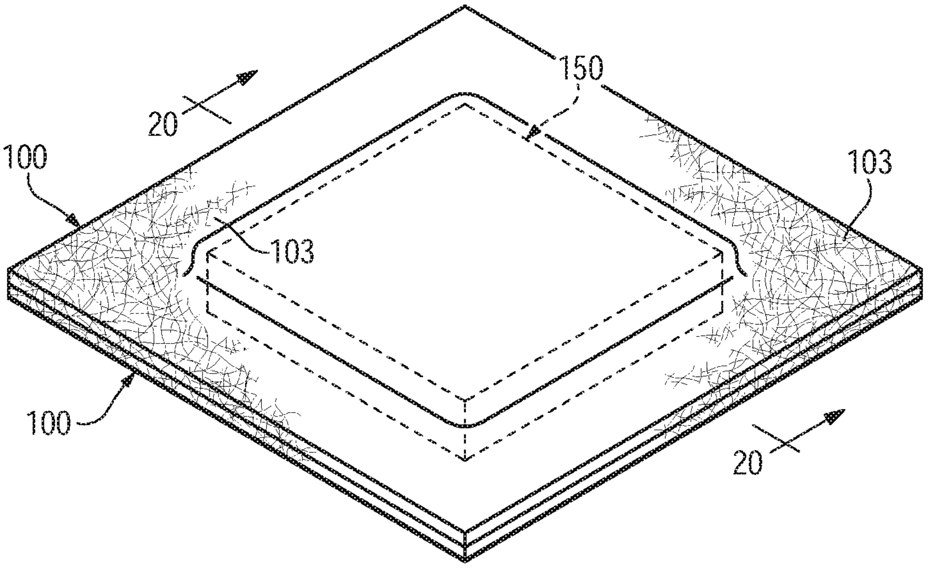


Figure 19

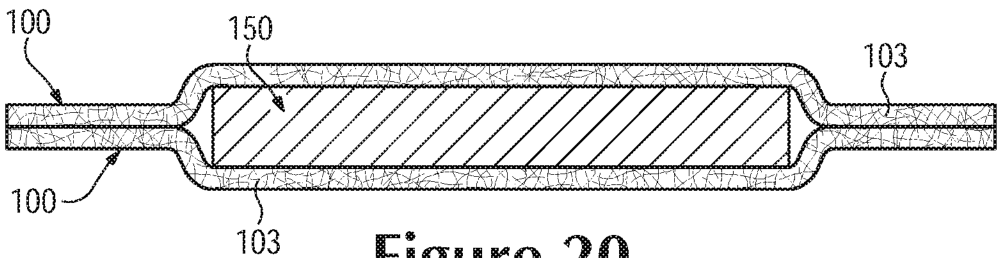


Figure 20

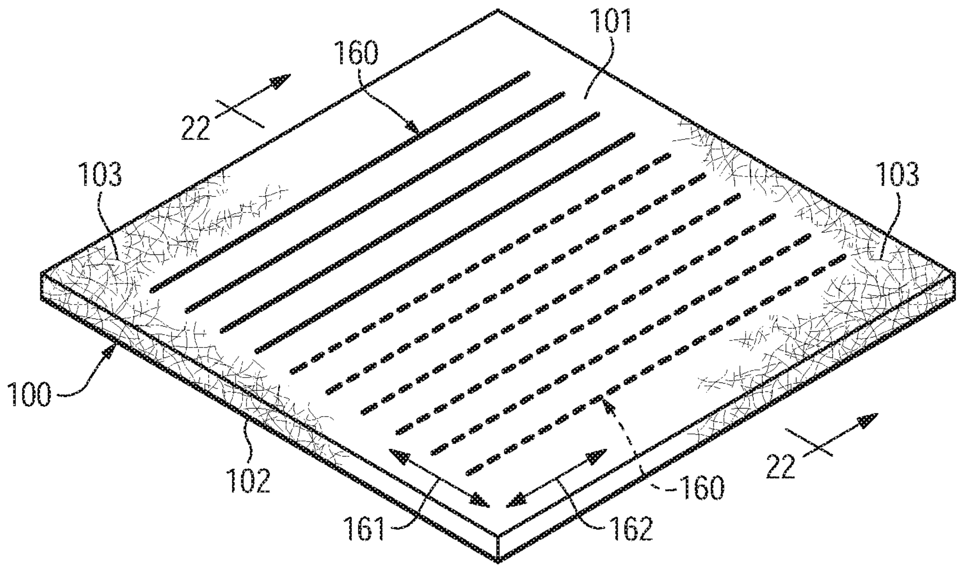


Figure 21

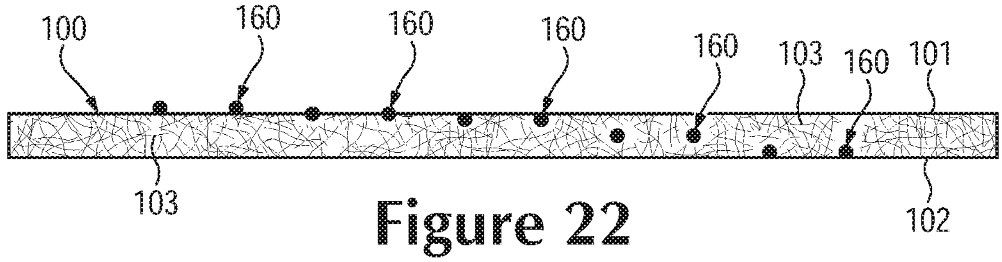


Figure 22

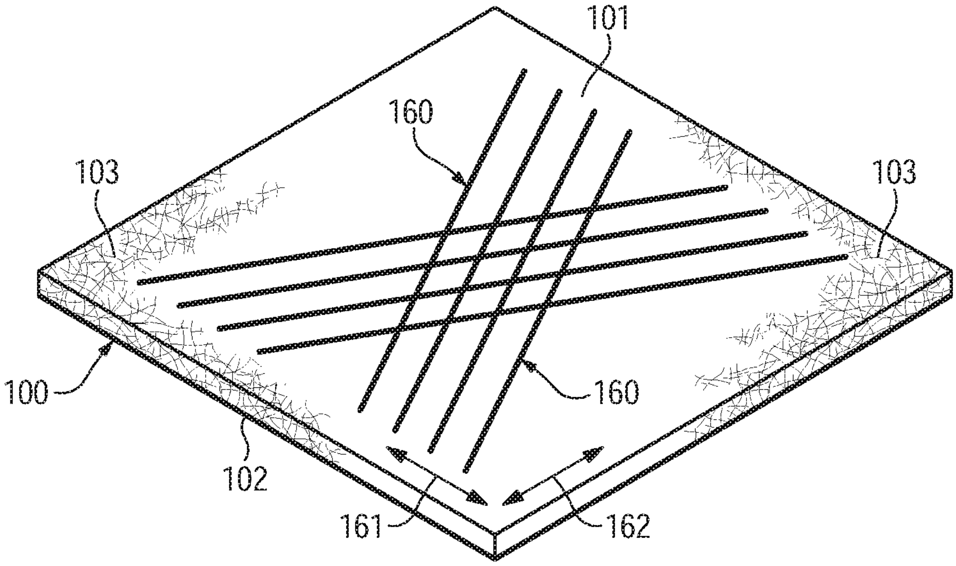


Figure 23A

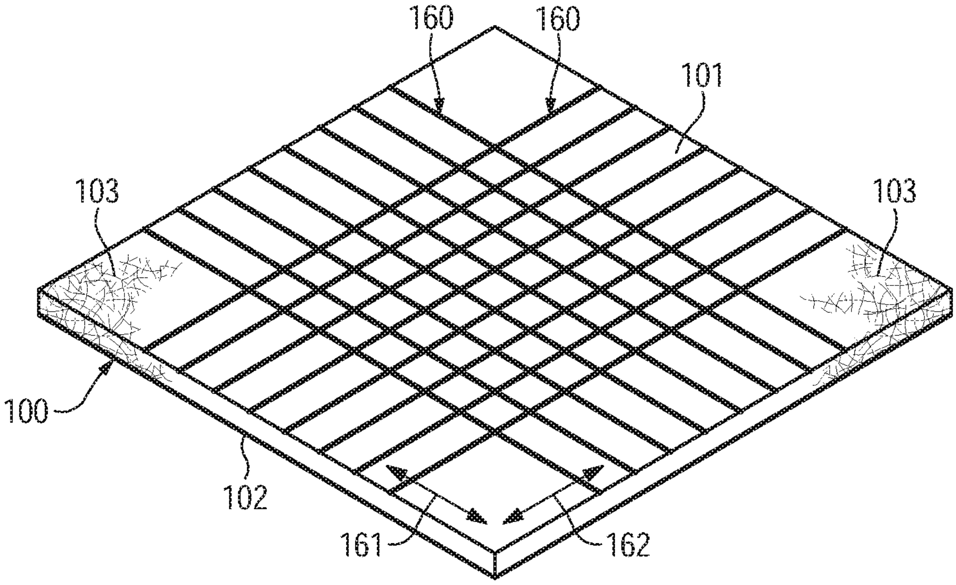
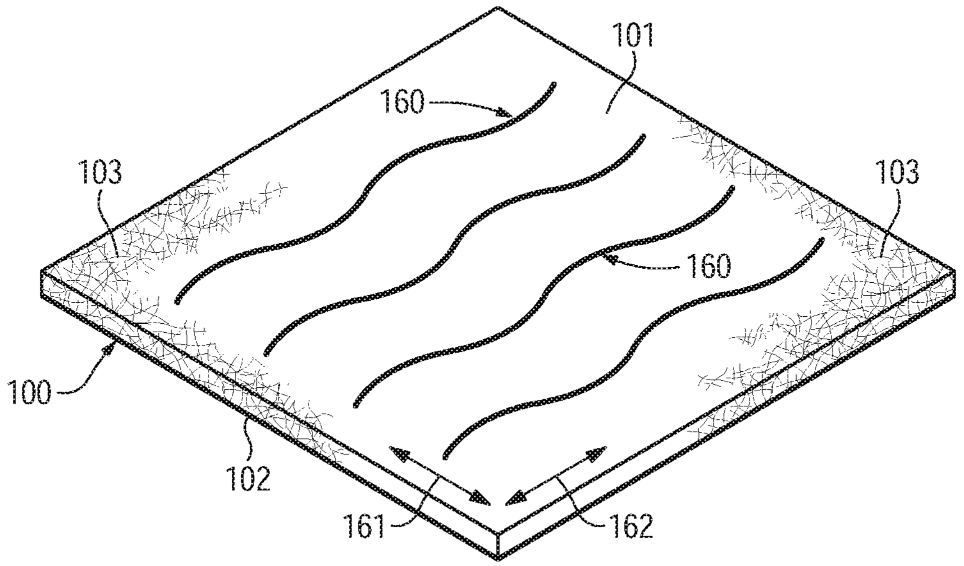


Figure 23B



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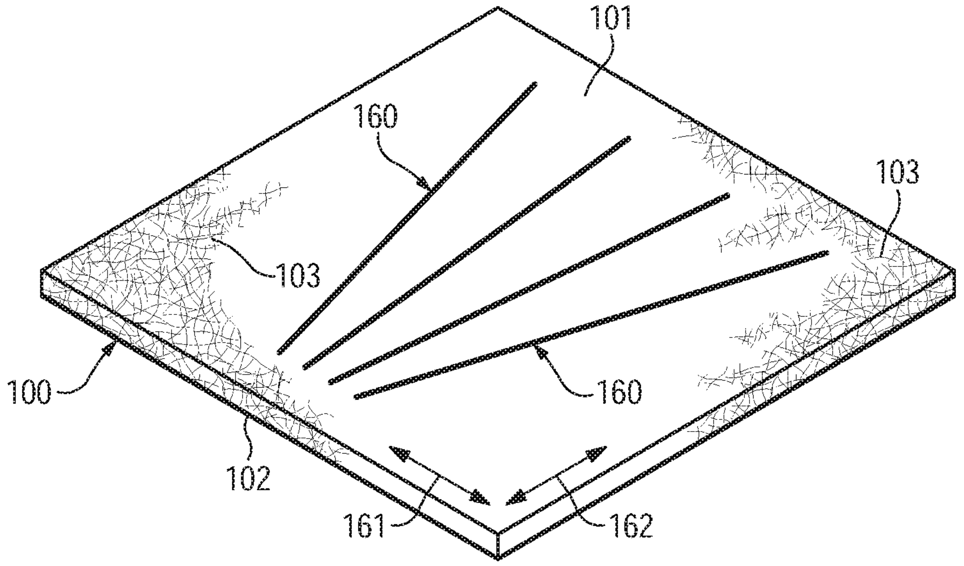


Figure 23D

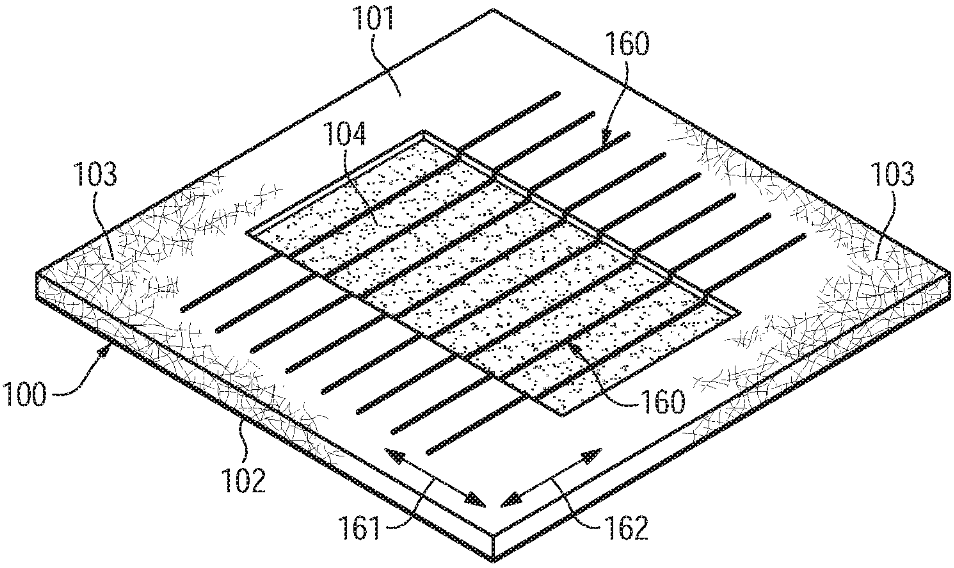


Figure 23E

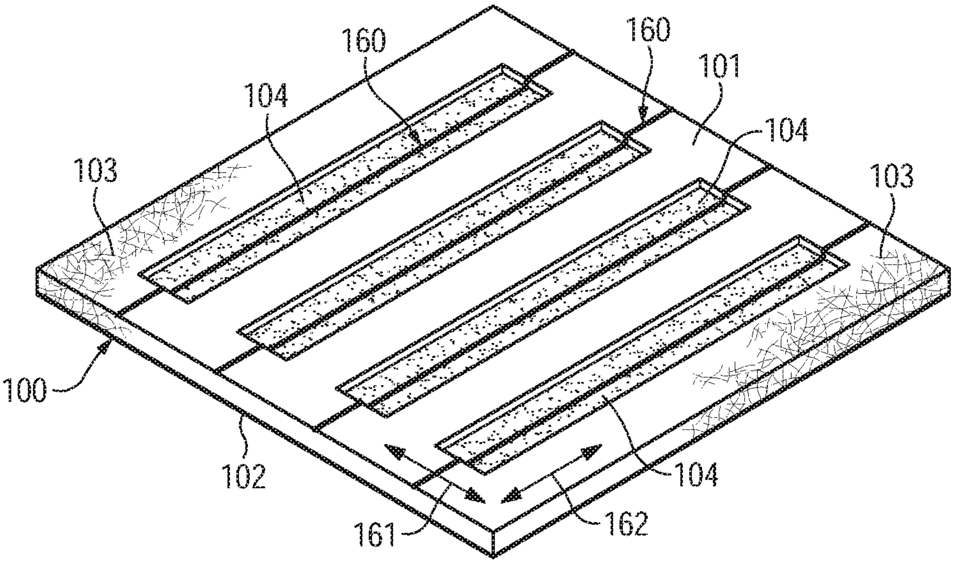


Figure 23F

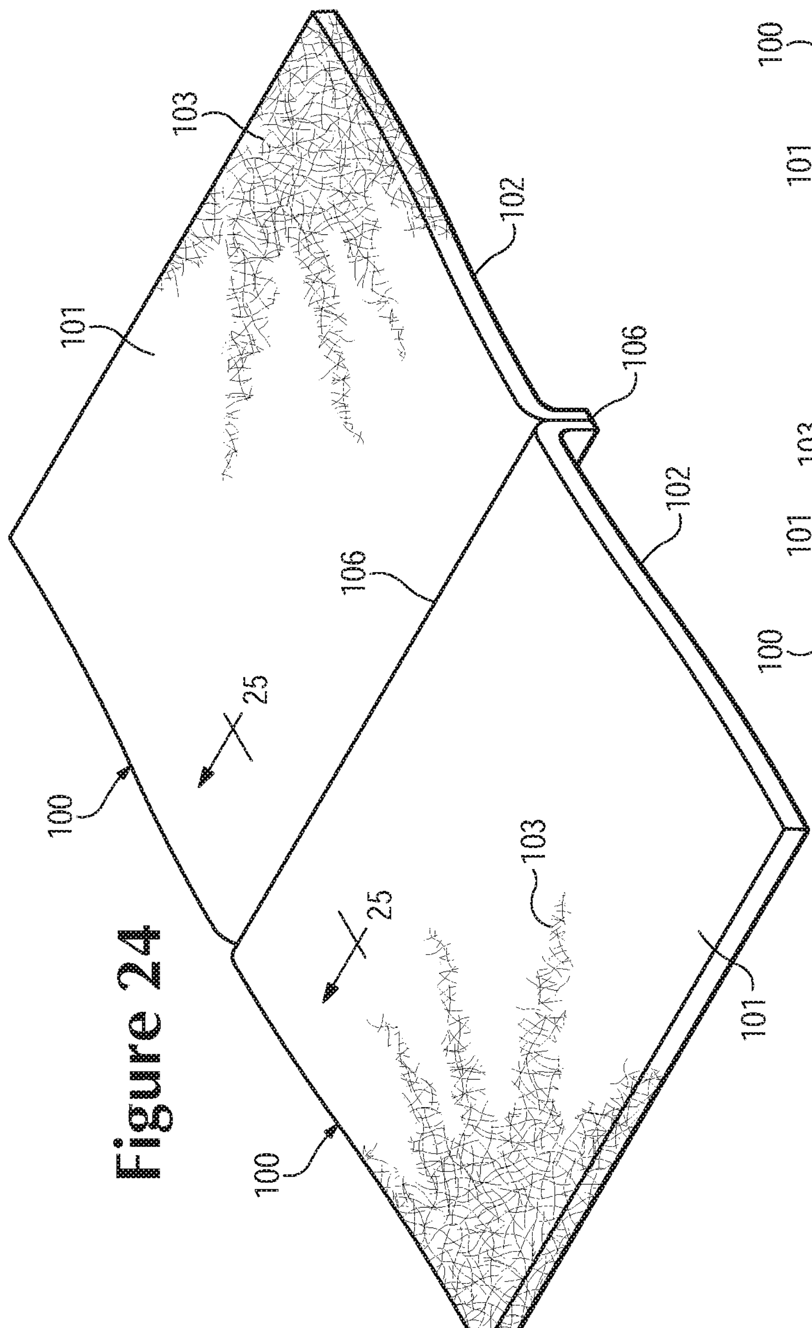


Figure 24

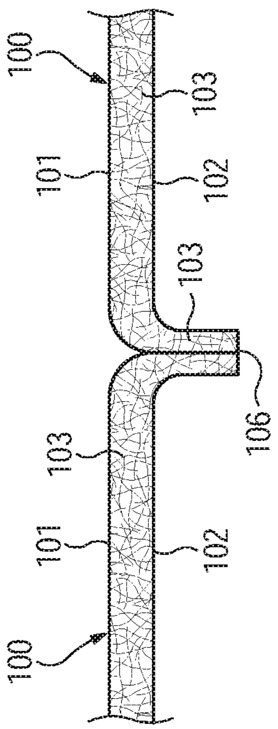


Figure 25

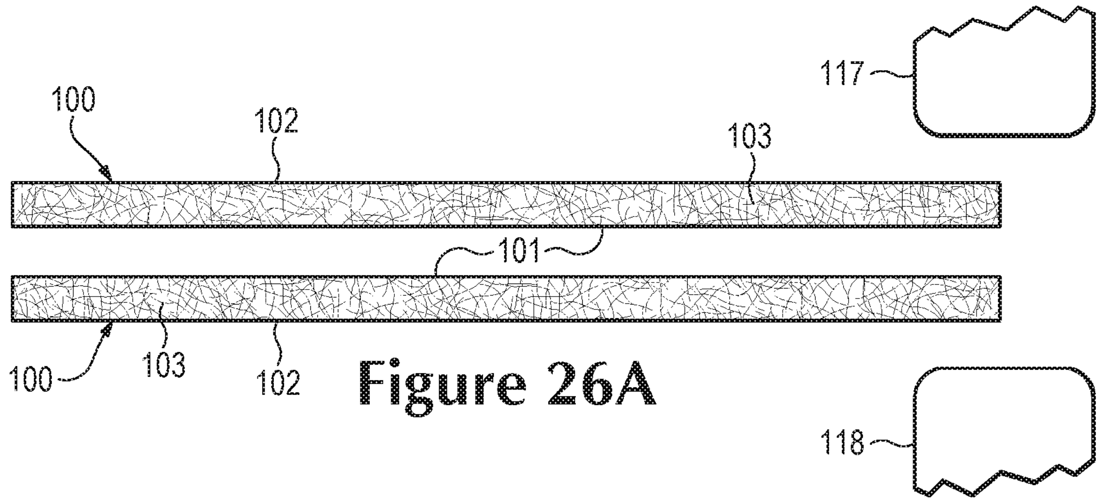


Figure 26A

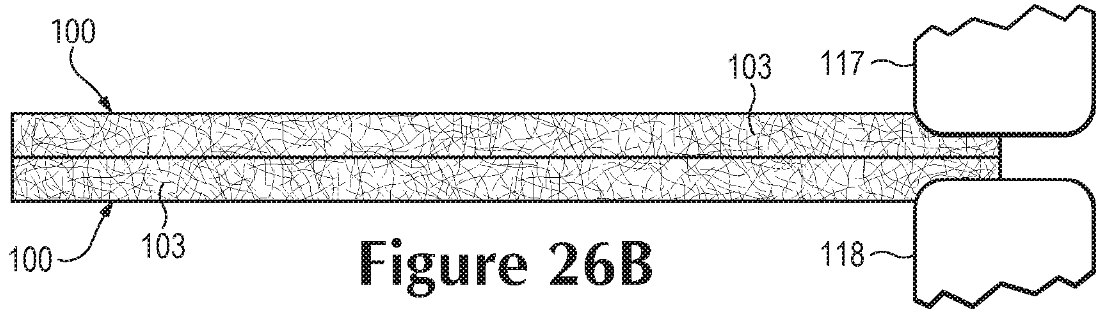
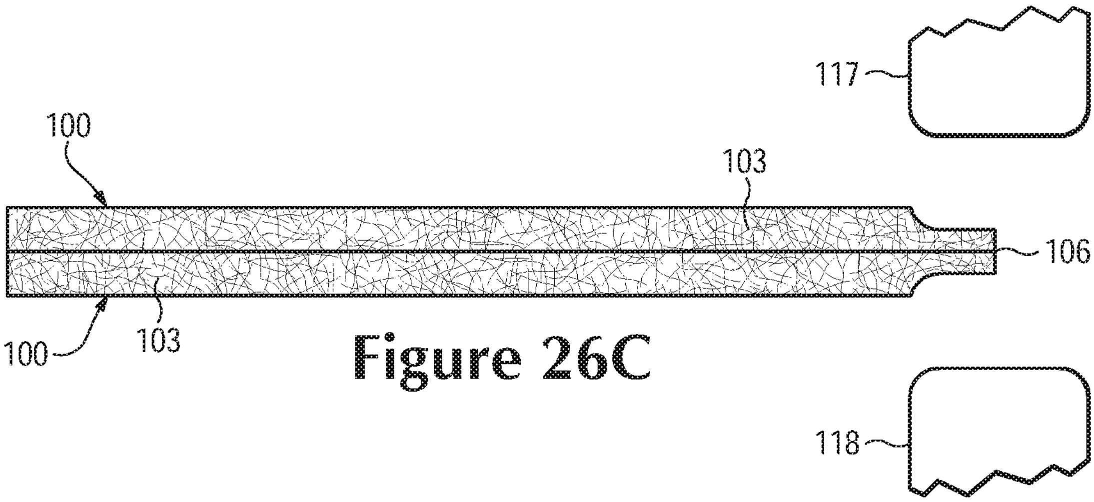


Figure 26B



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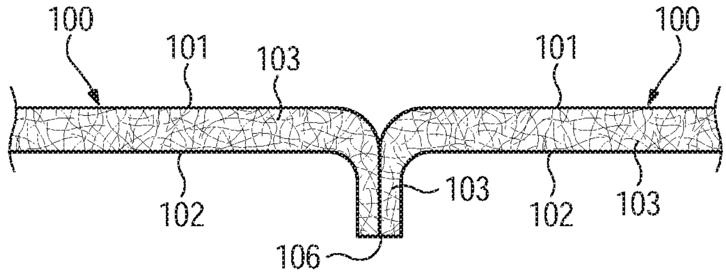

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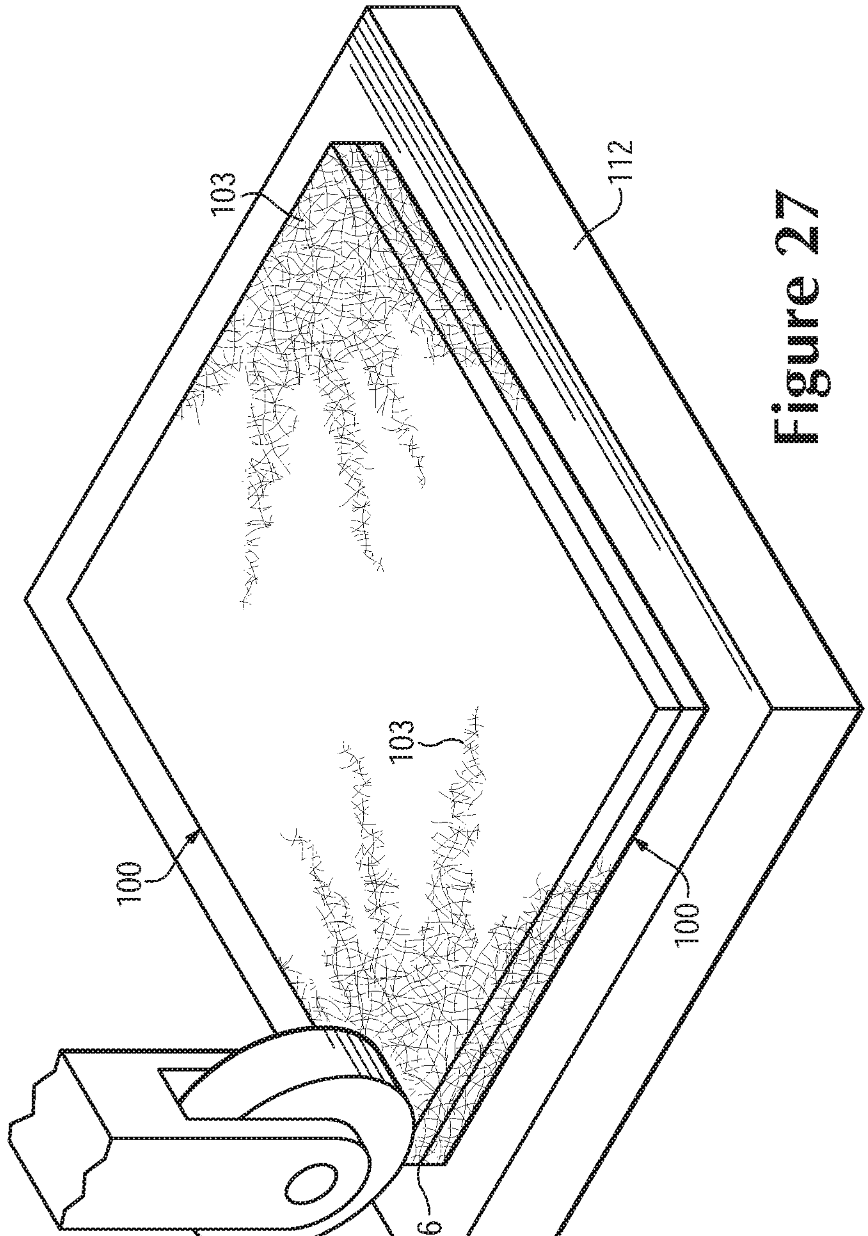


Figure 27

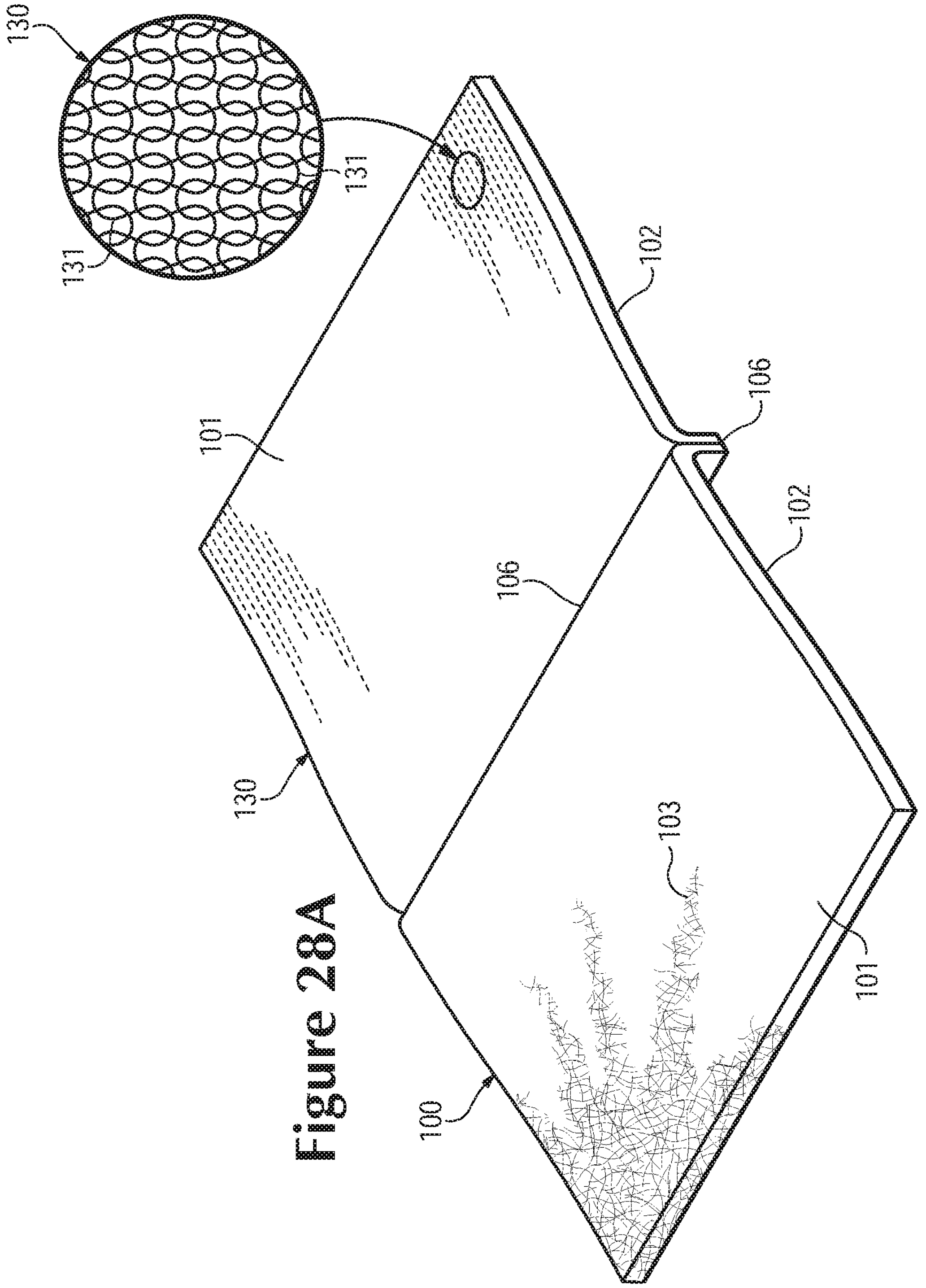


Figure 28A

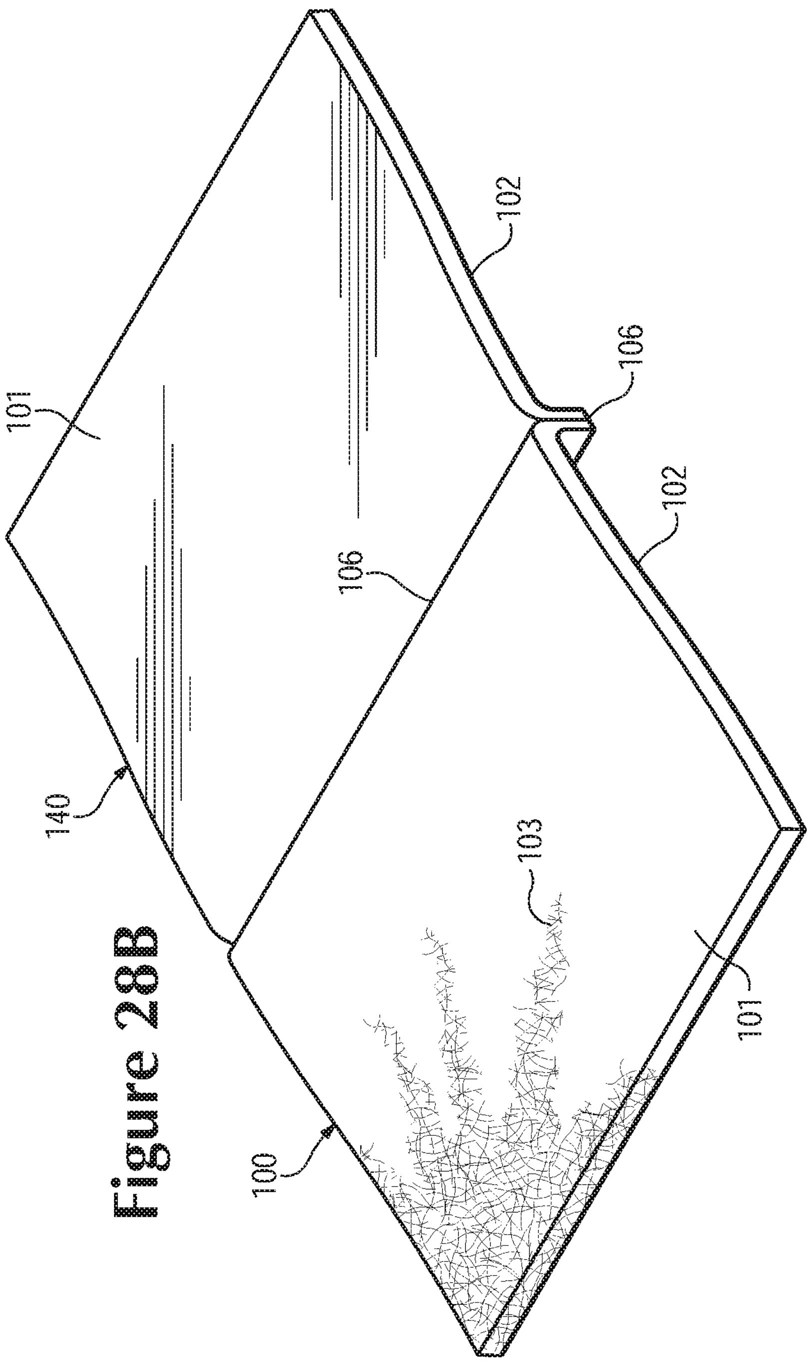


Figure 28B

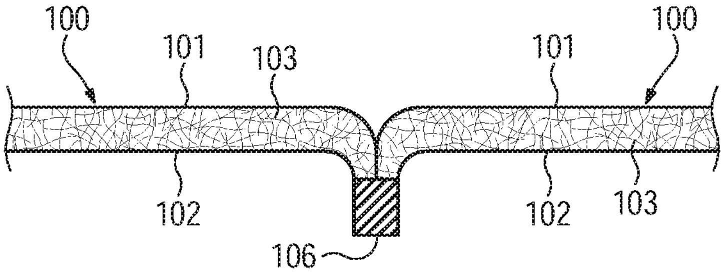
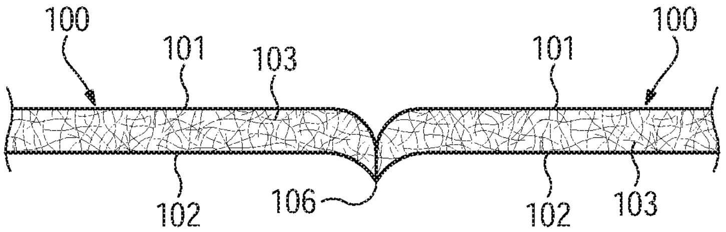


Figure 29A



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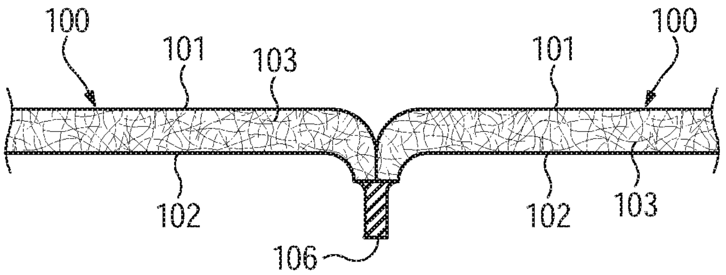

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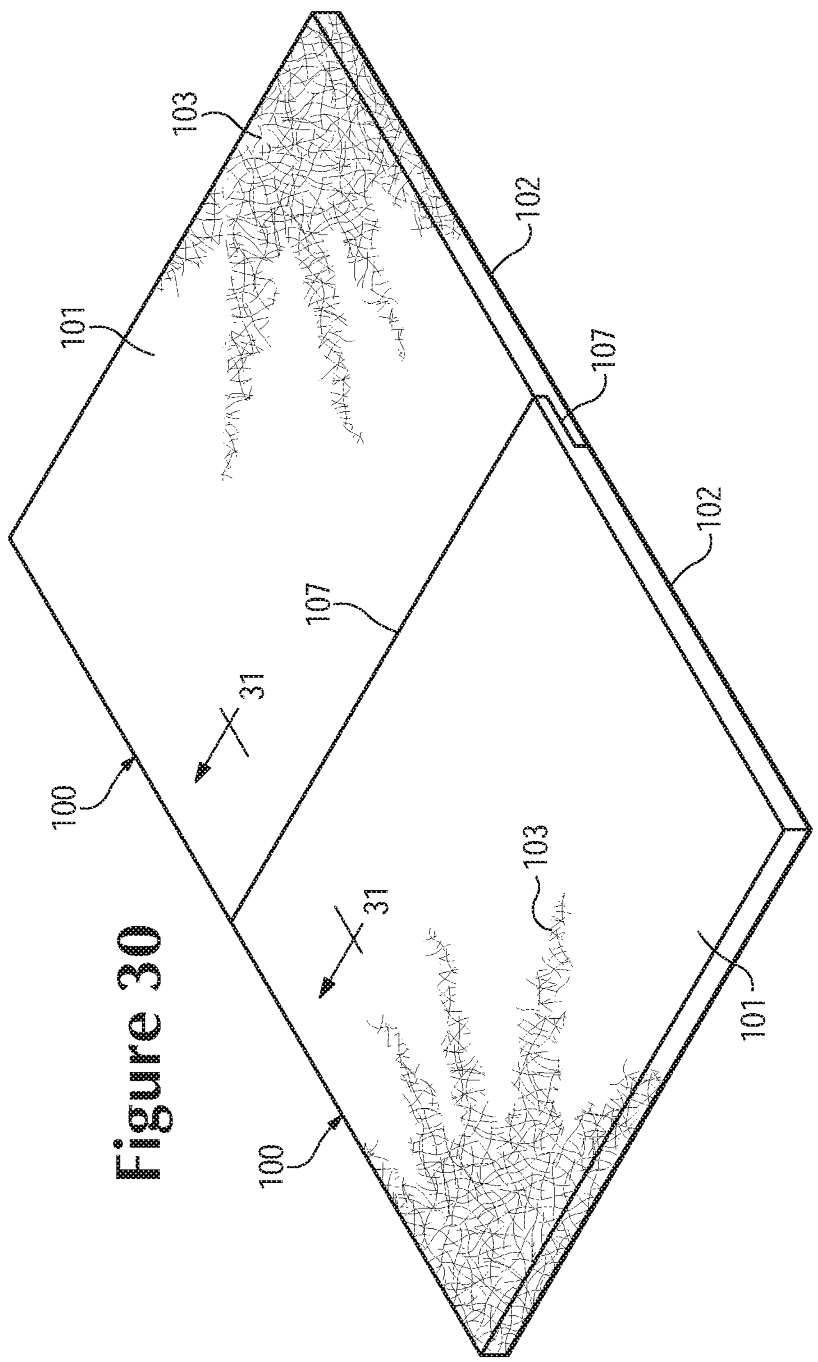
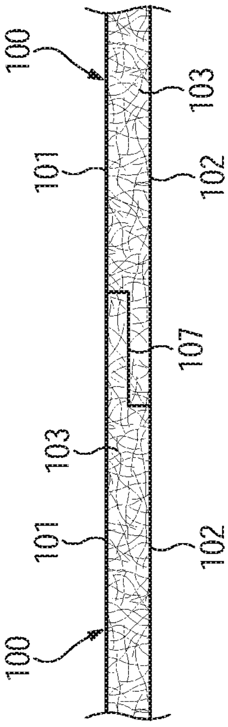


Figure 30



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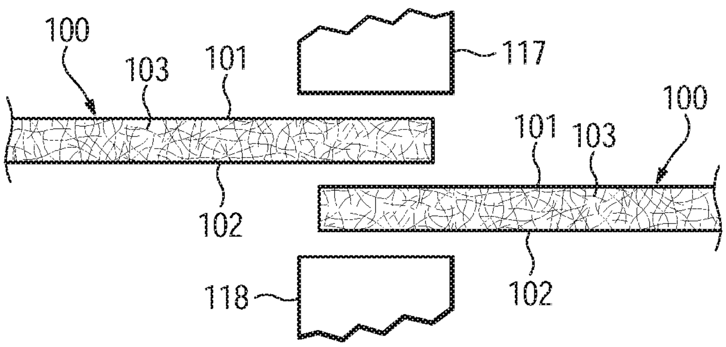
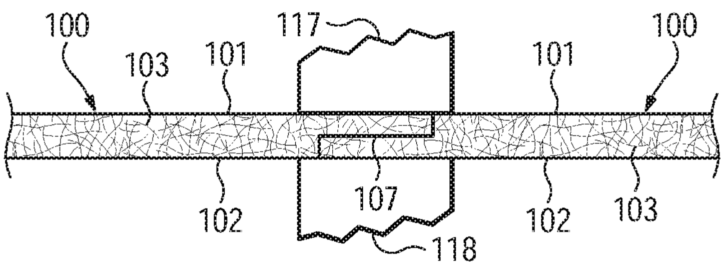


Figure 32A



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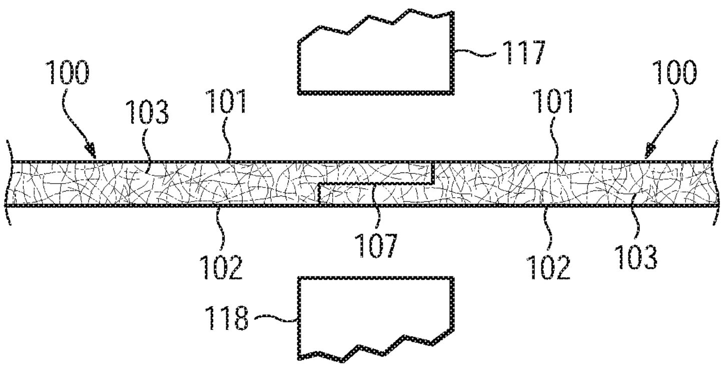

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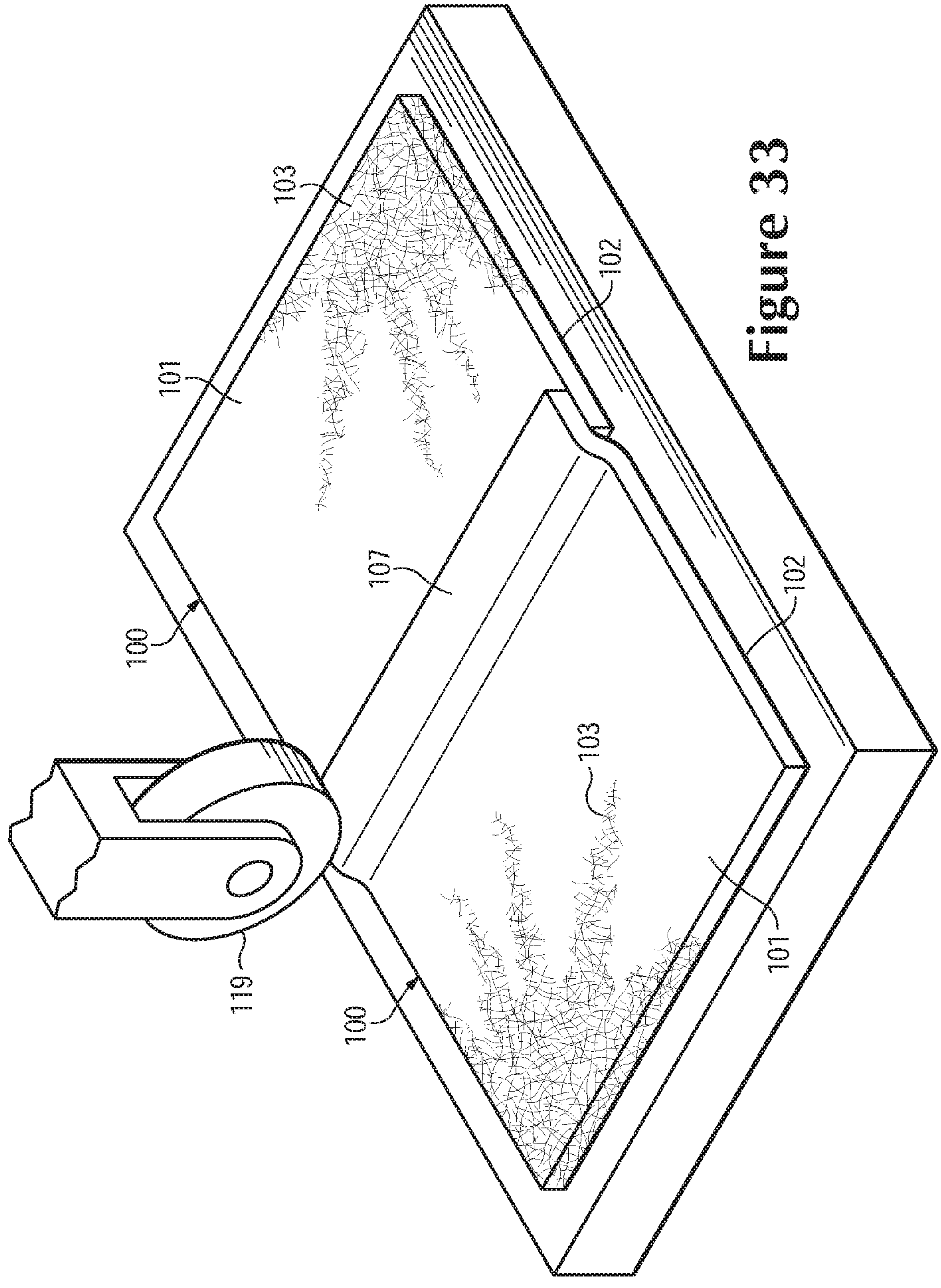

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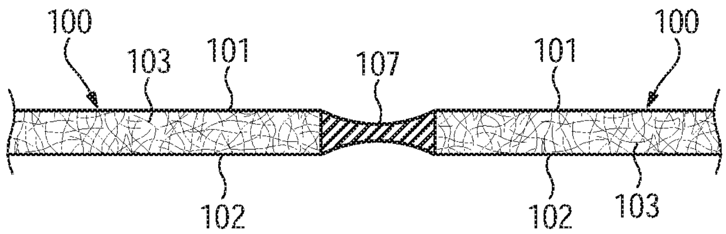

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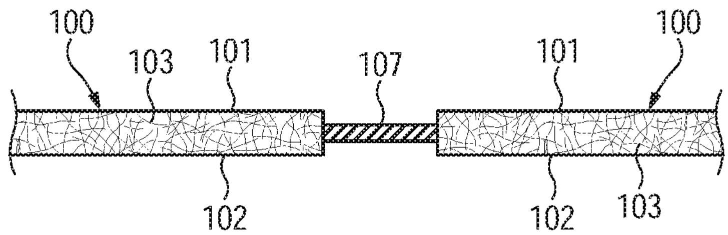

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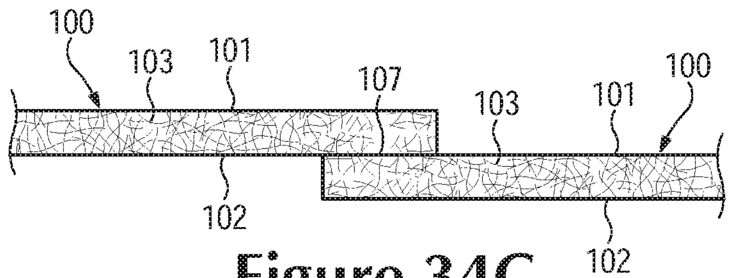

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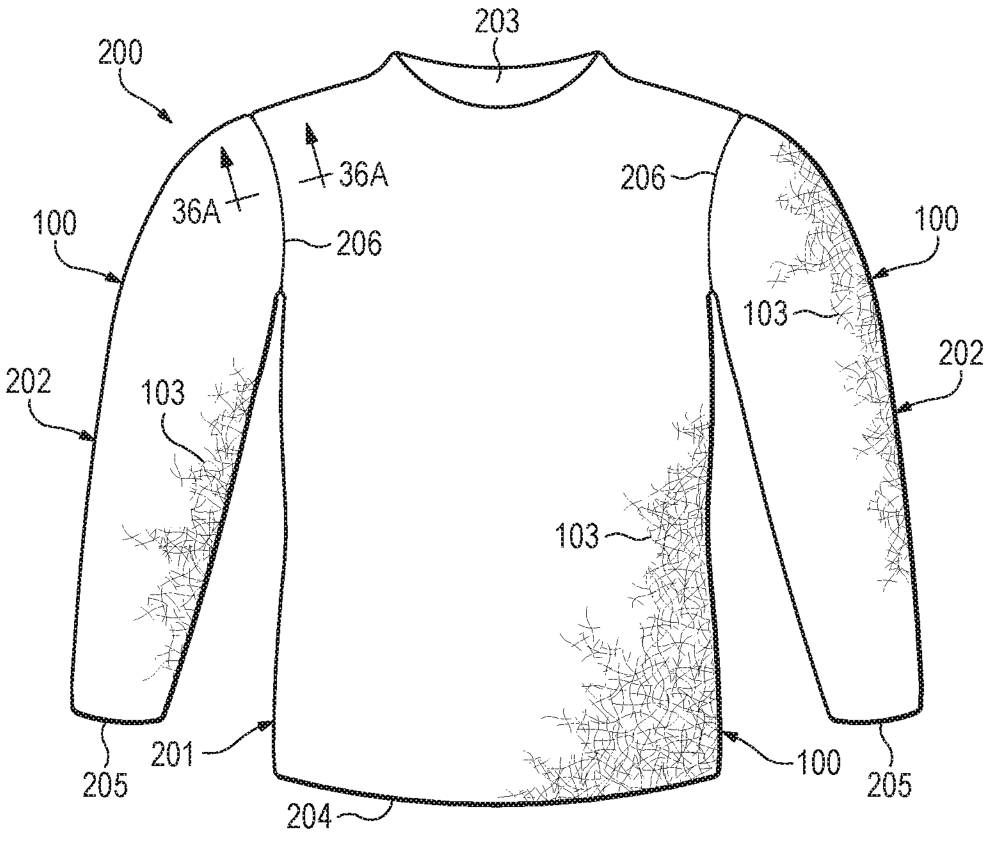
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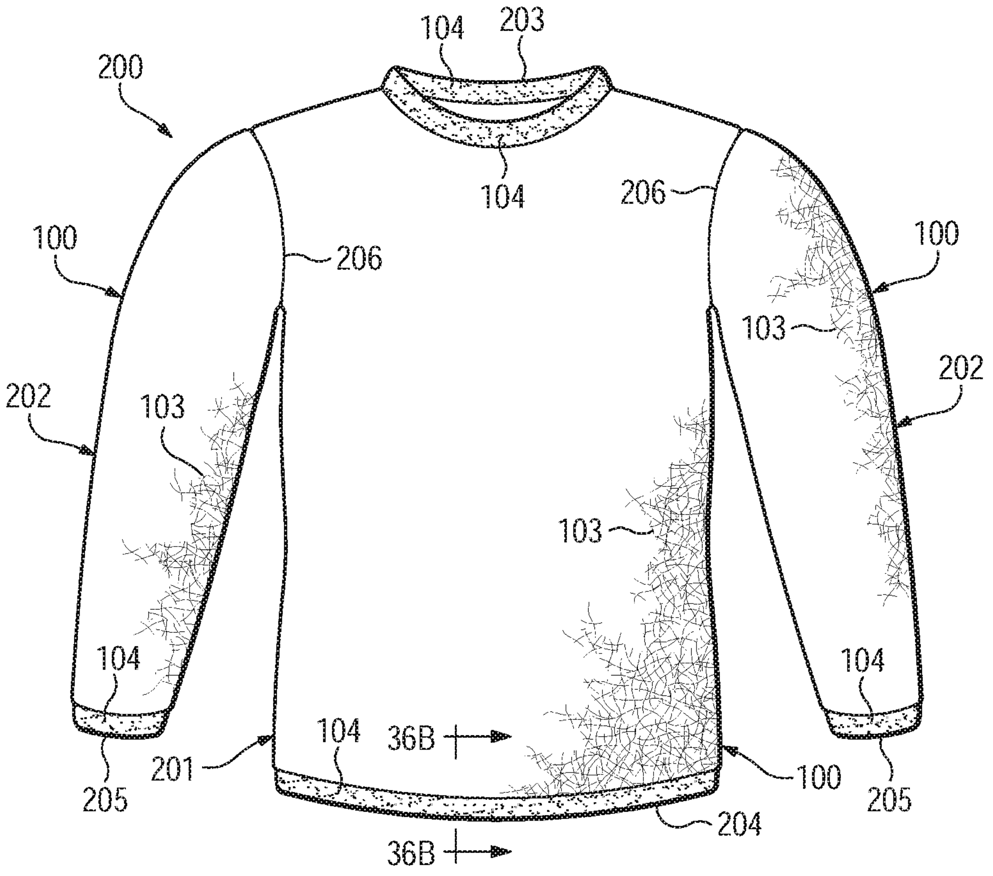
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Figure 35B

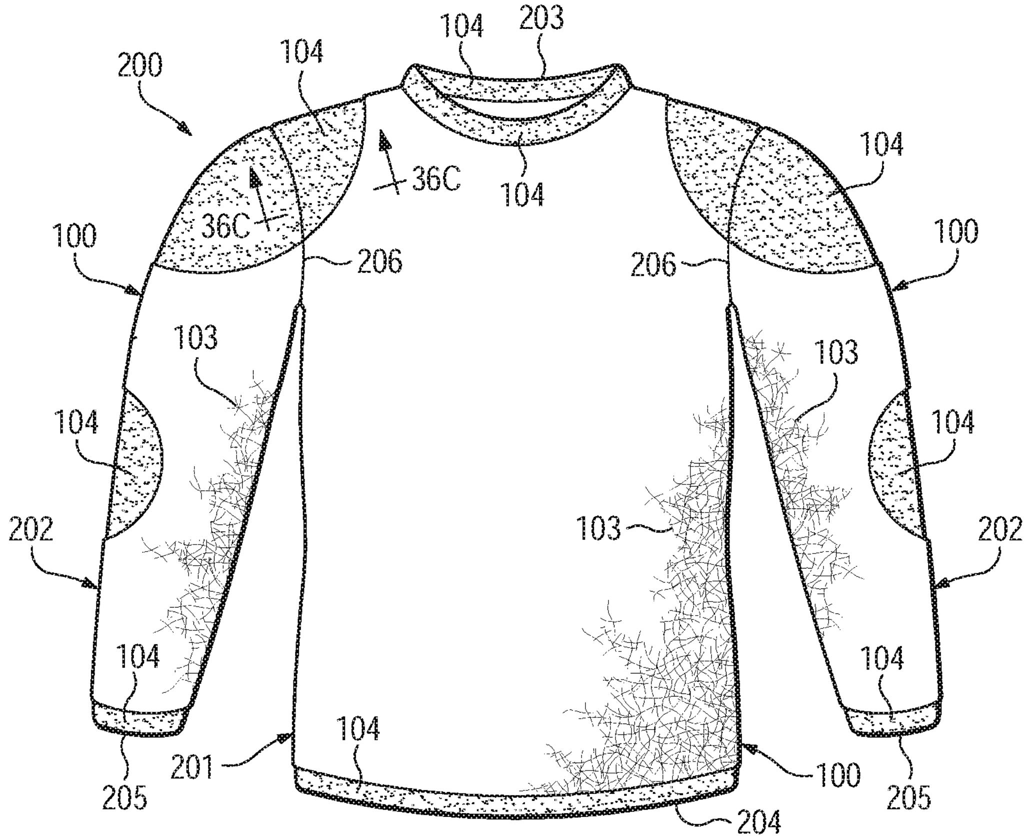
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Figure 35C

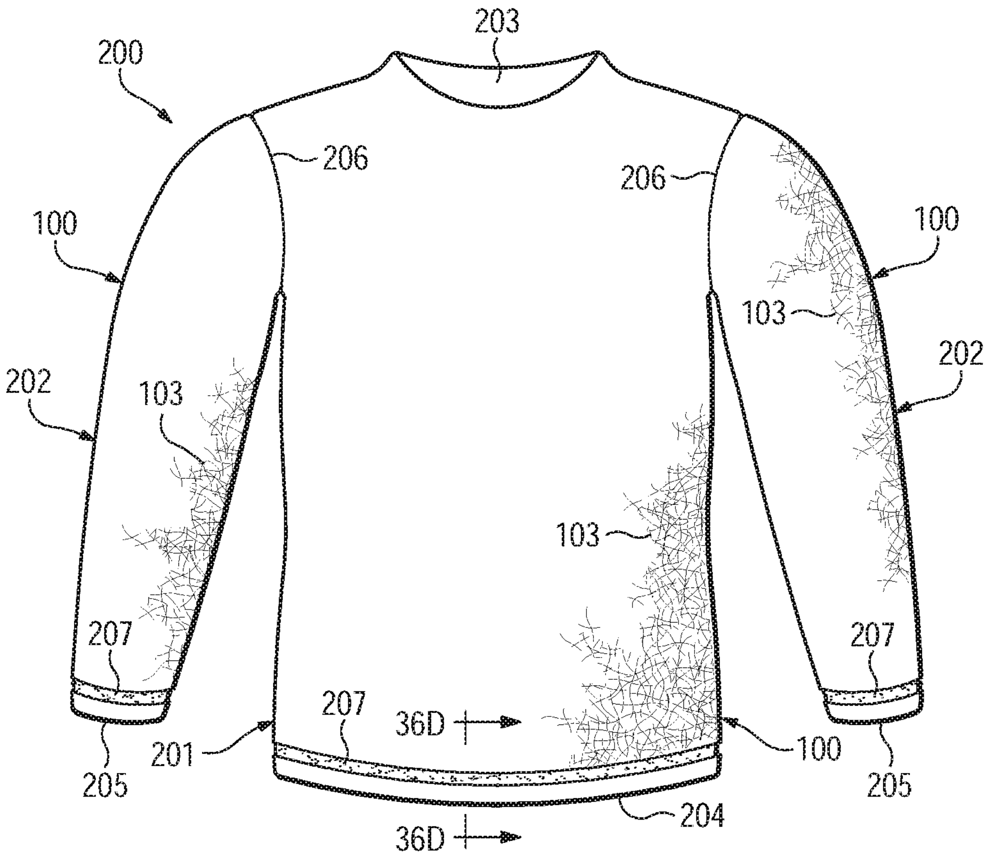
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Figure 35D

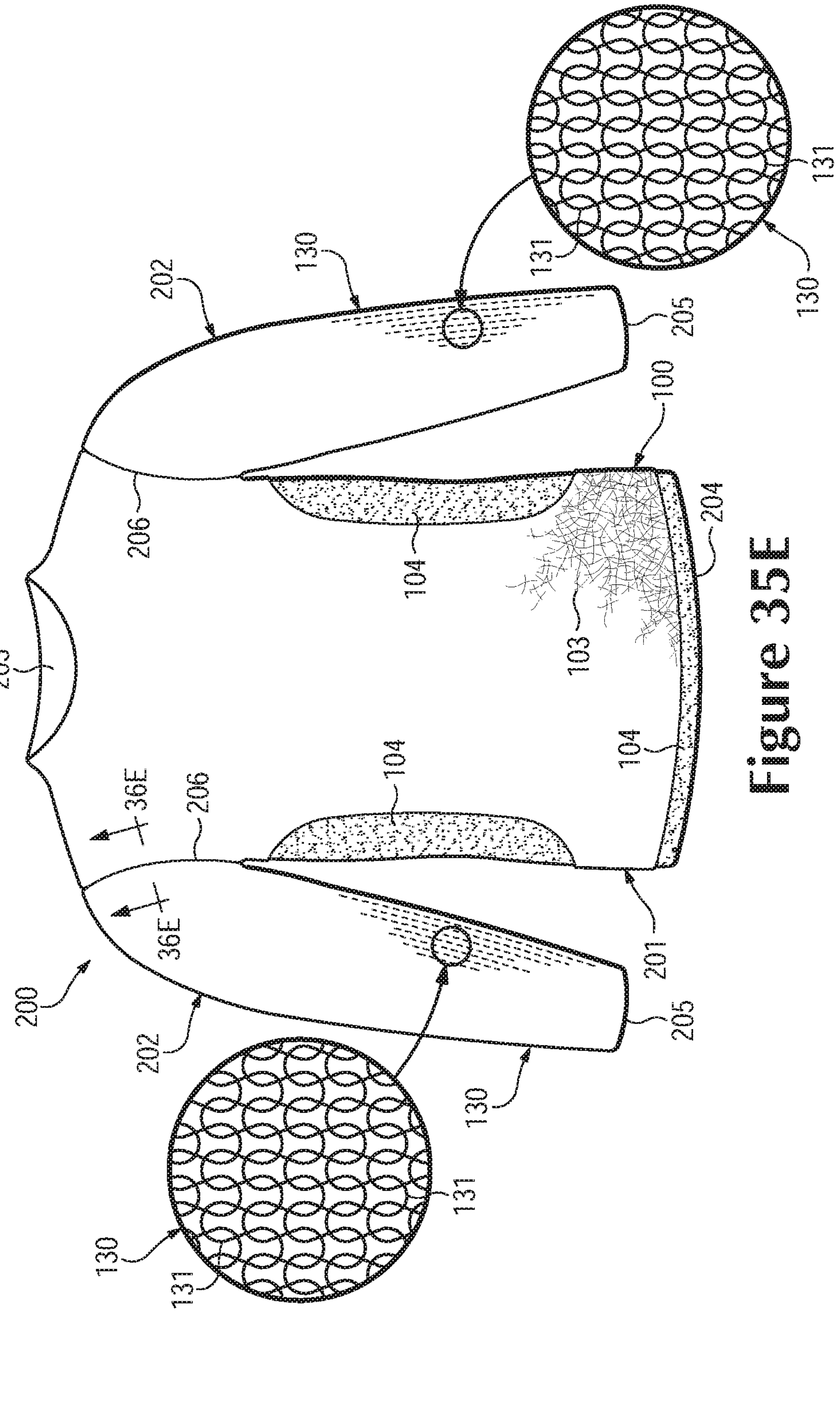
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Figure 35E

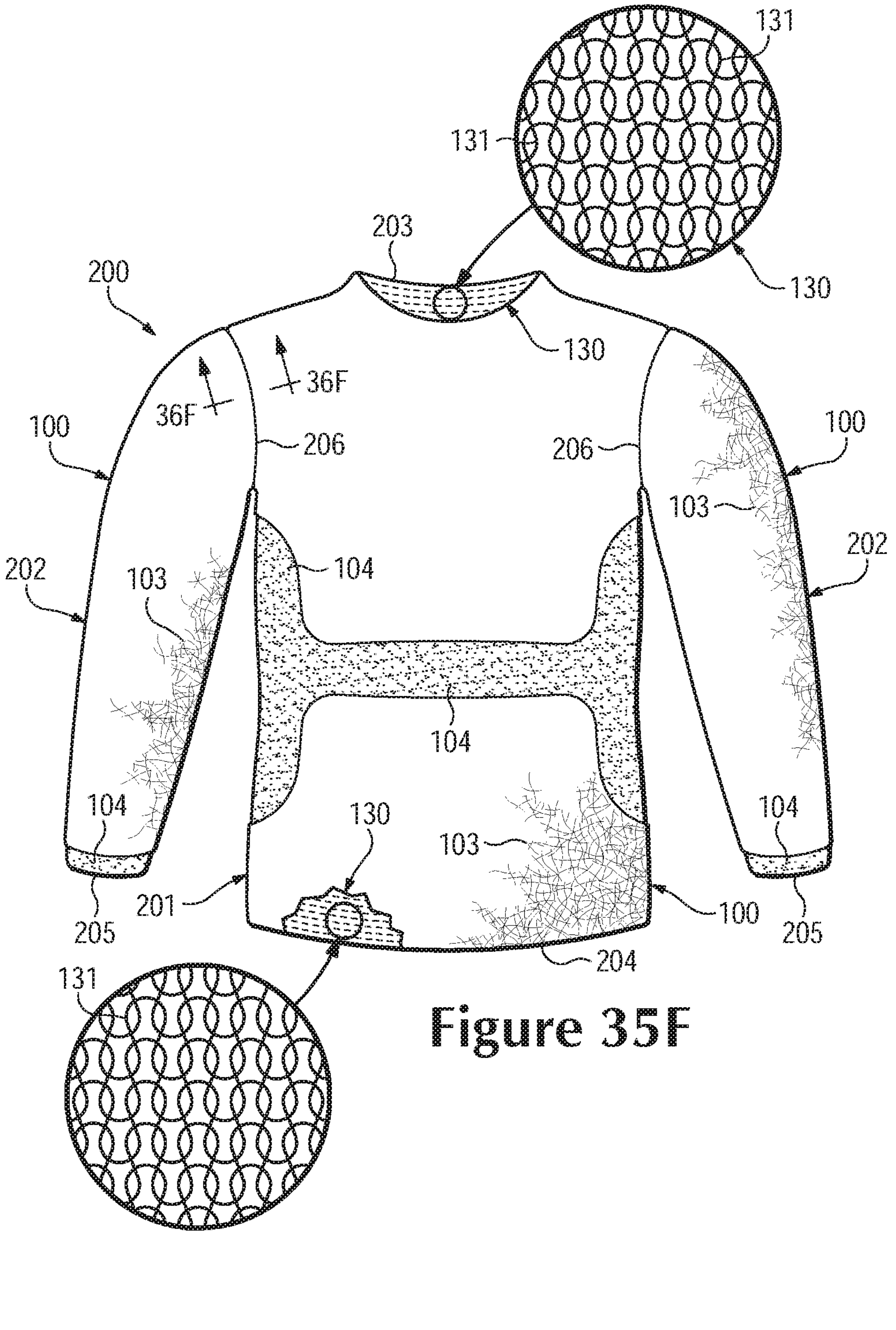
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Figure 35F

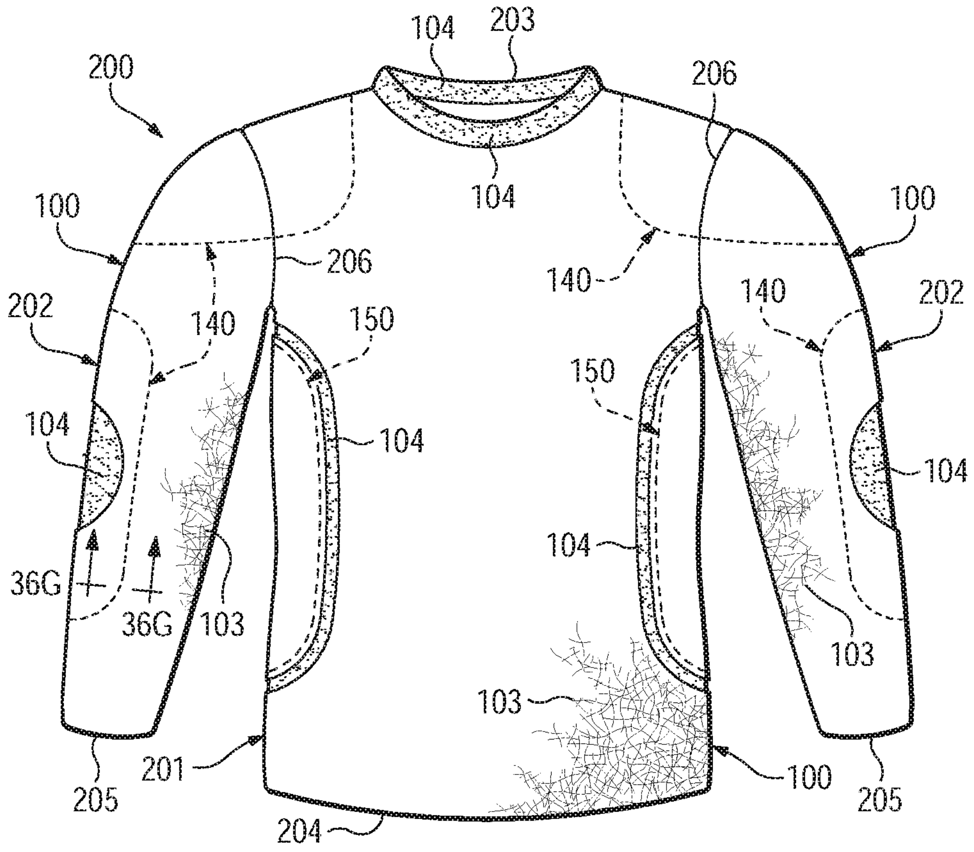

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Figure 35G

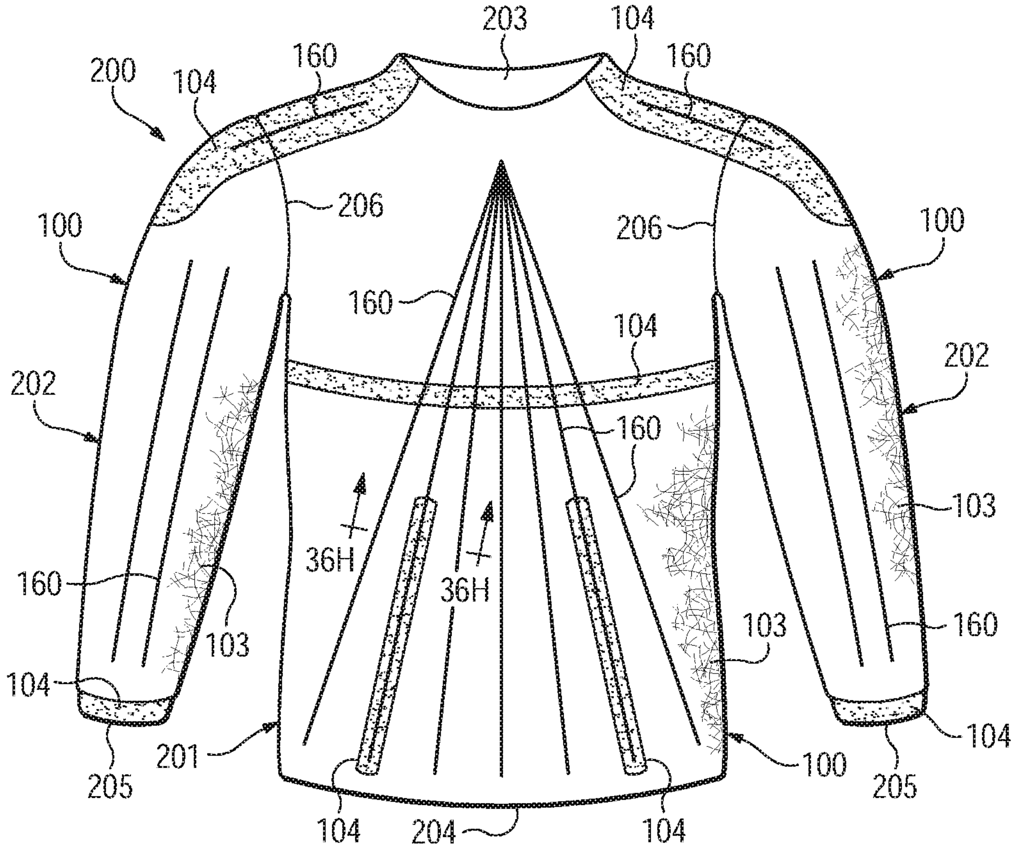
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Figure 35H

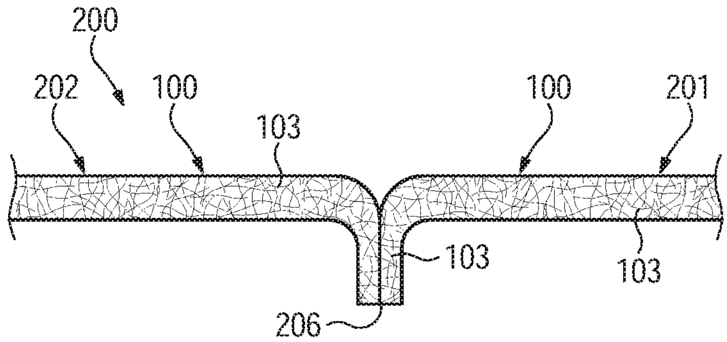

Figure 36A

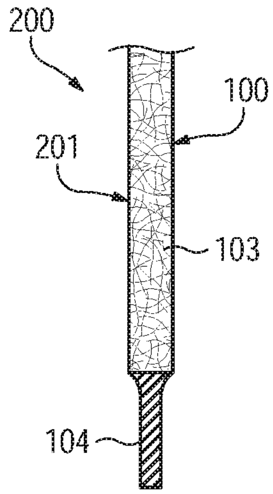

Figure 36B

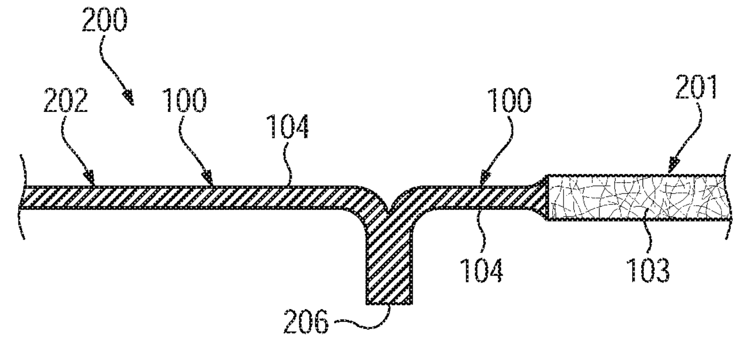

Figure 36C

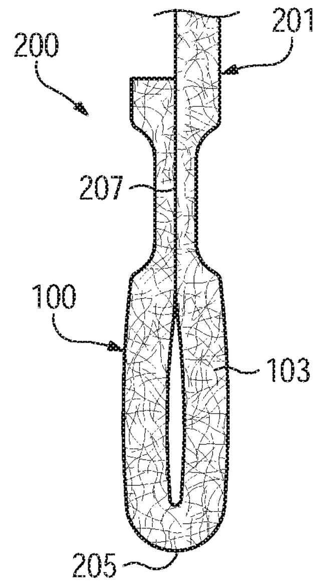

Figure 36D

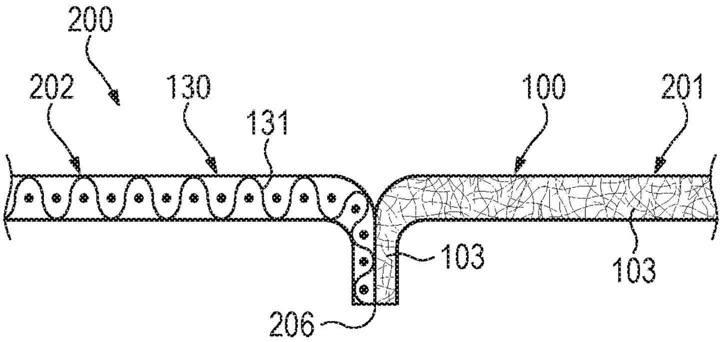

Figure 36E

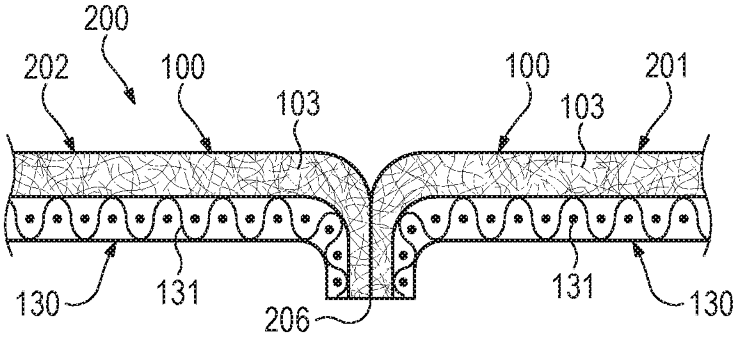

Figure 36F

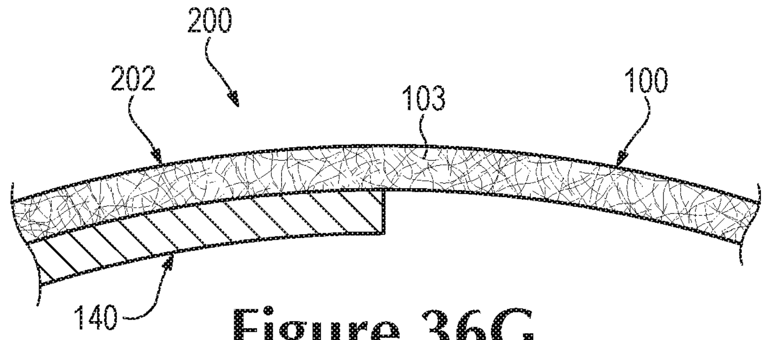

Figure 36G

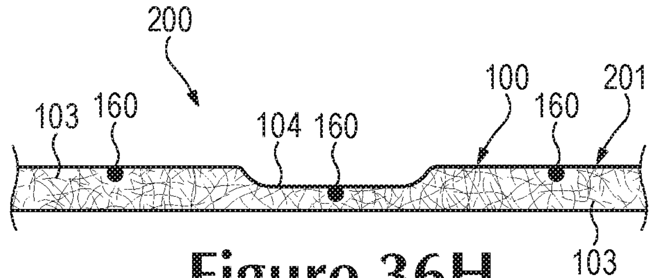

Figure 36H

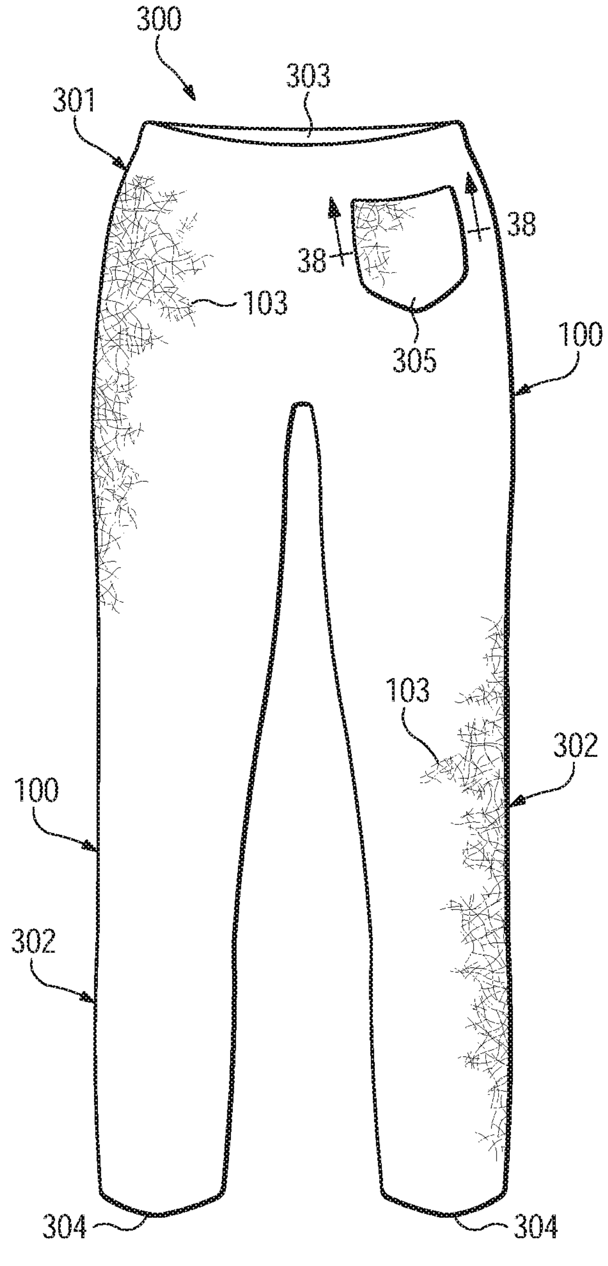

Figure 37A

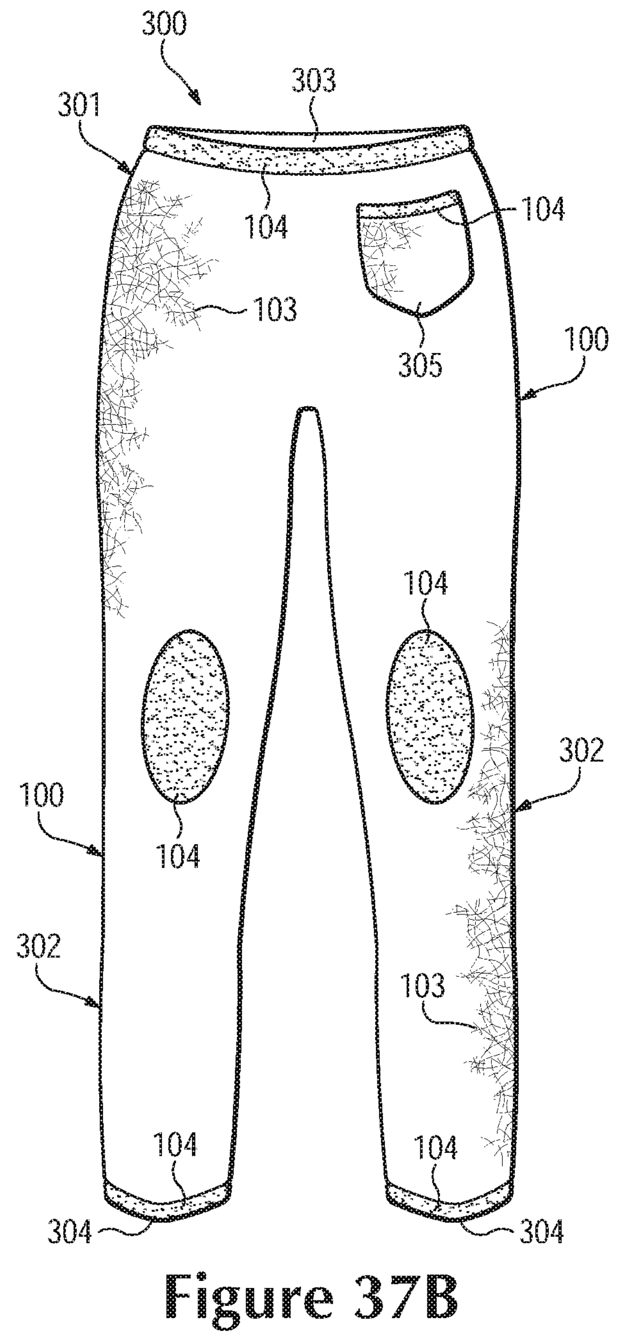
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Figure 37B

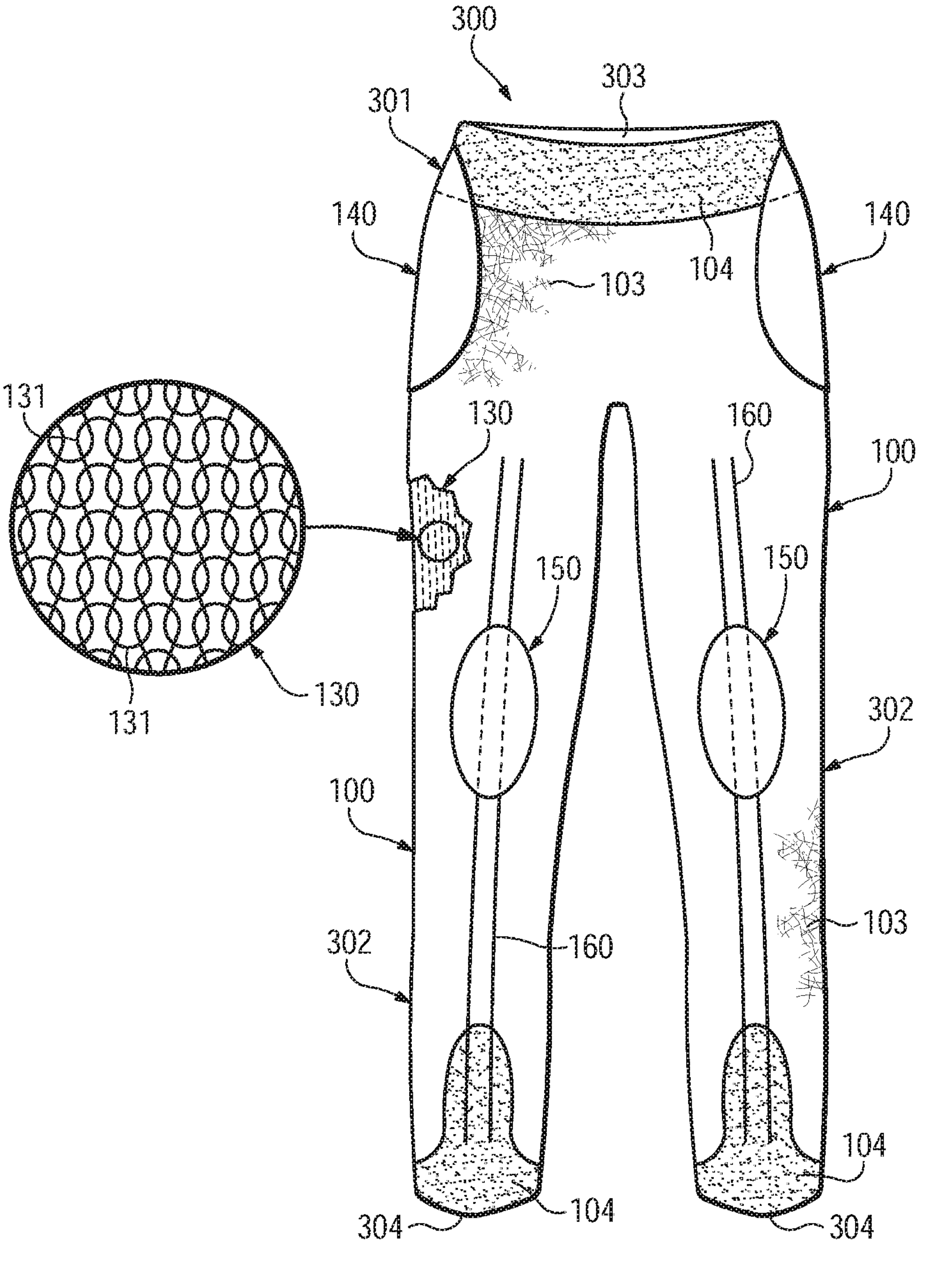
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Figure 37C

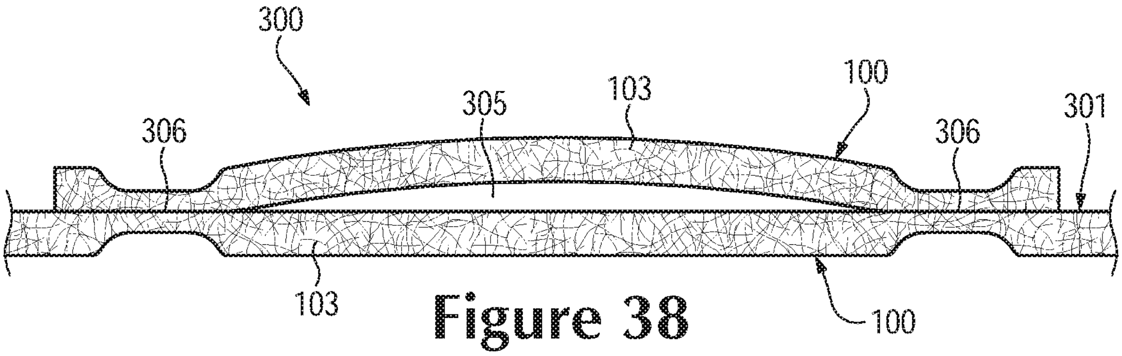

Figure 38

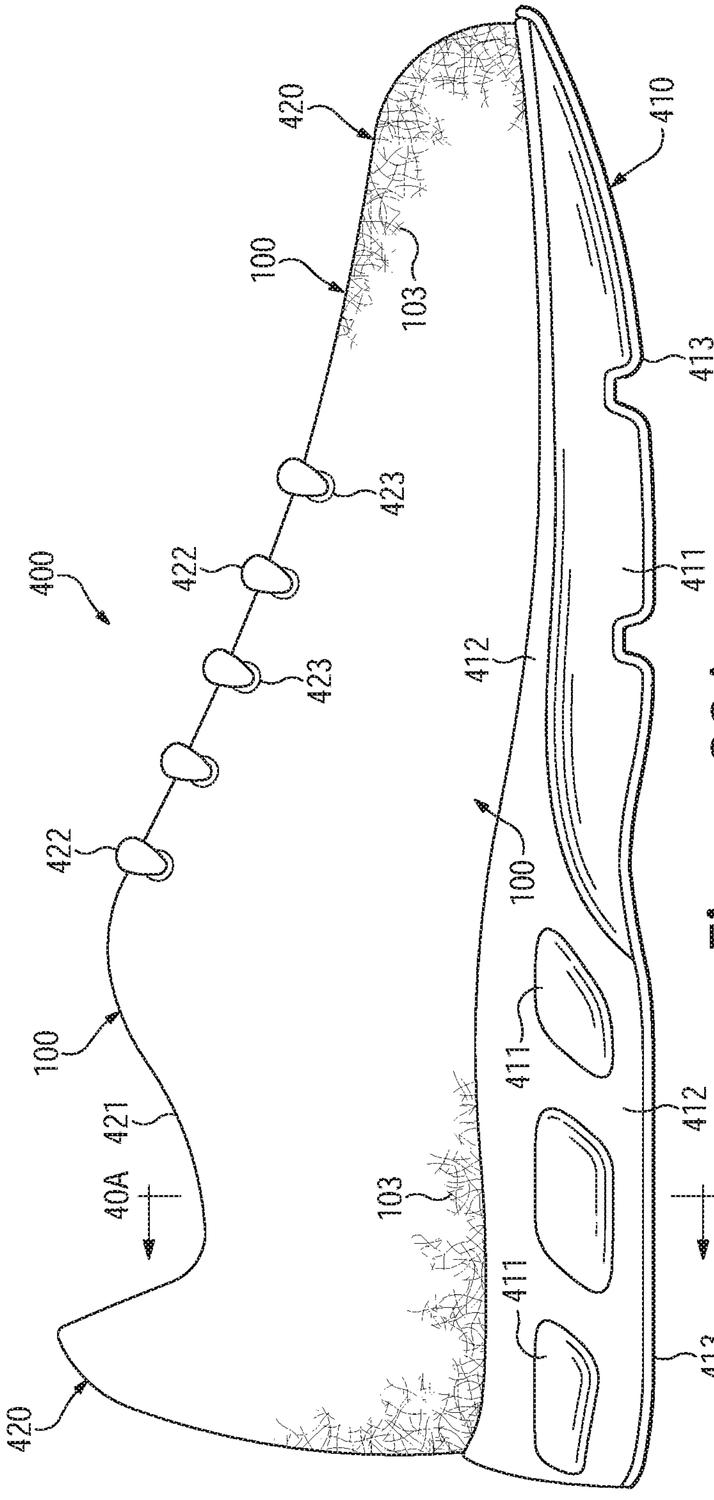
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Figure 39A

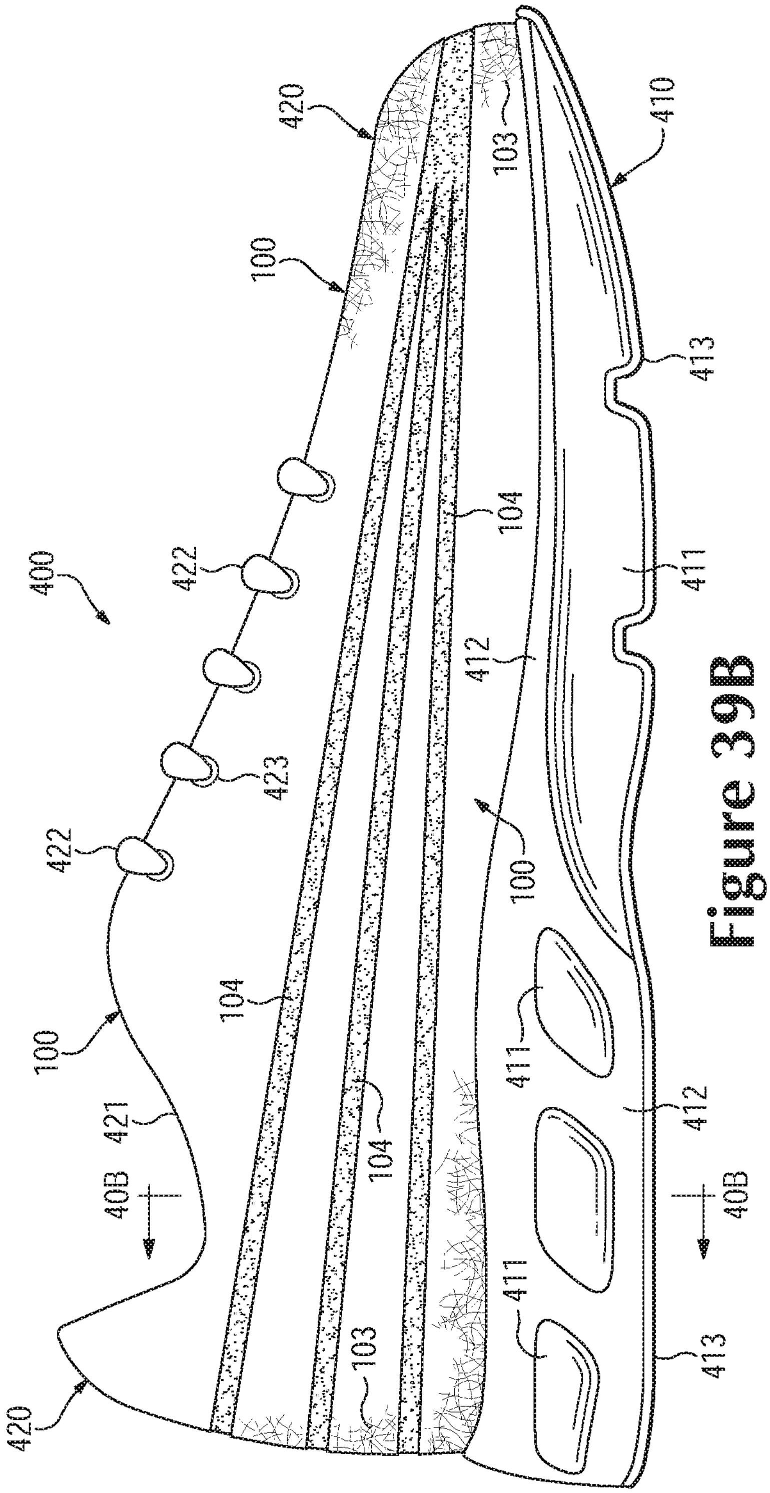
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Figure 39B

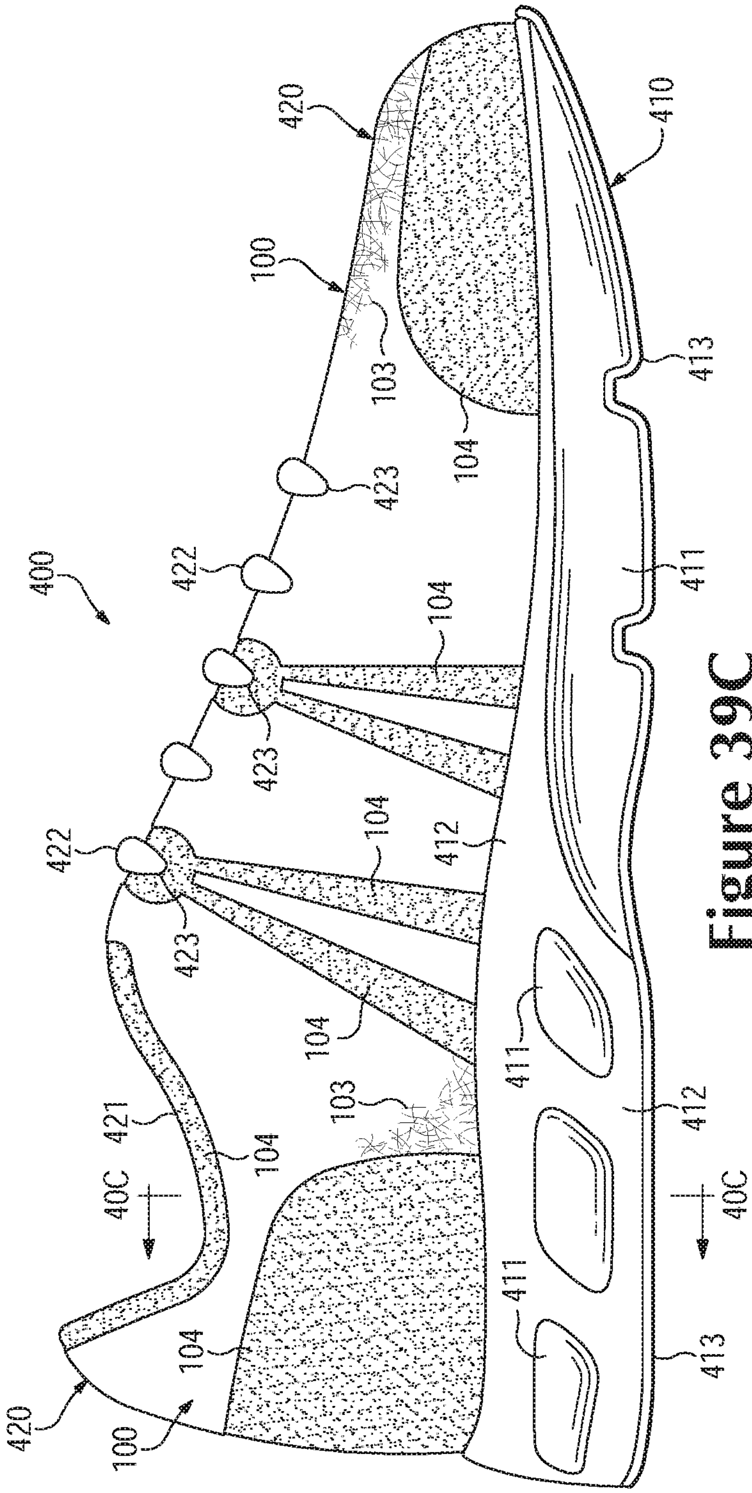
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Figure 39C

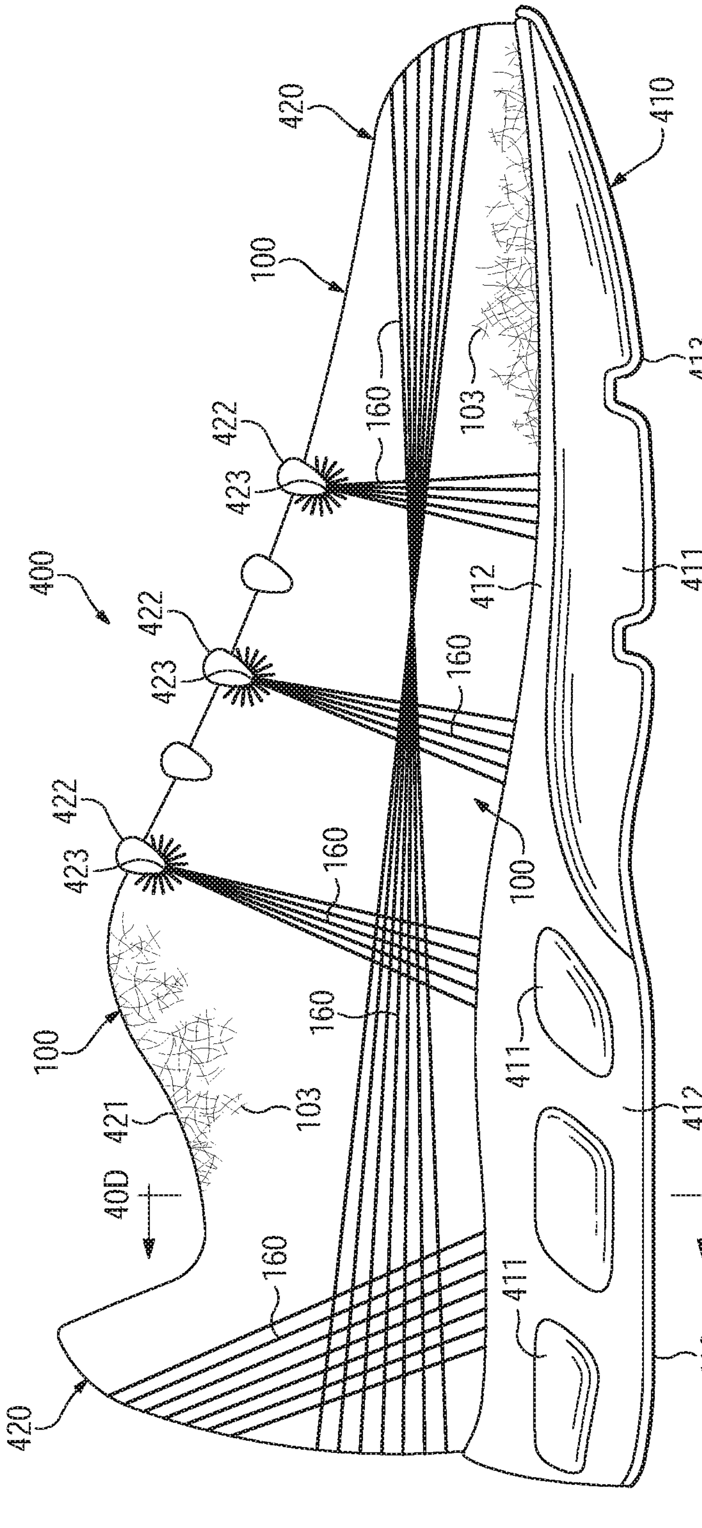

Figure 39D

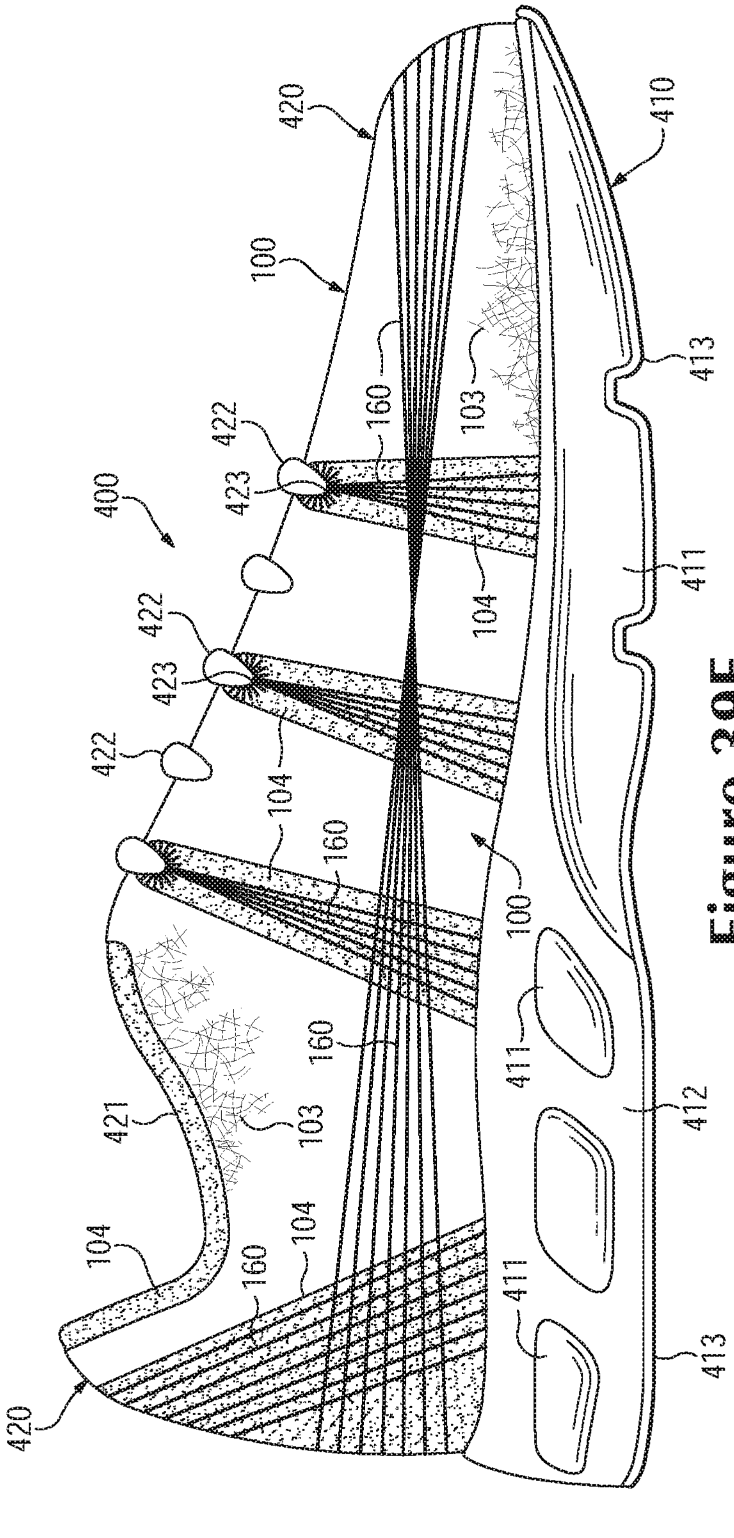

Figure 39E

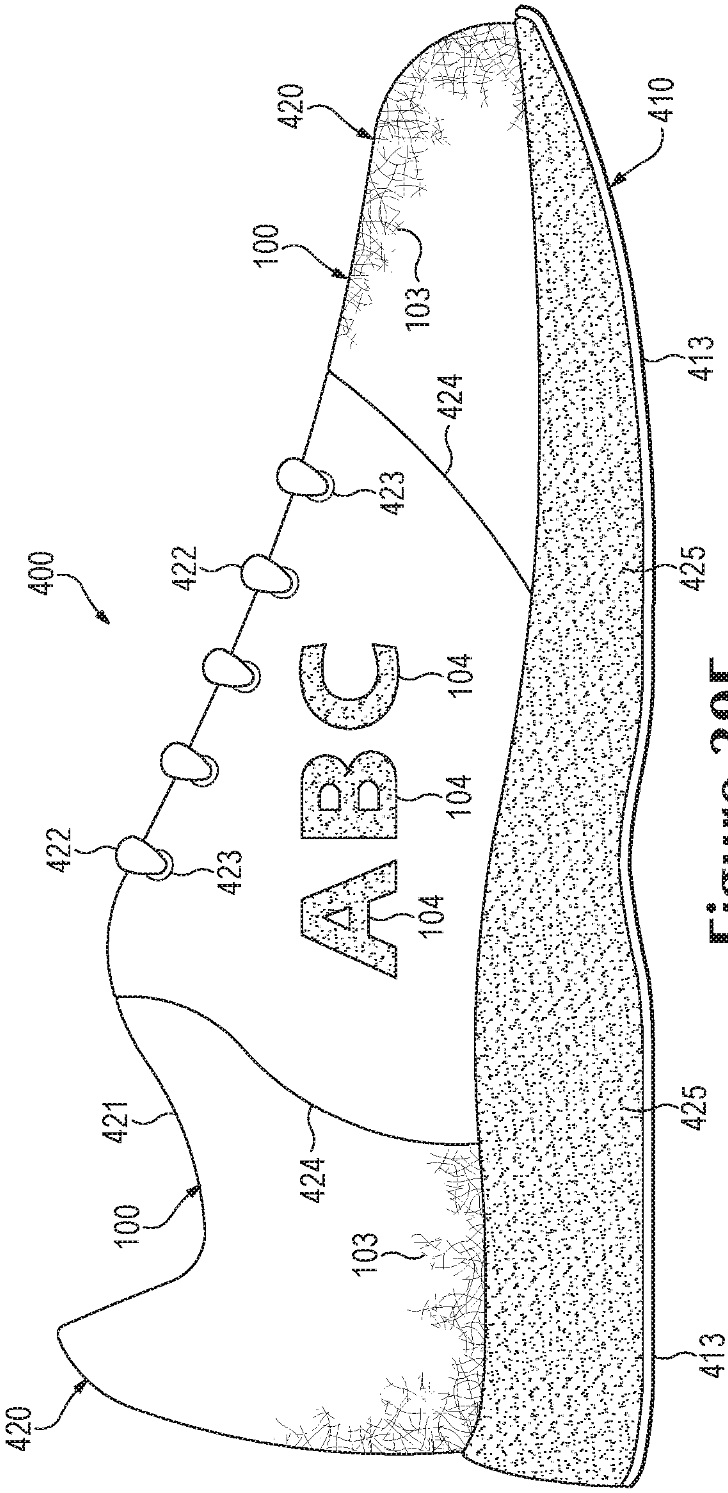

Figure 39F

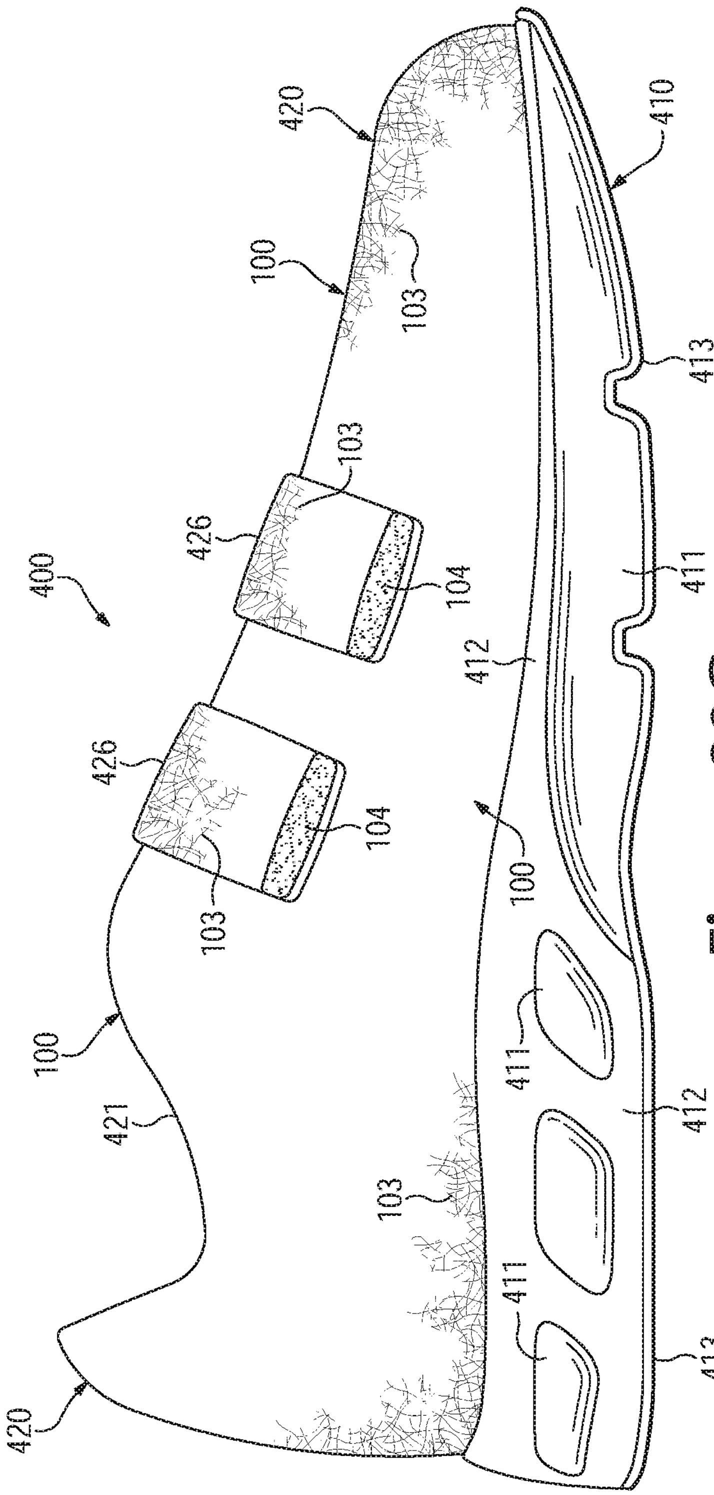

Figure 39G

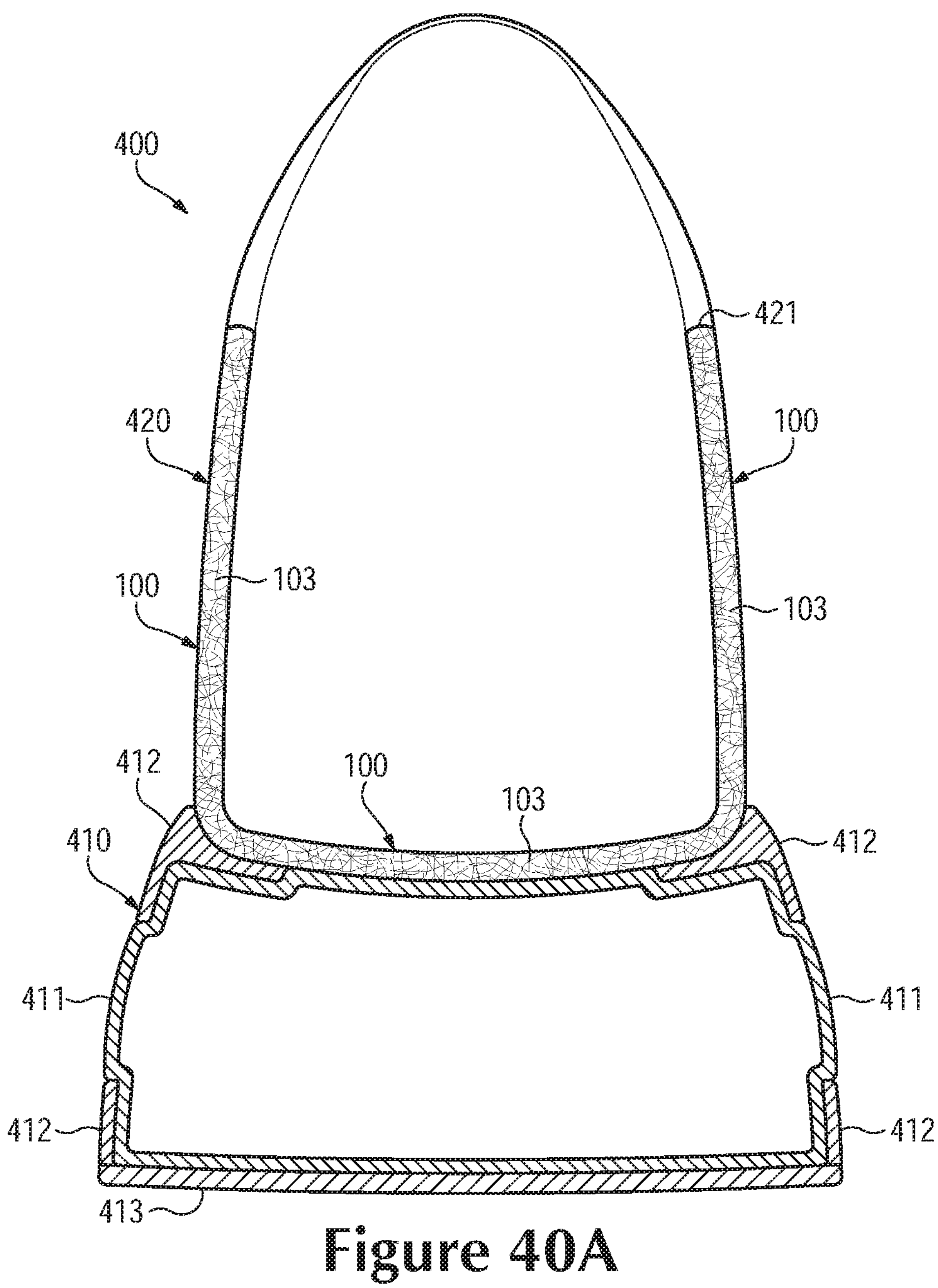

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Figure 40A

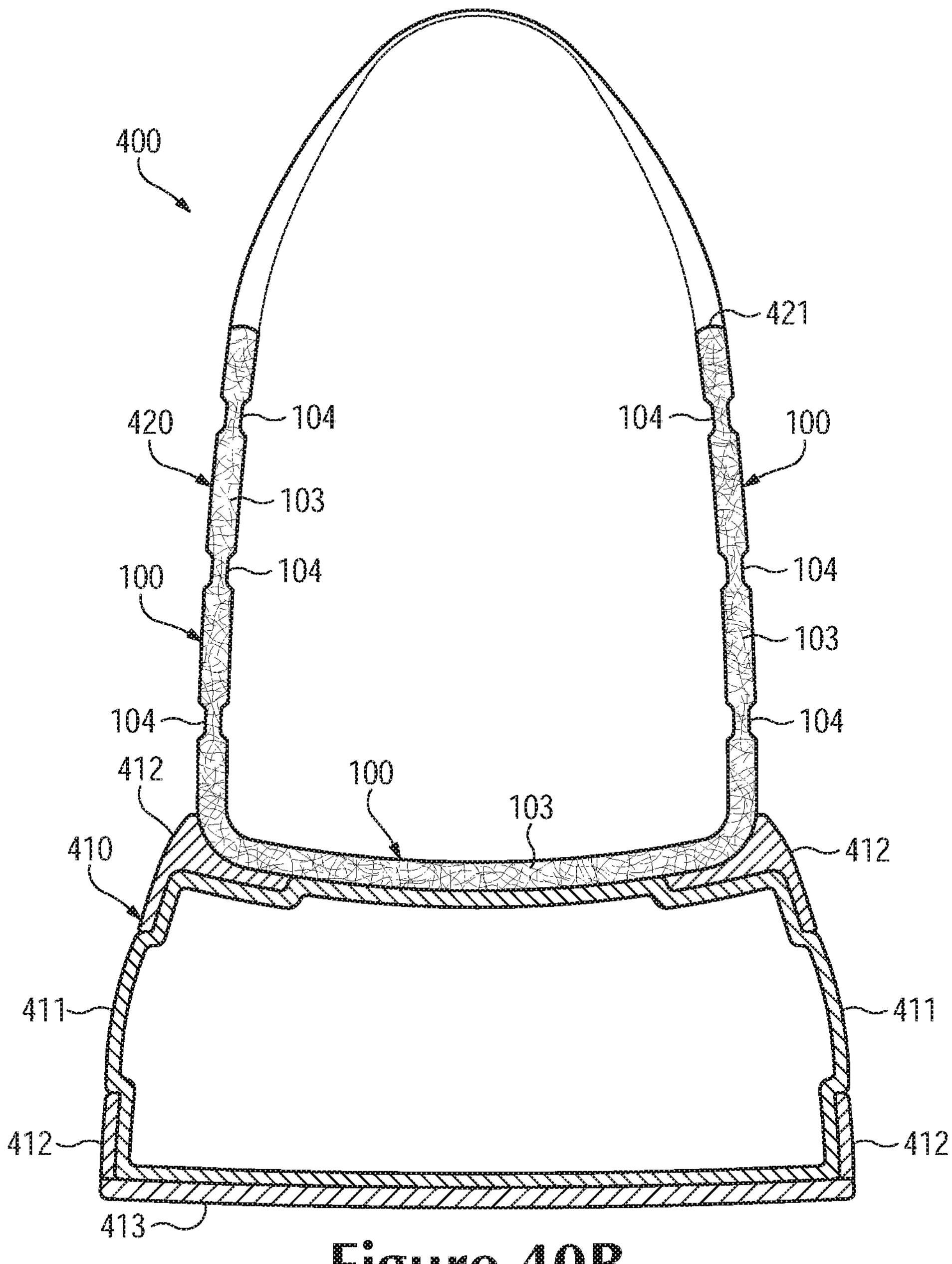
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Figure 40B

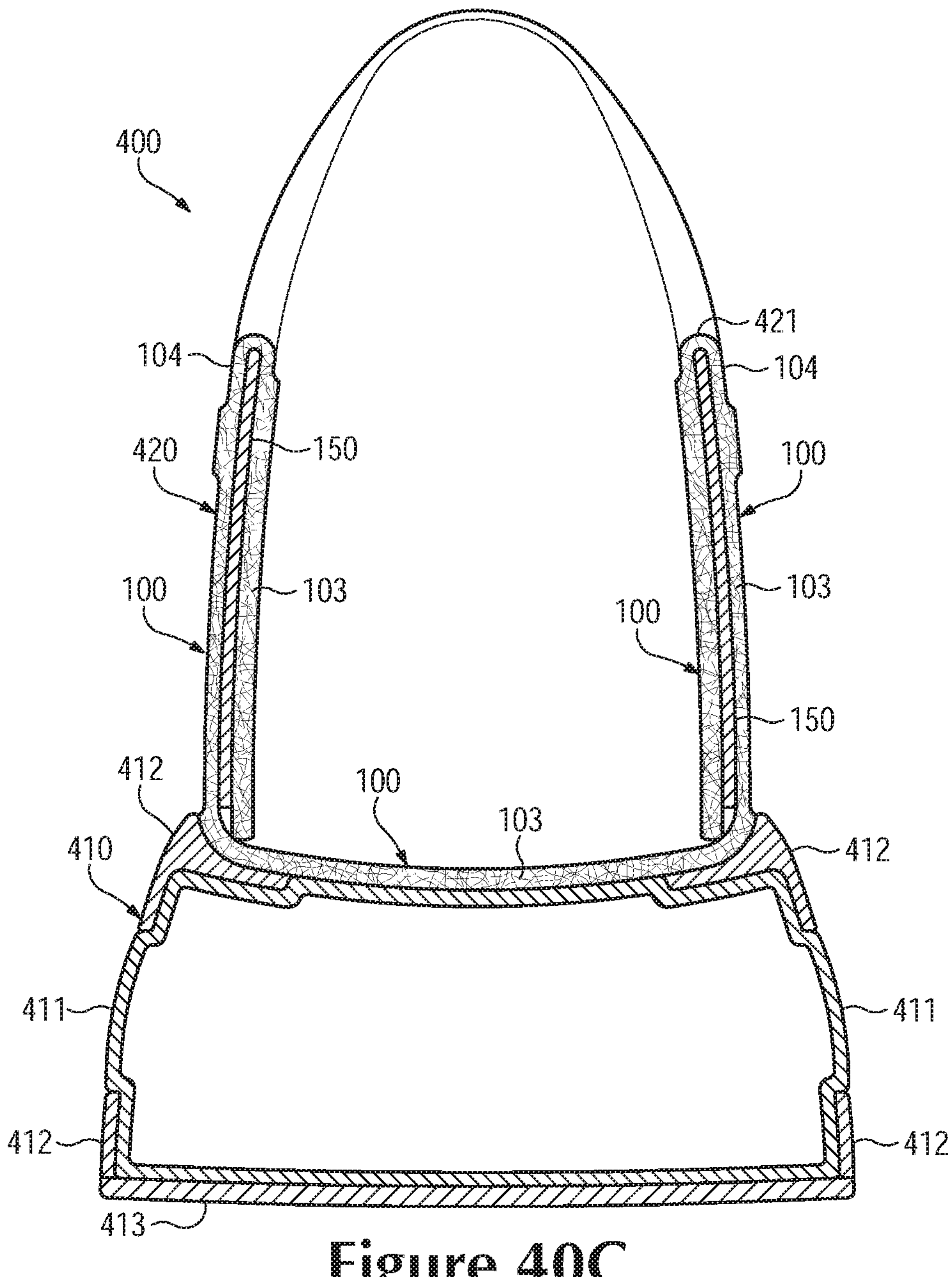
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Figure 40C

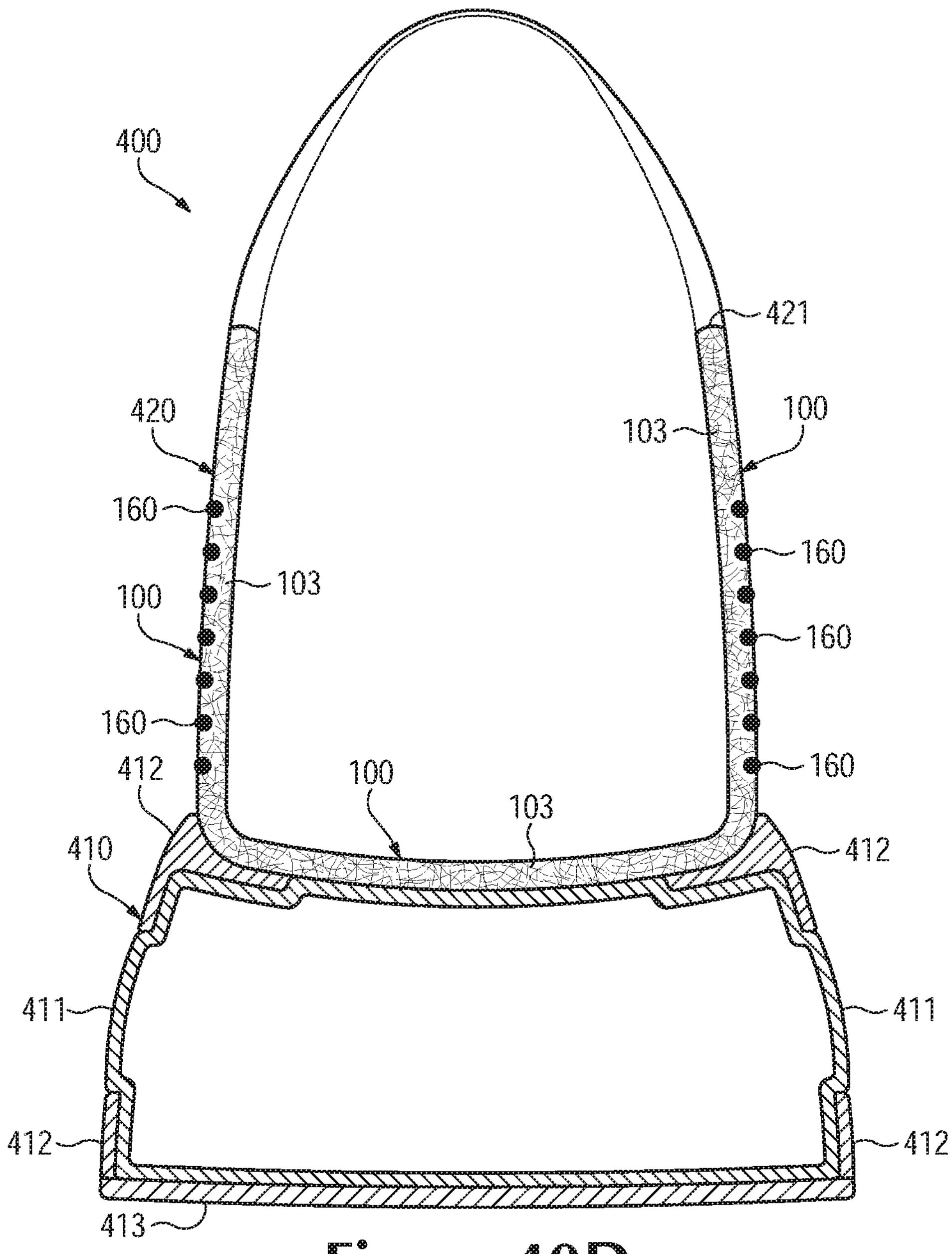
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Figure 40D

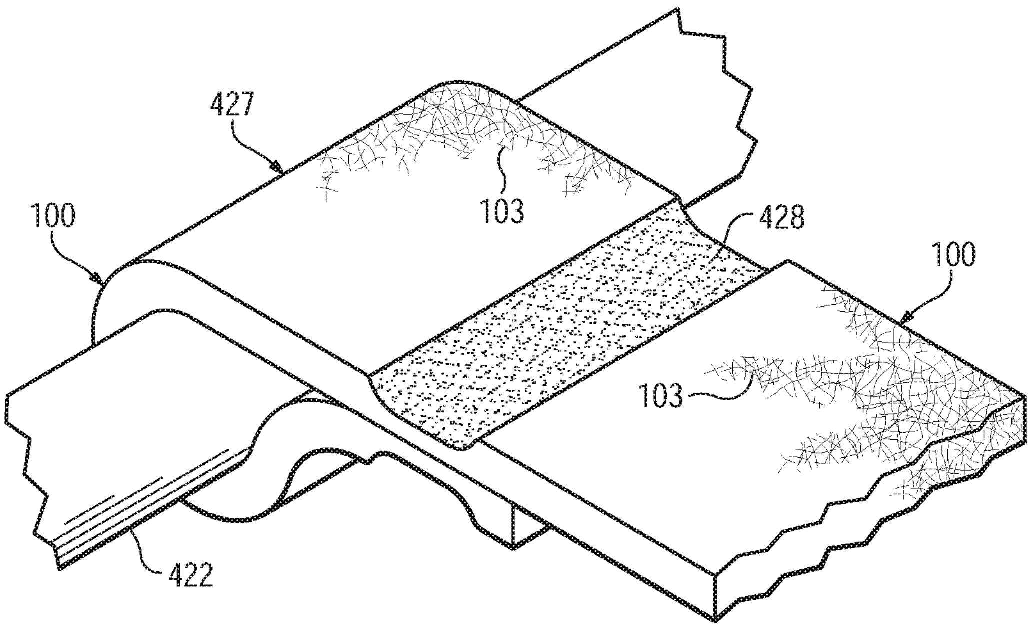


Figure 41

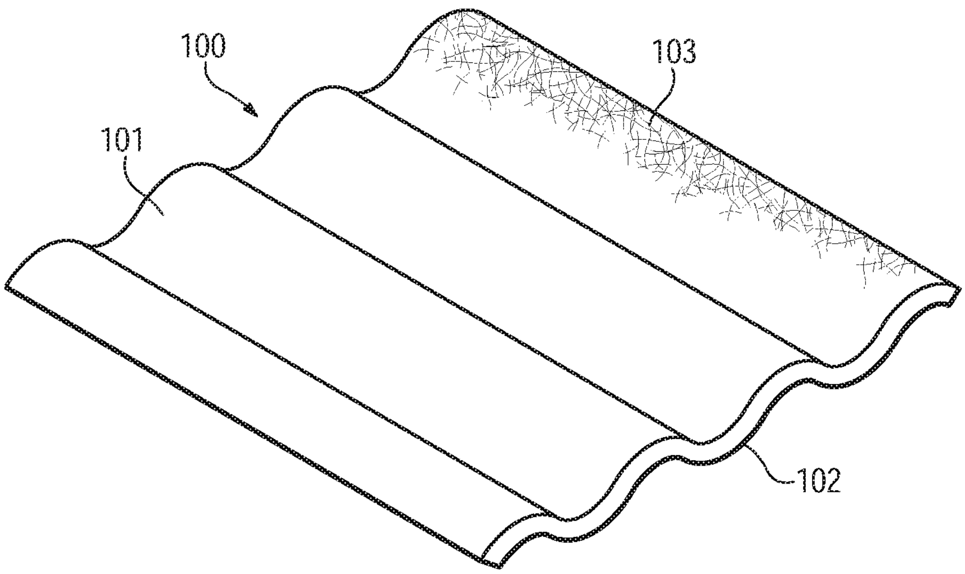


Figure 42A

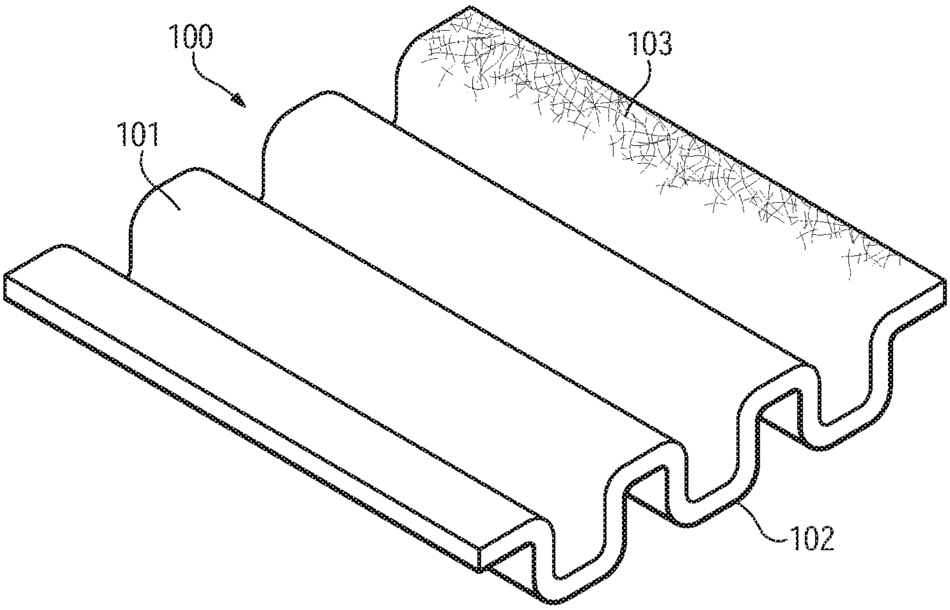


Figure 42B

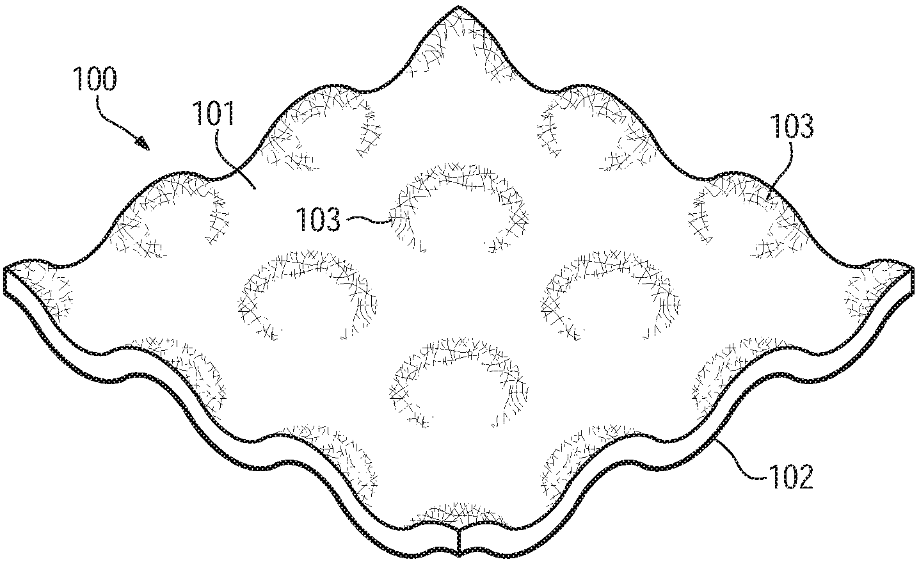


Figure 42C

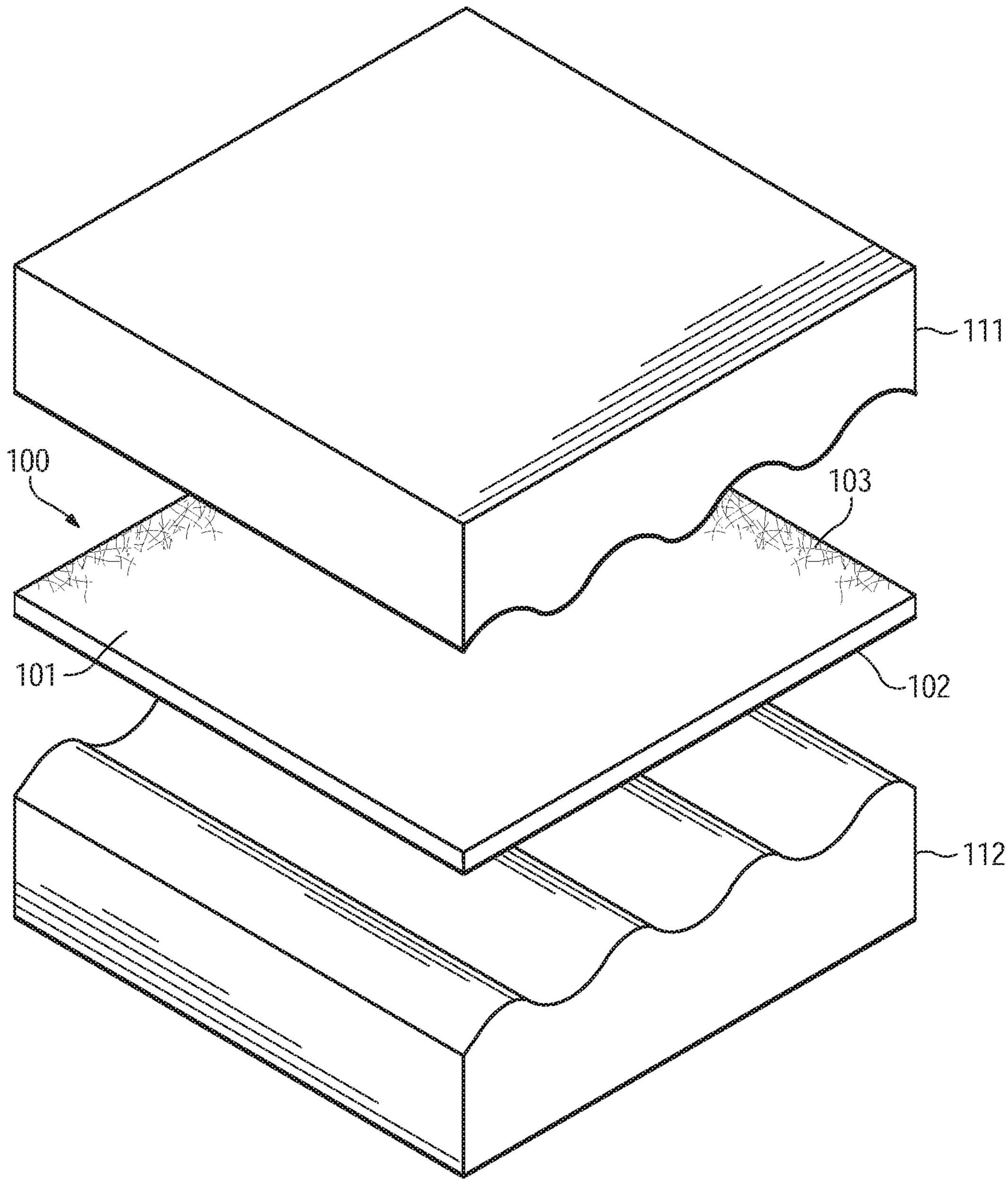


Figure 43A

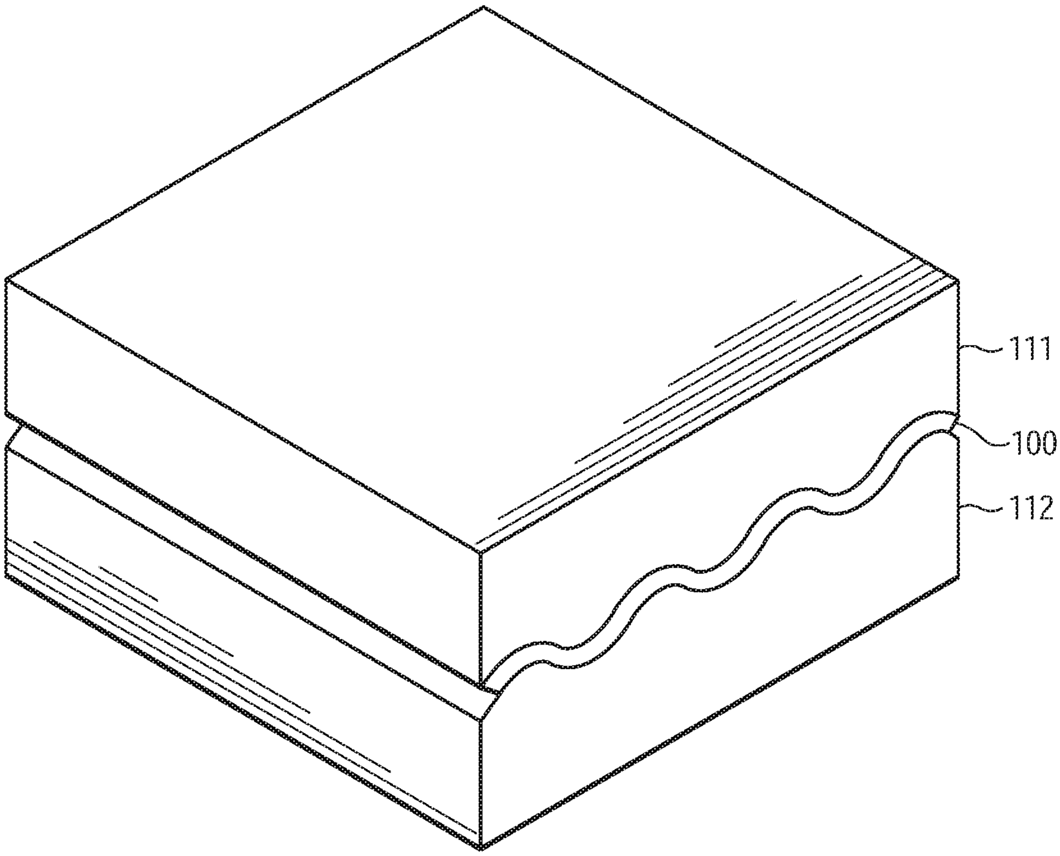


Figure 43B

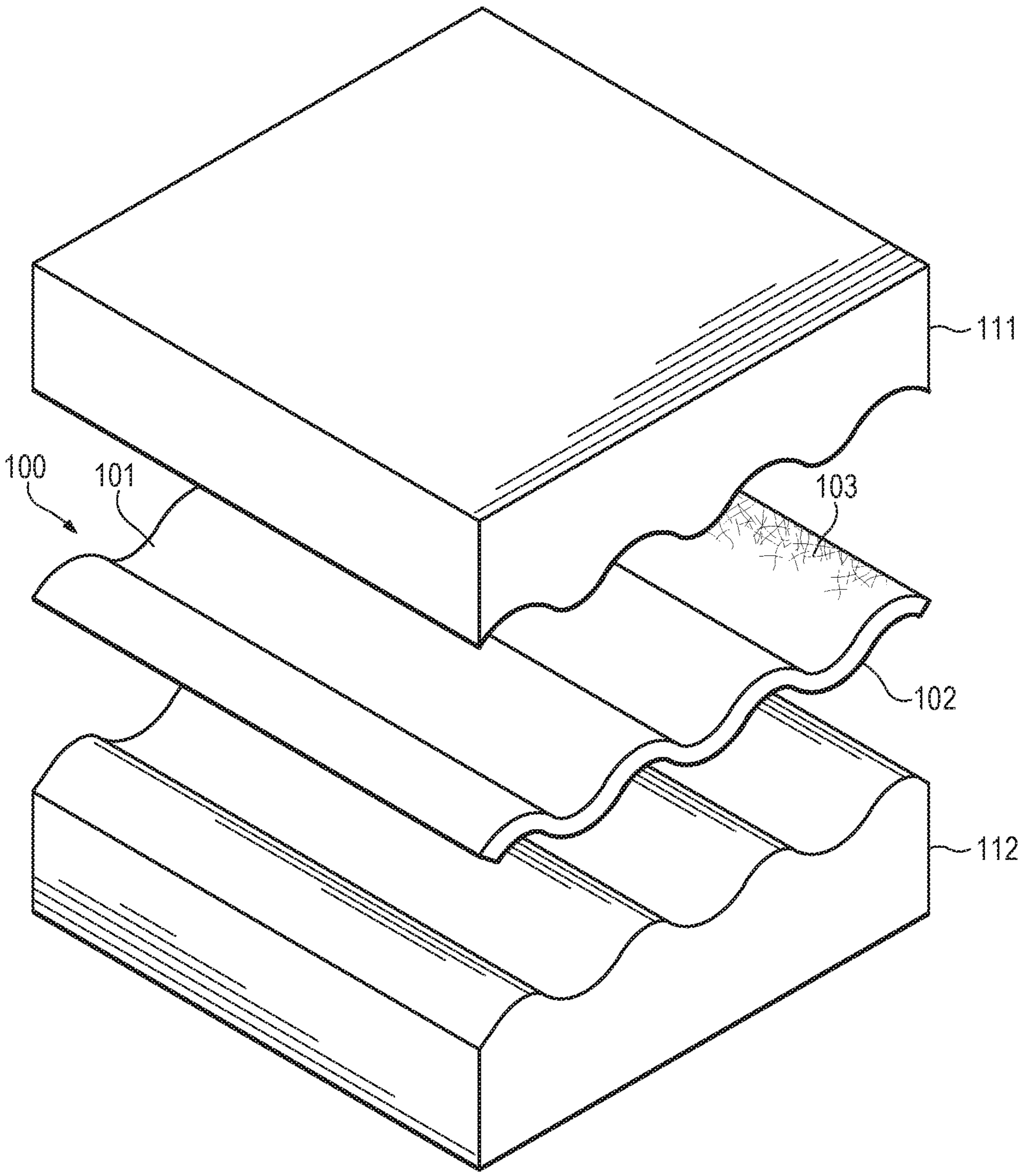


Figure 43C

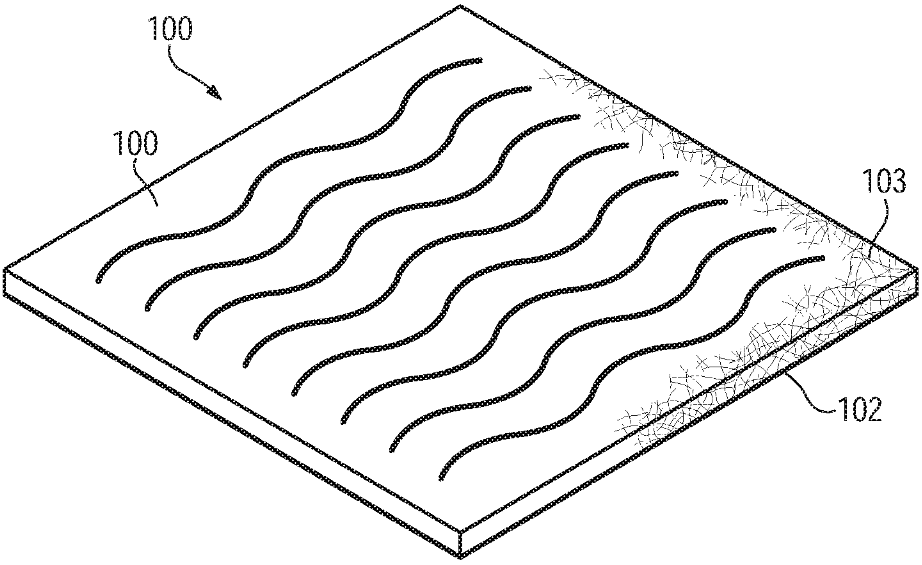


Figure 44A

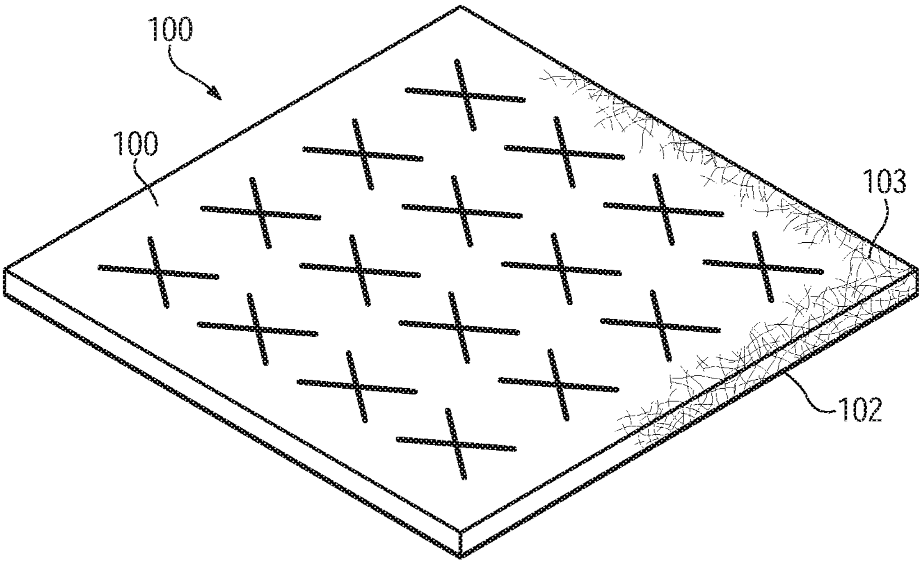


Figure 44B

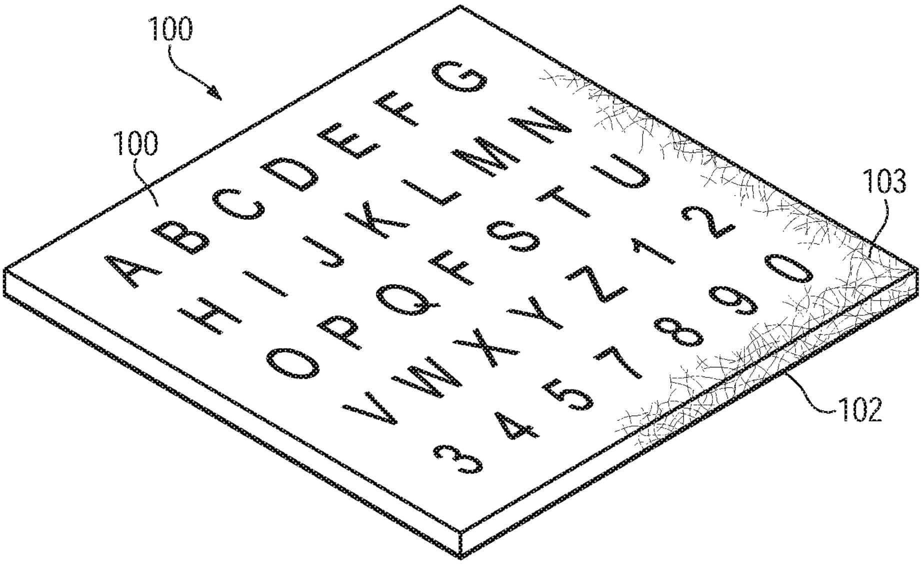


Figure 44C

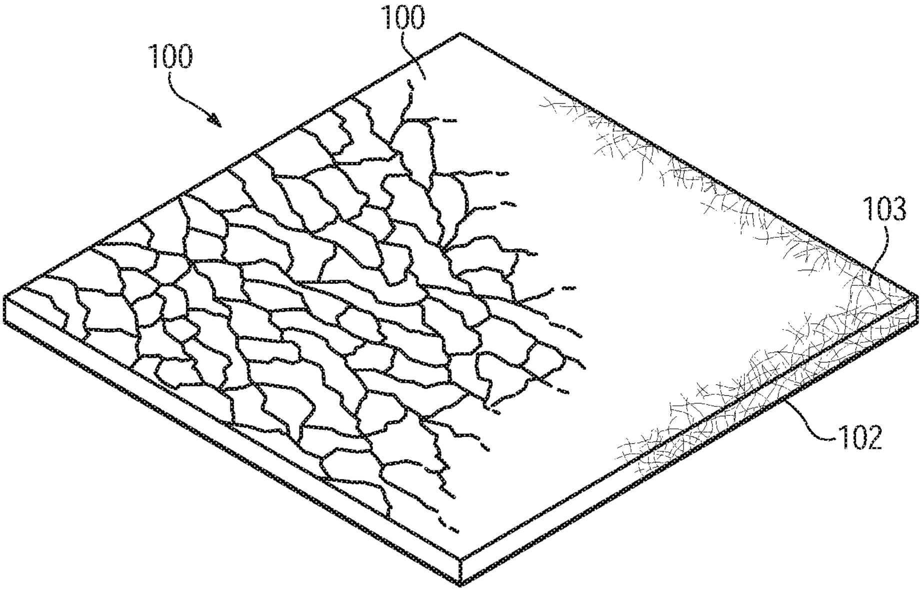


Figure 44D

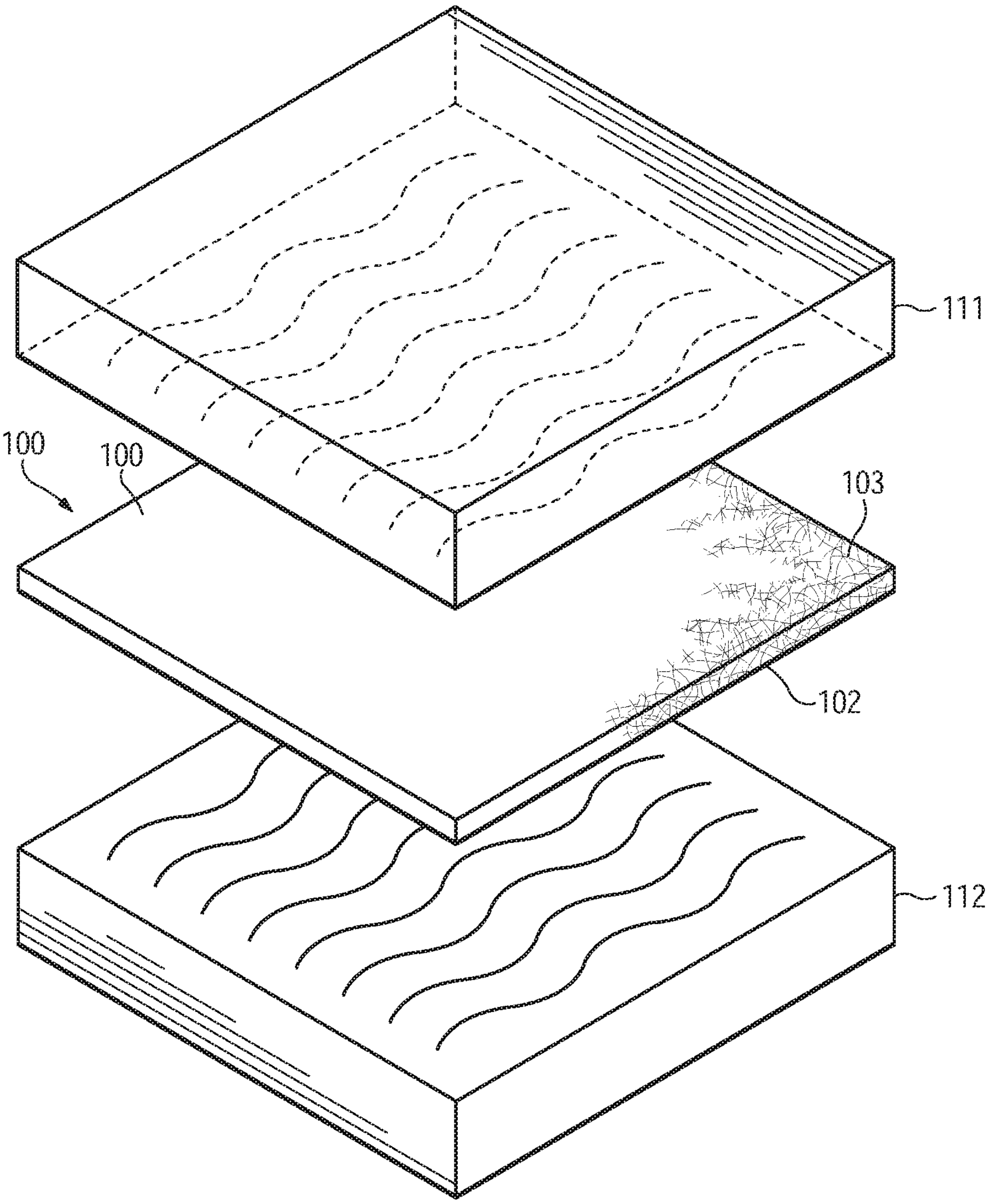


Figure 45A

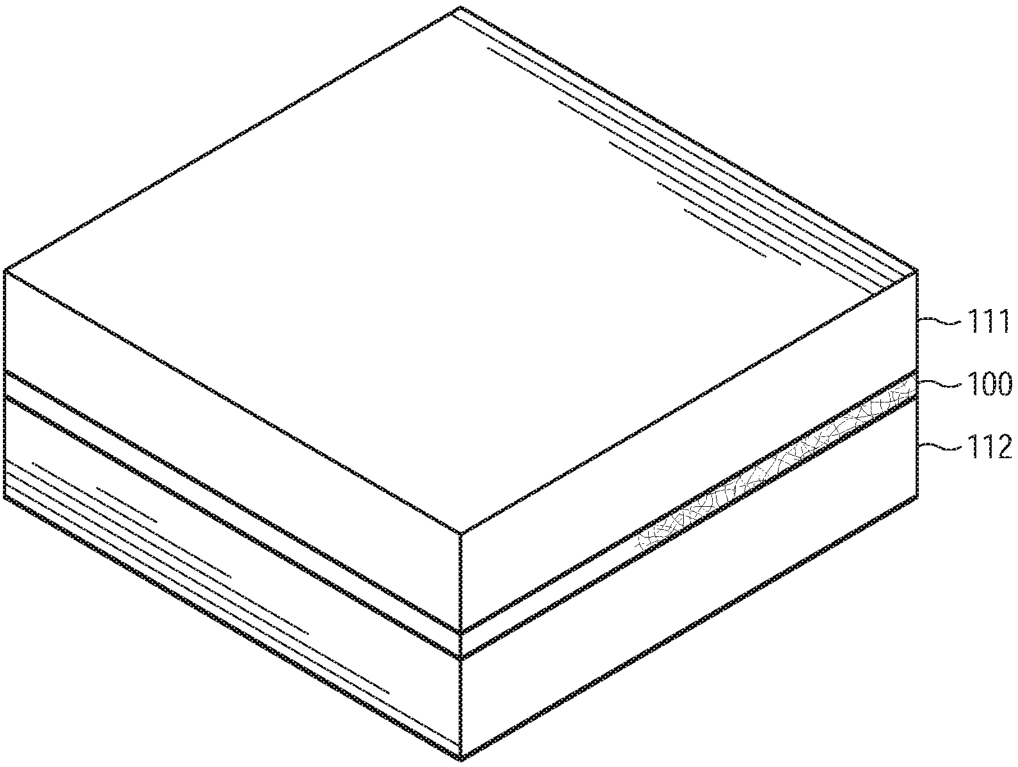


Figure 45B

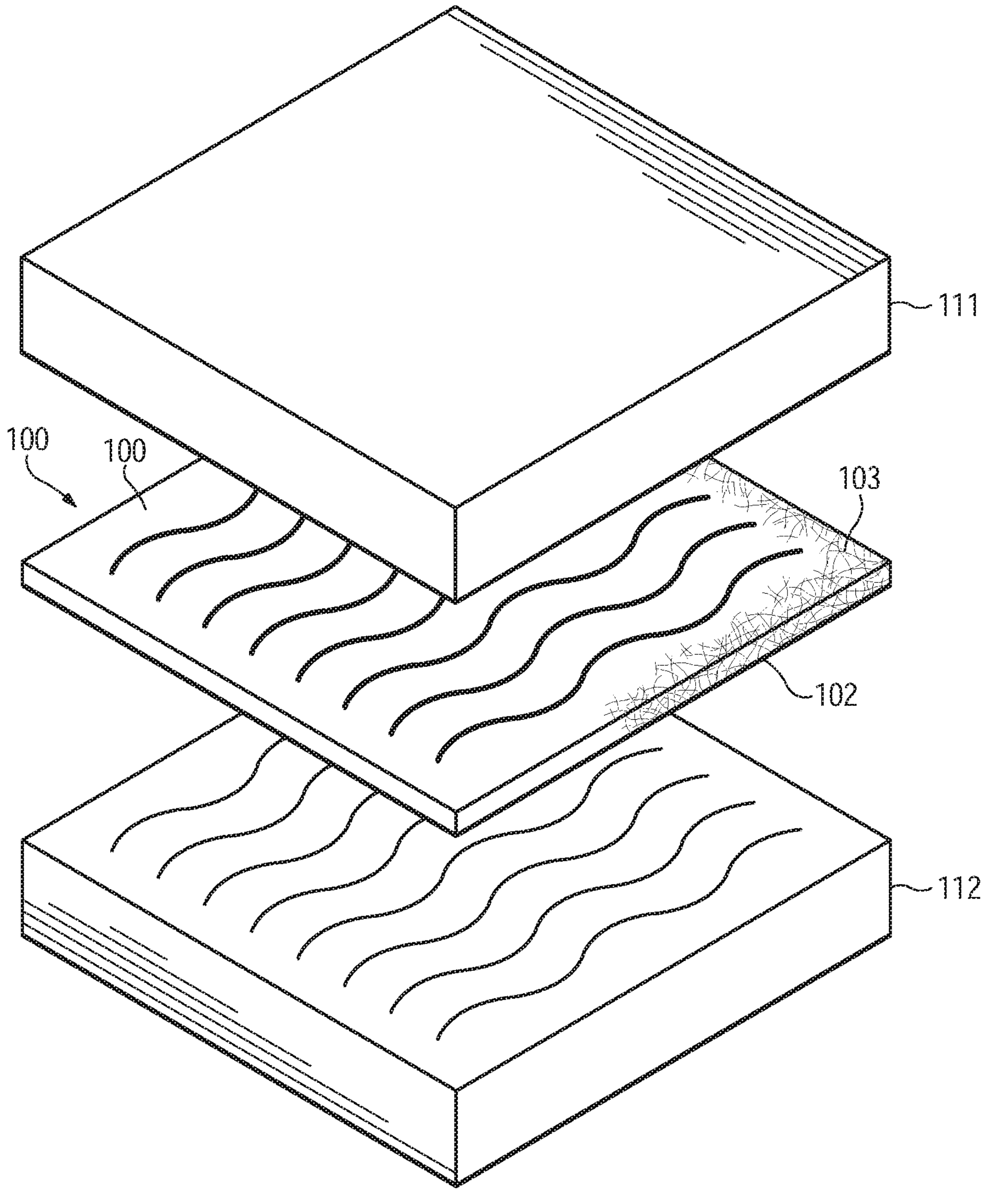


Figure 45C

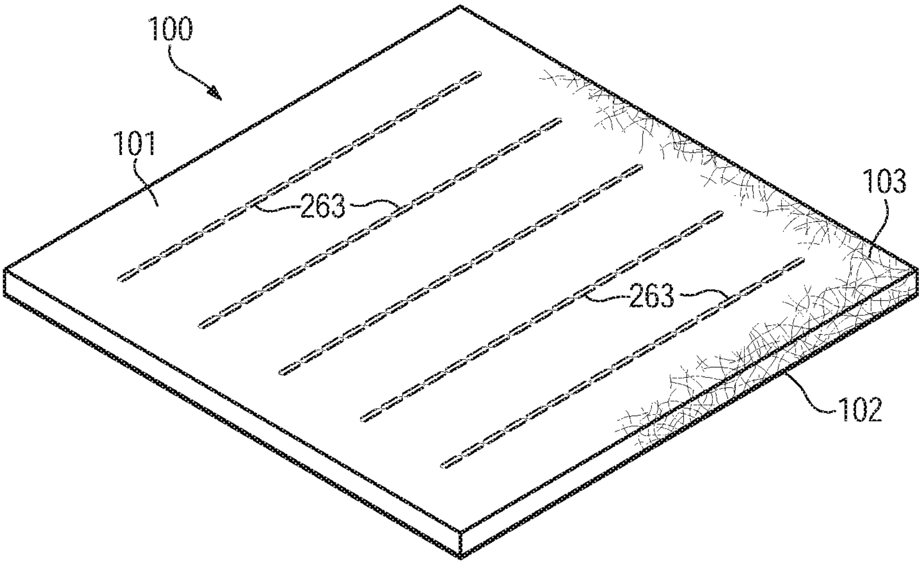


Figure 46A

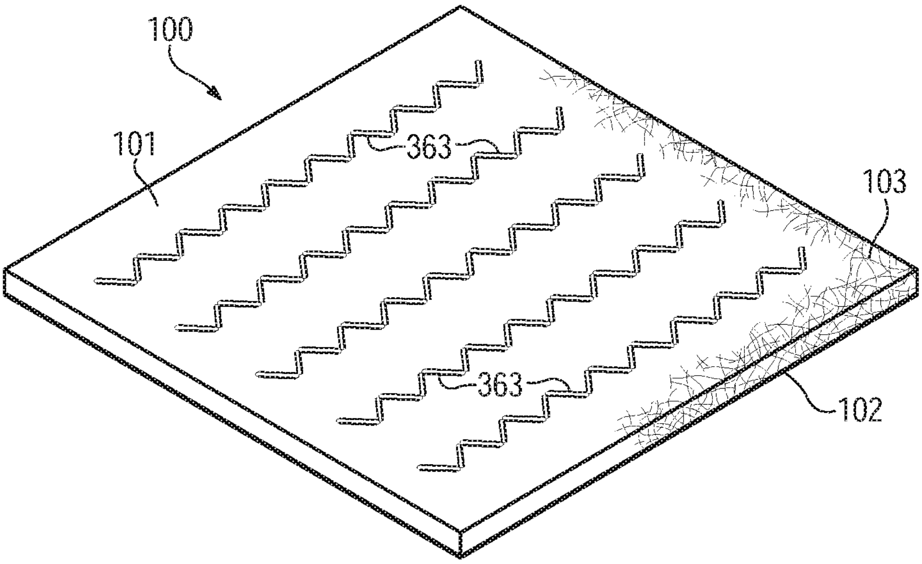


Figure 46B

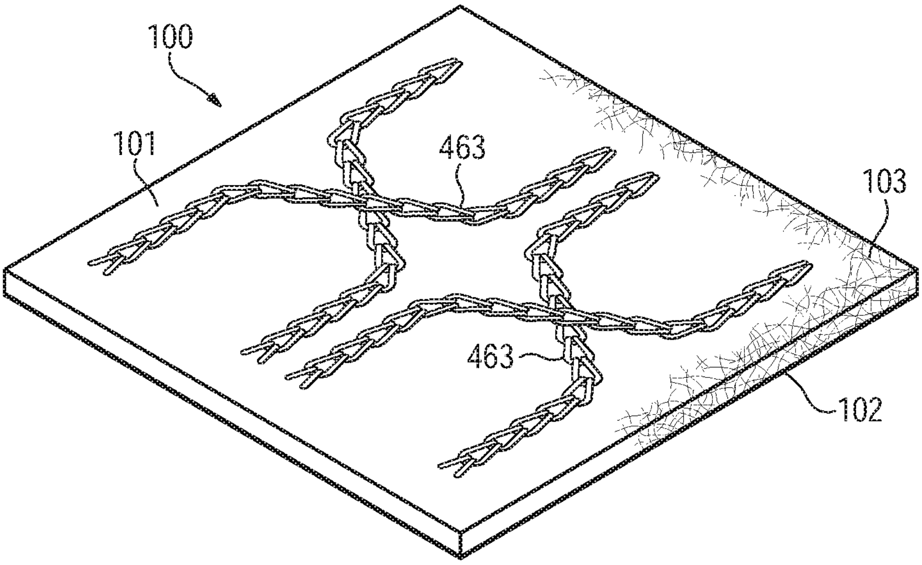


Figure 46C

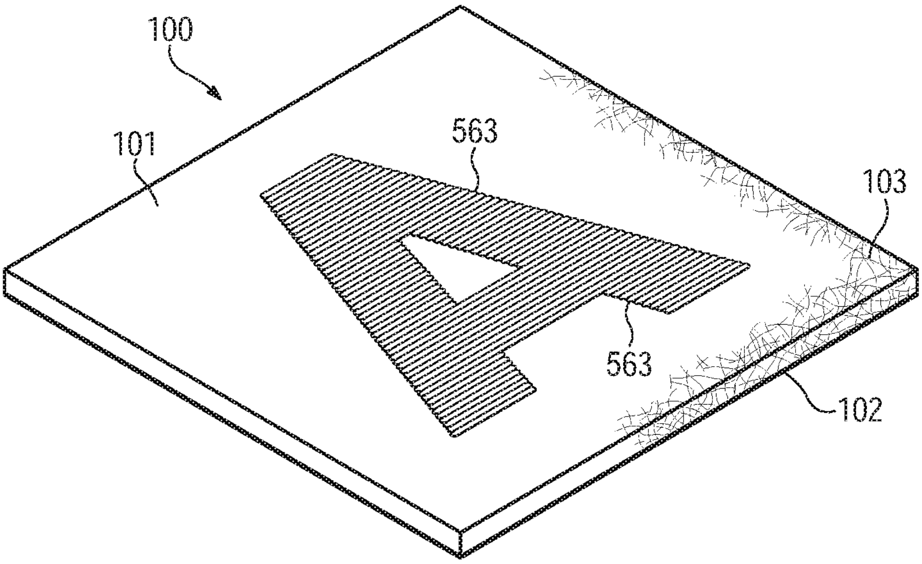


Figure 46D

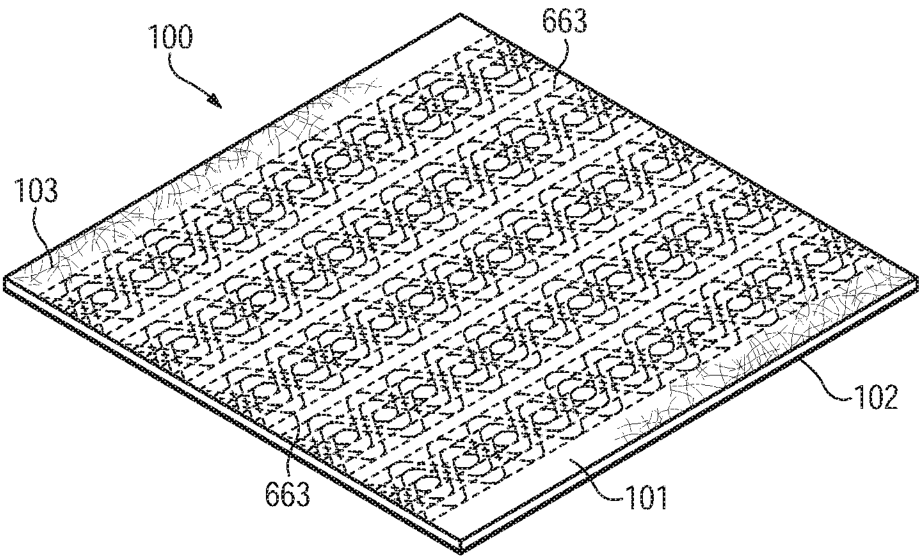


Figure 46E

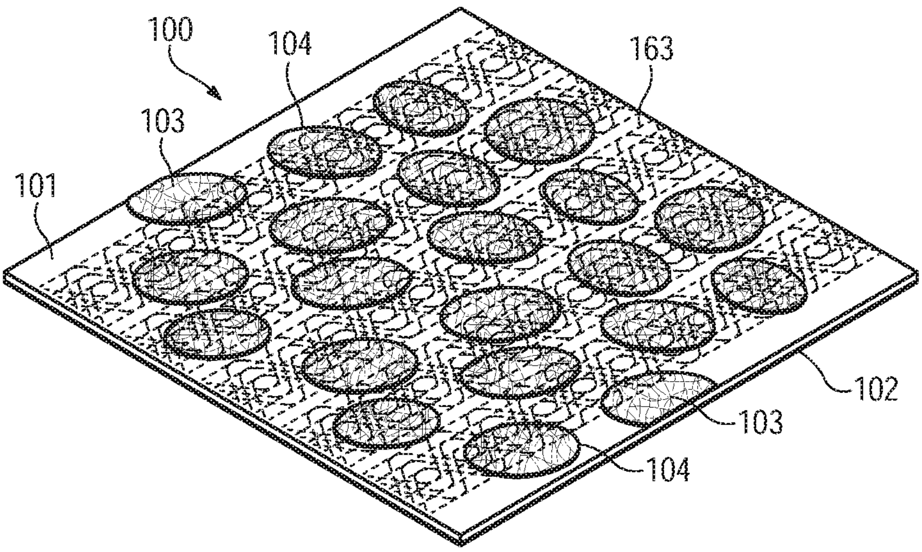


Figure 46F

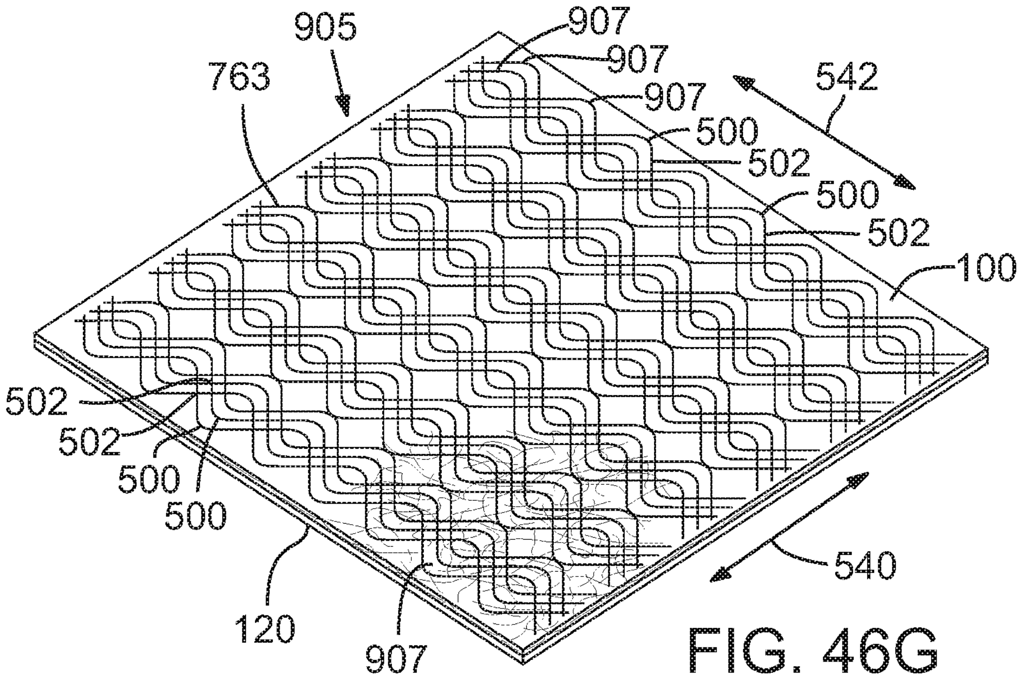


FIG. 46G

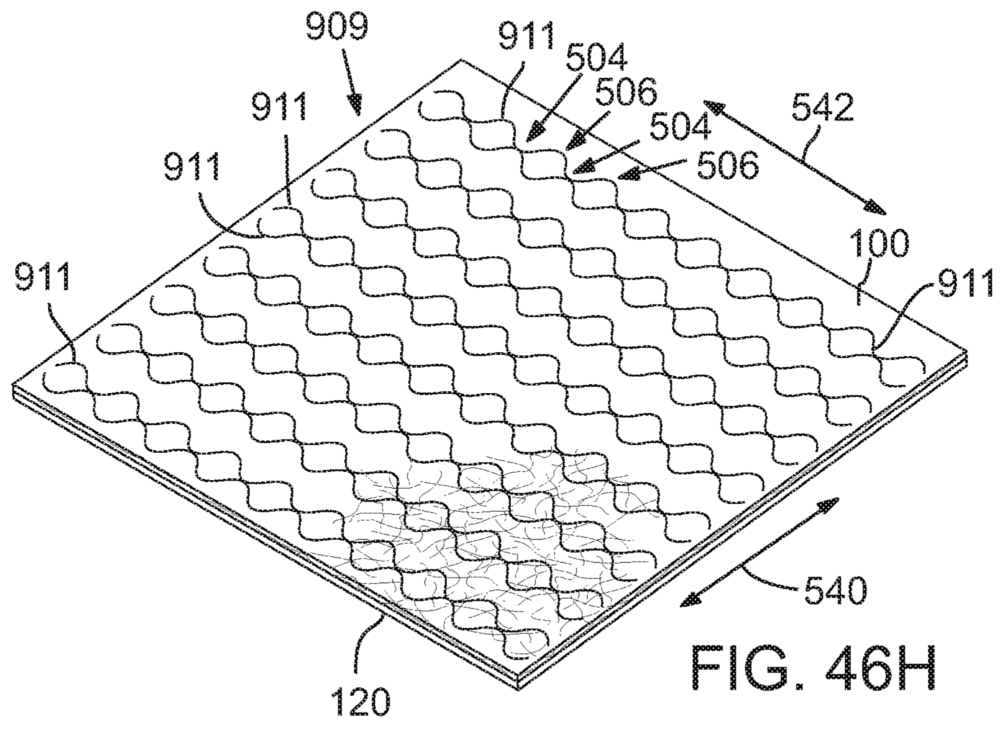


FIG. 46H

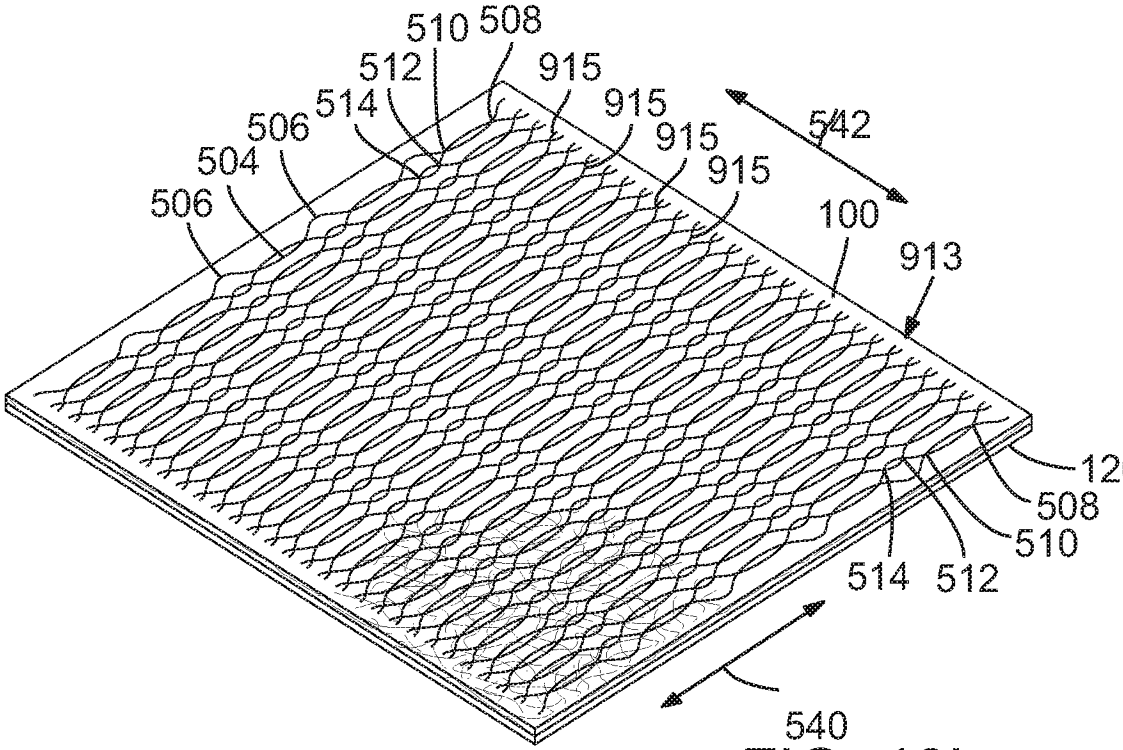


FIG. 46I

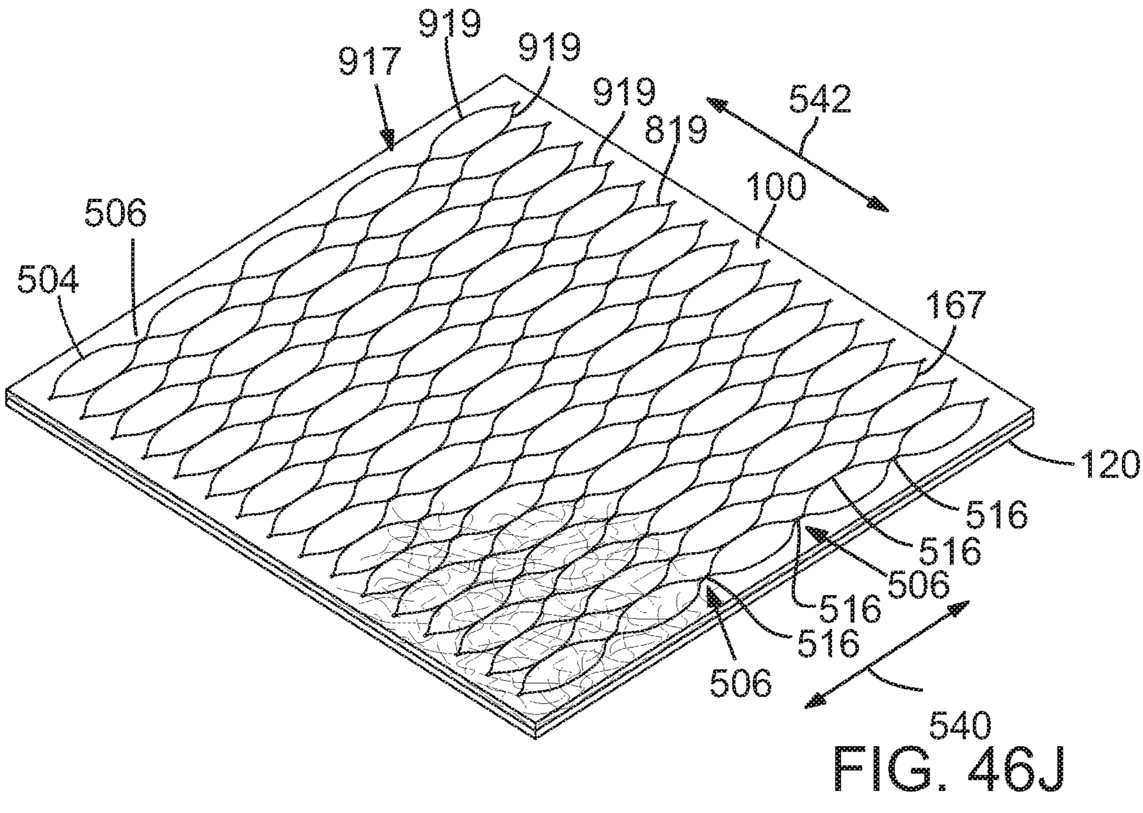


FIG. 46J

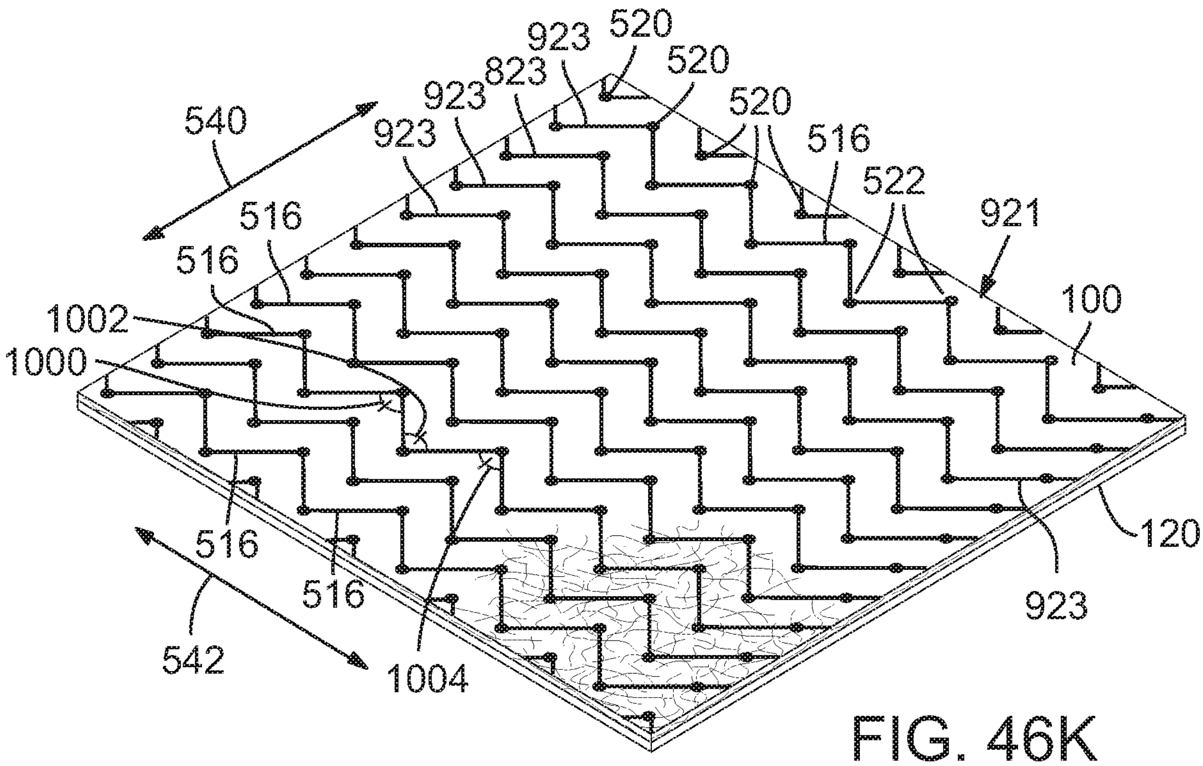


FIG. 46K

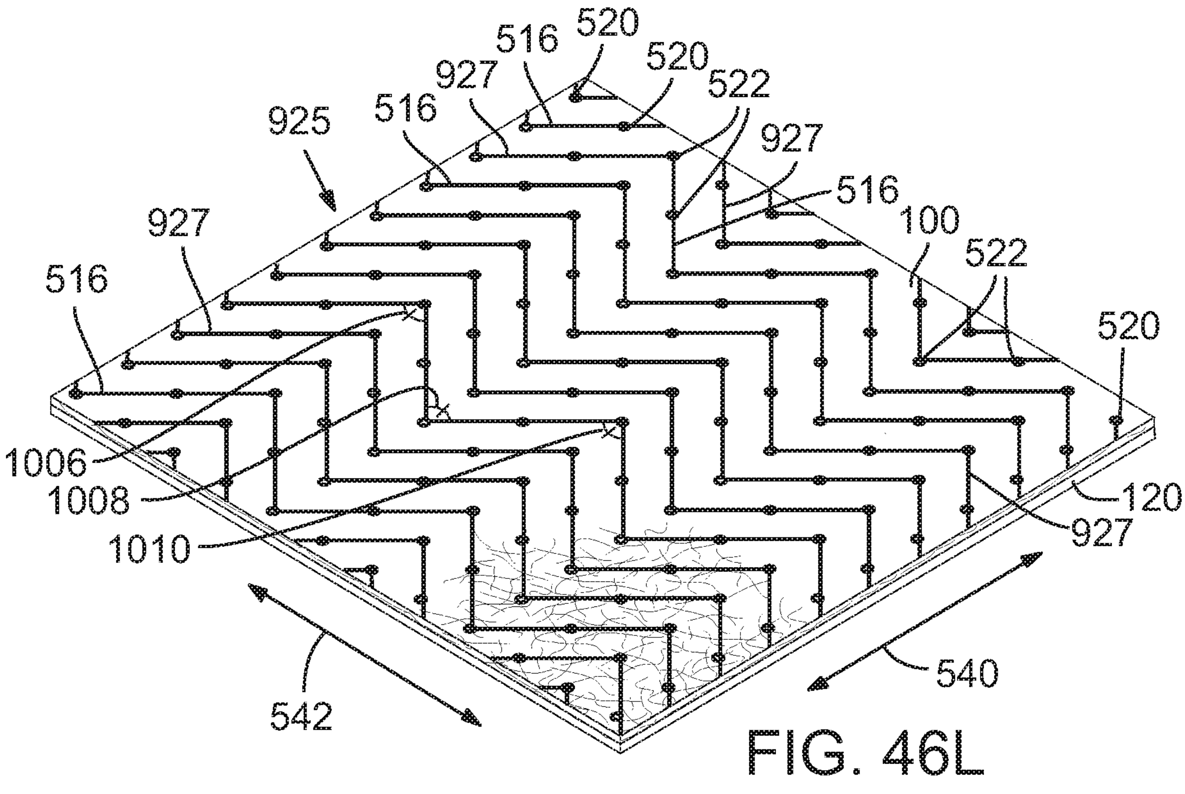


FIG. 46L

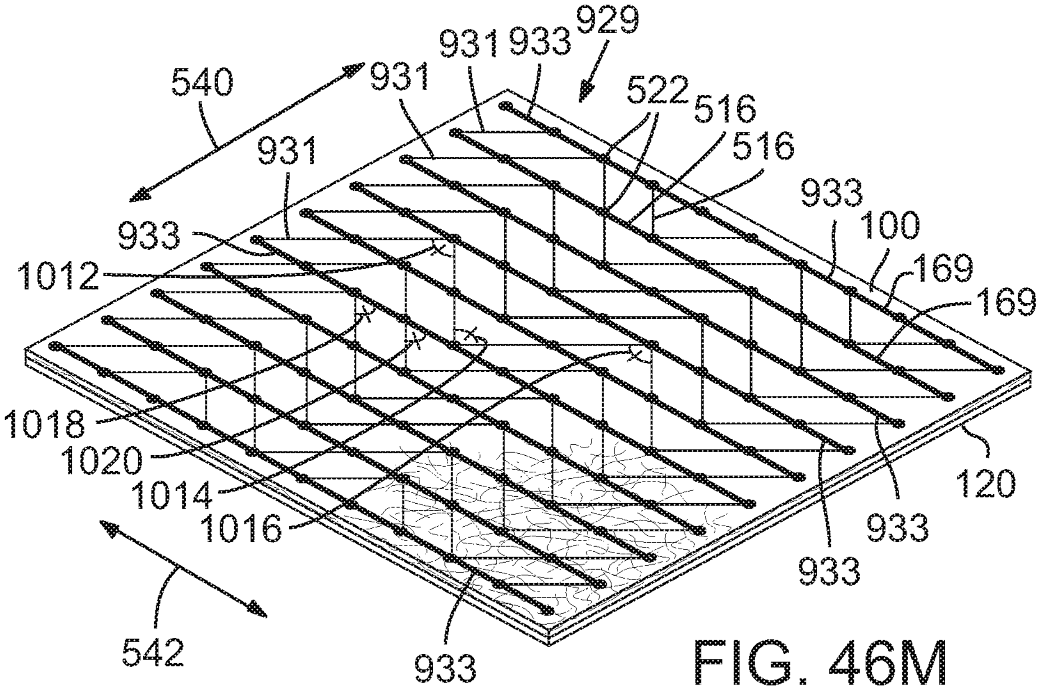


FIG. 46M

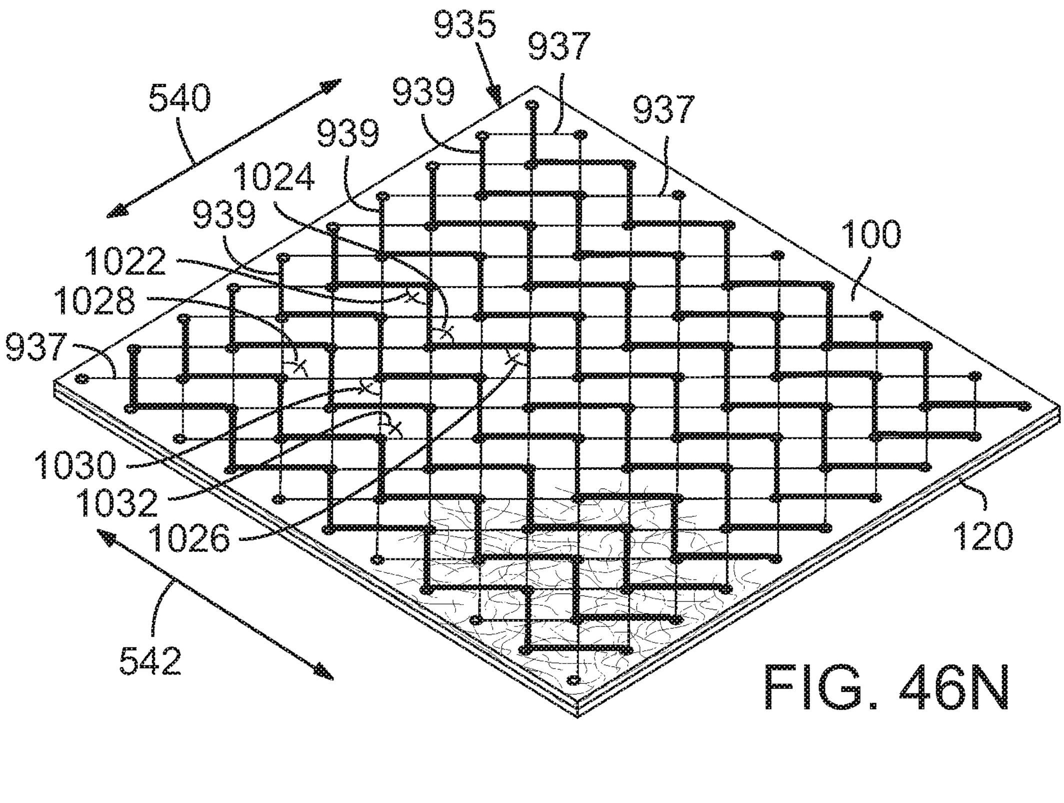


FIG. 46N

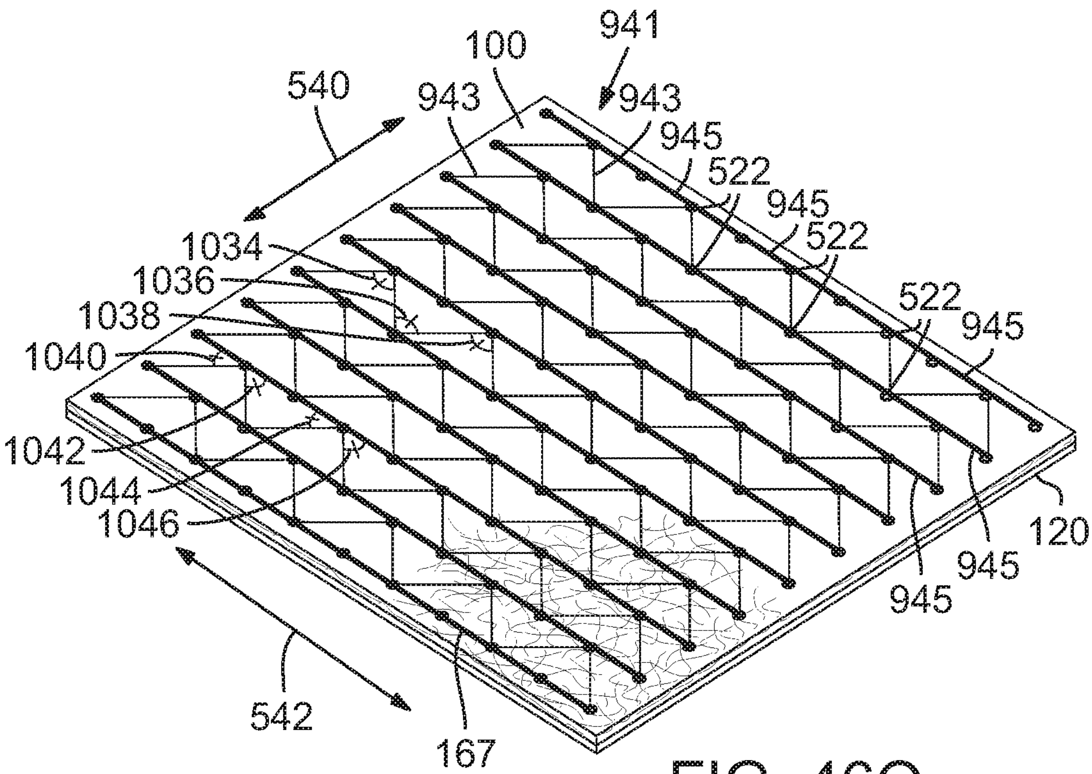


FIG. 46O

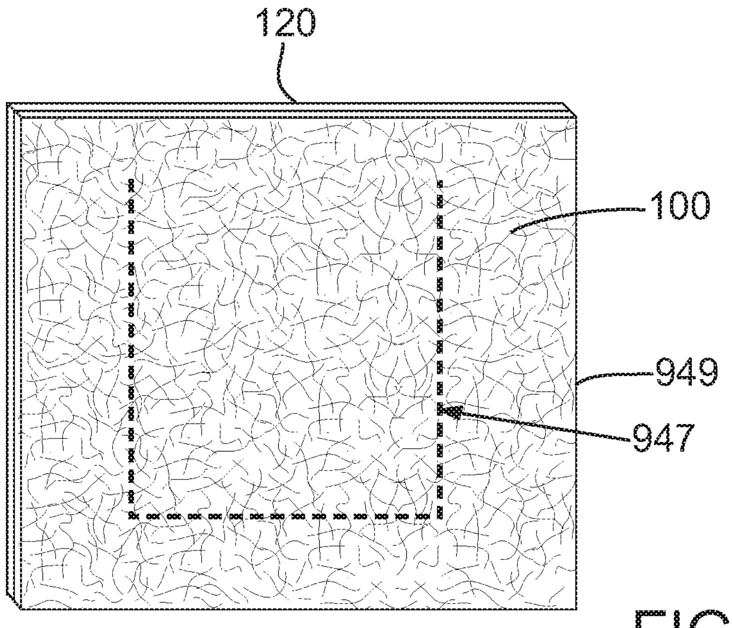


FIG. 46P

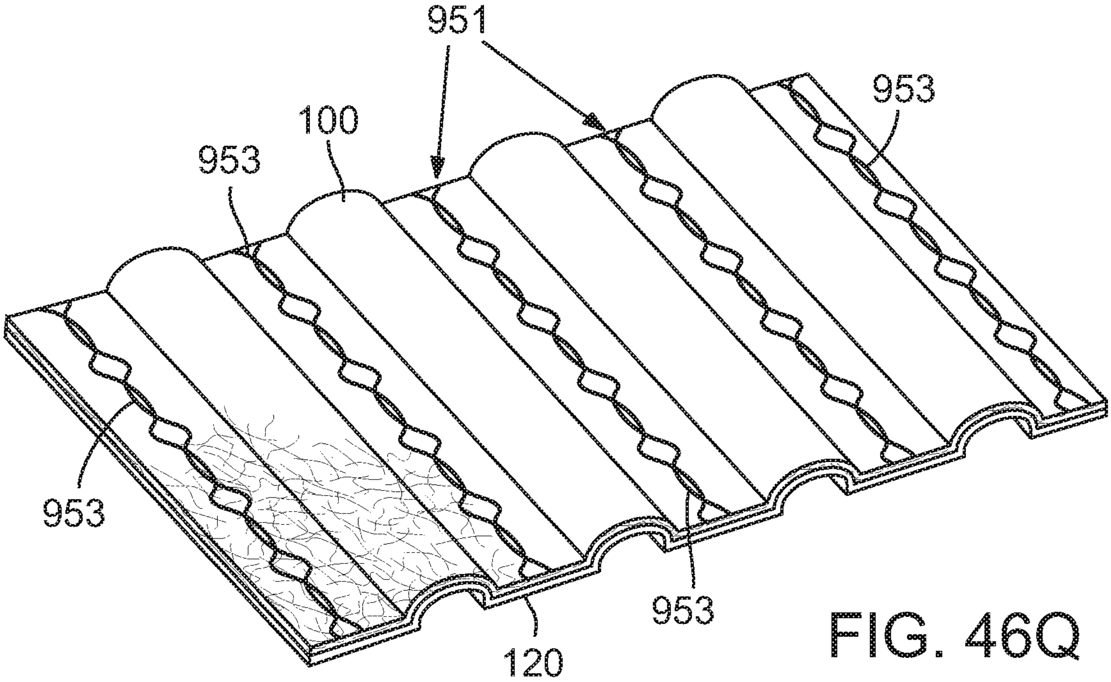


FIG. 46Q

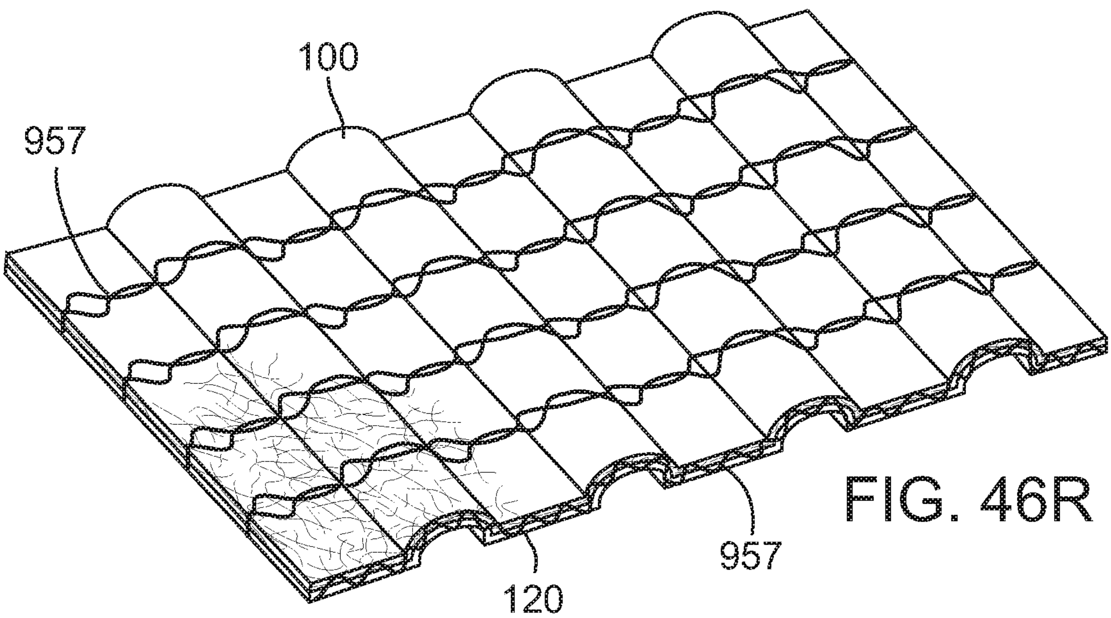


FIG. 46R

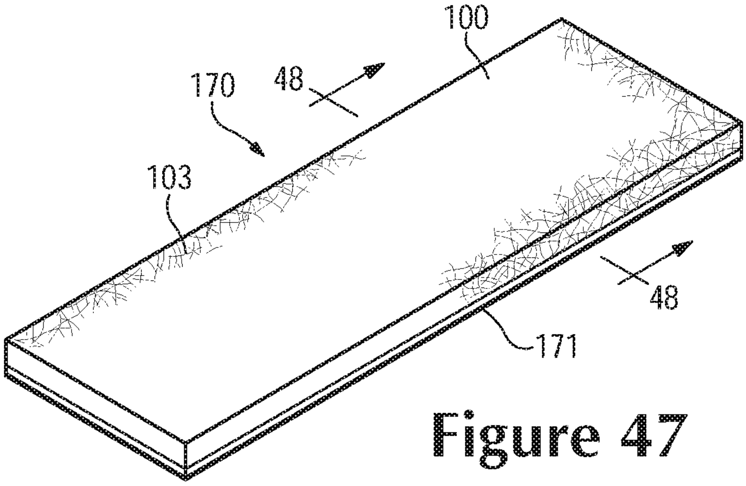


Figure 47

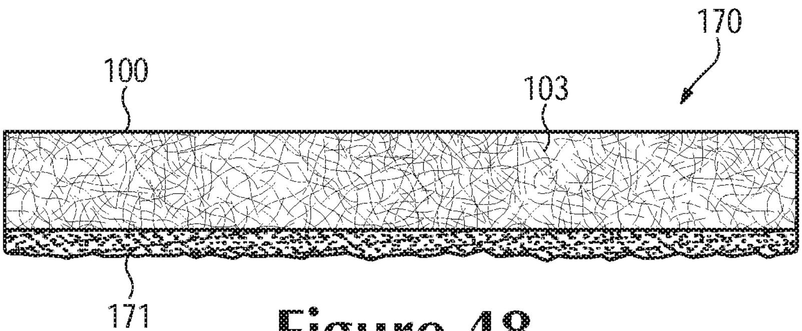


Figure 48

Figure 49A

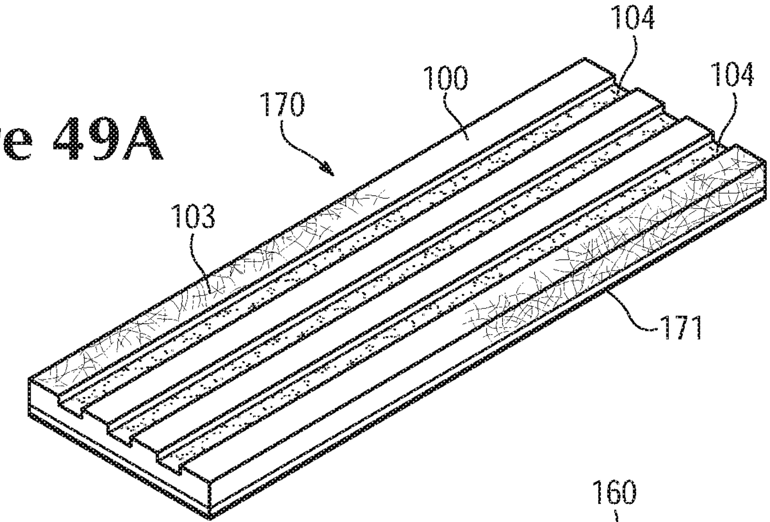


Figure 49B

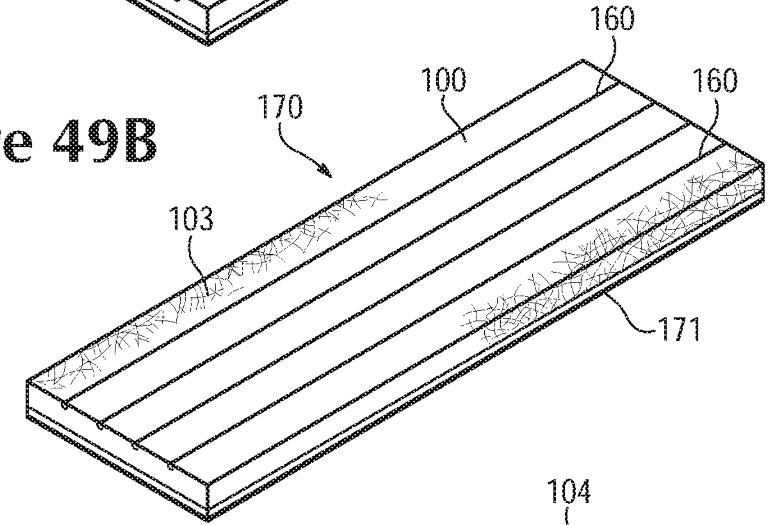
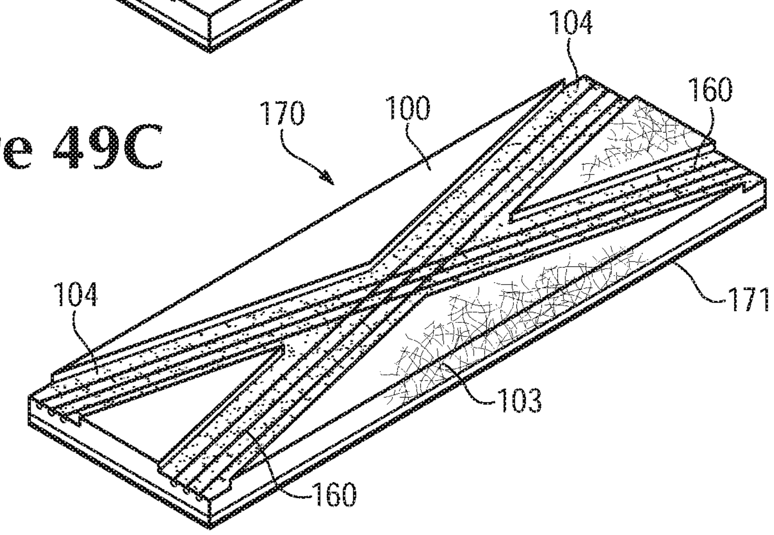


Figure 49C



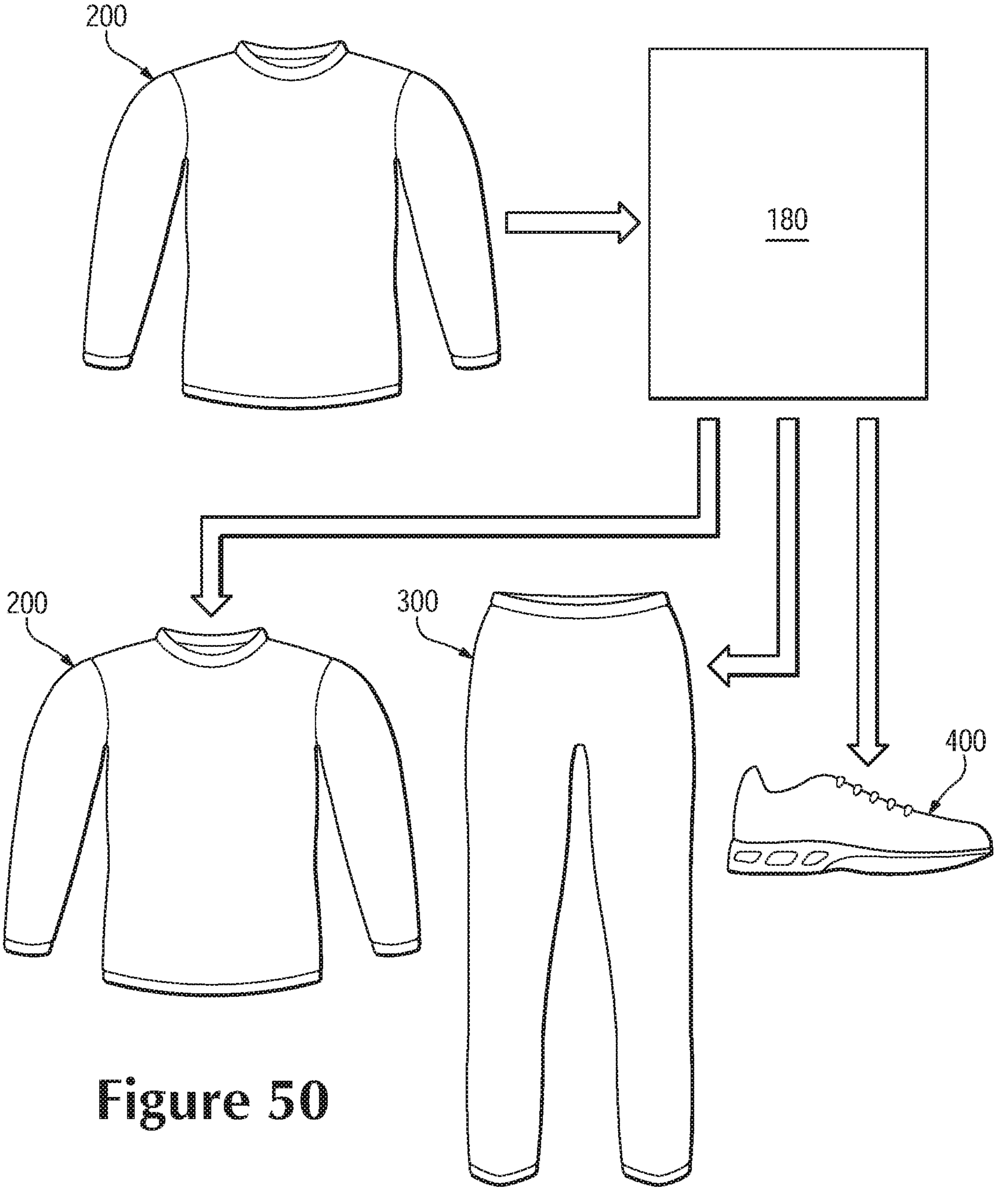


Figure 50

INTERNATIONAL SEARCH REPORT

International application No. PCT/US2016/021442

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B29C 65/62; B32B 5/06; B32B 7/08 (2016.01)

CPC - B29C 65/62; B32B 5/06; B32B 7/08 (2016.02)

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)

IPC(8) - B29C 65/62, 65/72; B32B 5/06, 5/24, 5/26, 7/02, 7/08; D04H 1/4358, 1/4374, 1/558 (2016.01)

CPC - B29C 65/62, 65/72; B32B 5/022, 5/06, 5/24, 5/26, 7/02, 7/045, 7/08; D04H 1/4358, 1/4374, 1/558 (2016.02)

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

USPC - 112/402, 415, 441; 428/102, 212; 442/381, 392, 394; IPC(8) - B29C 65/62, 65/72; B32B 5/06, 5/24, 5/26, 7/02, 7/08; D04H 1/4358, 1/4374, 1/558; CPC - see above (keyword delimited)

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

Orbit, Google Patents, Google.

Search terms used: nonwoven, stitch, component, layer, polyurethane, permeable.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/0199520 A1 (DUA et al) 12 August 2010 (12.08.2010) entire document	1-3, 9-13, 16-20
A	US 2014/0209233 A1 (NIKE INC) 31 July 2014 (31.07.2014) entire document	1-3, 9-13, 16-20
A	US 2013/0260087 A1 (WOODS II et al) 03 October 2013 (03.10.2013) entire document	1-3, 9-13, 16-20

☐ 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

"E" earlier application or patent but 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 citation 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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 April 2016	23 MAY 2016
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/021442

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4-8, 14, 15
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.