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(54) **ARTICLE OF APPAREL INCORPORATING A MODIFIABLE TEXTILE STRUCTURE**

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(57) **ABSTRACT**

An article of apparel is disclosed that includes a textile with at least one property that changes upon exposure to a physical stimulus. The textile has a modifiable structure formed from yarns that exhibit a dimensional-transformation upon exposure to the physical stimulus. The yarns have a first set of dimensions when unexposed to the physical stimulus, and the yarns have a second set of dimensions when exposed to the physical stimulus. The structure of the textile is modified by exposing the textile to the physical stimulus such that the yarns transform from the first set of dimensions to the second set of dimensions and change the property of the textile.

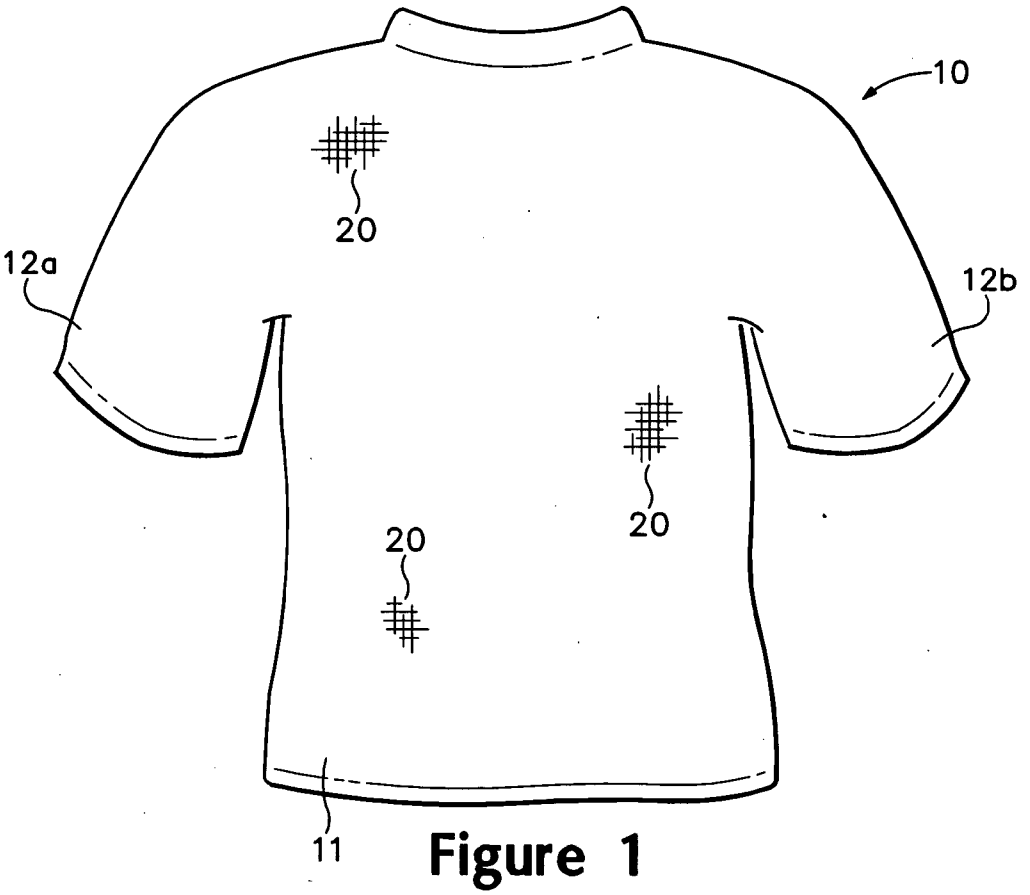


Figure 1

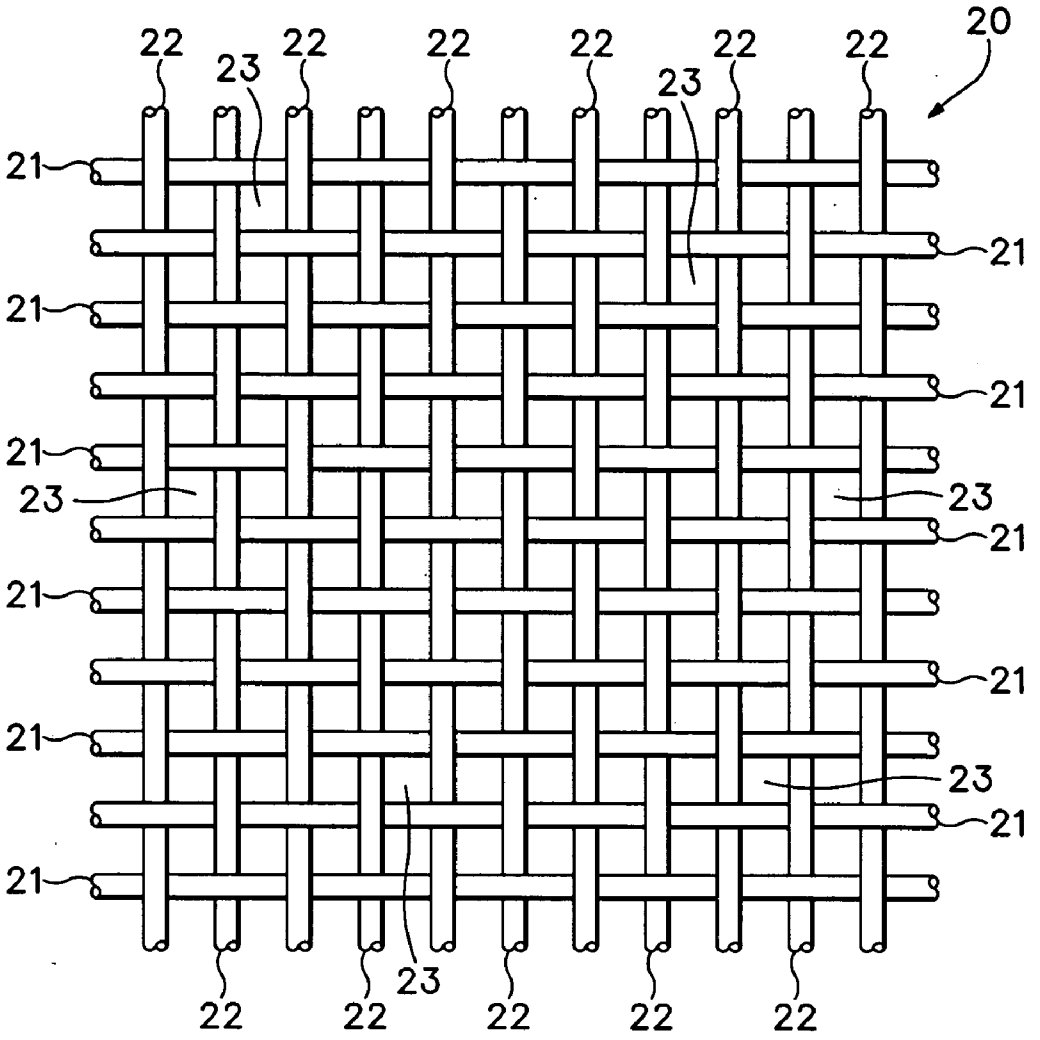
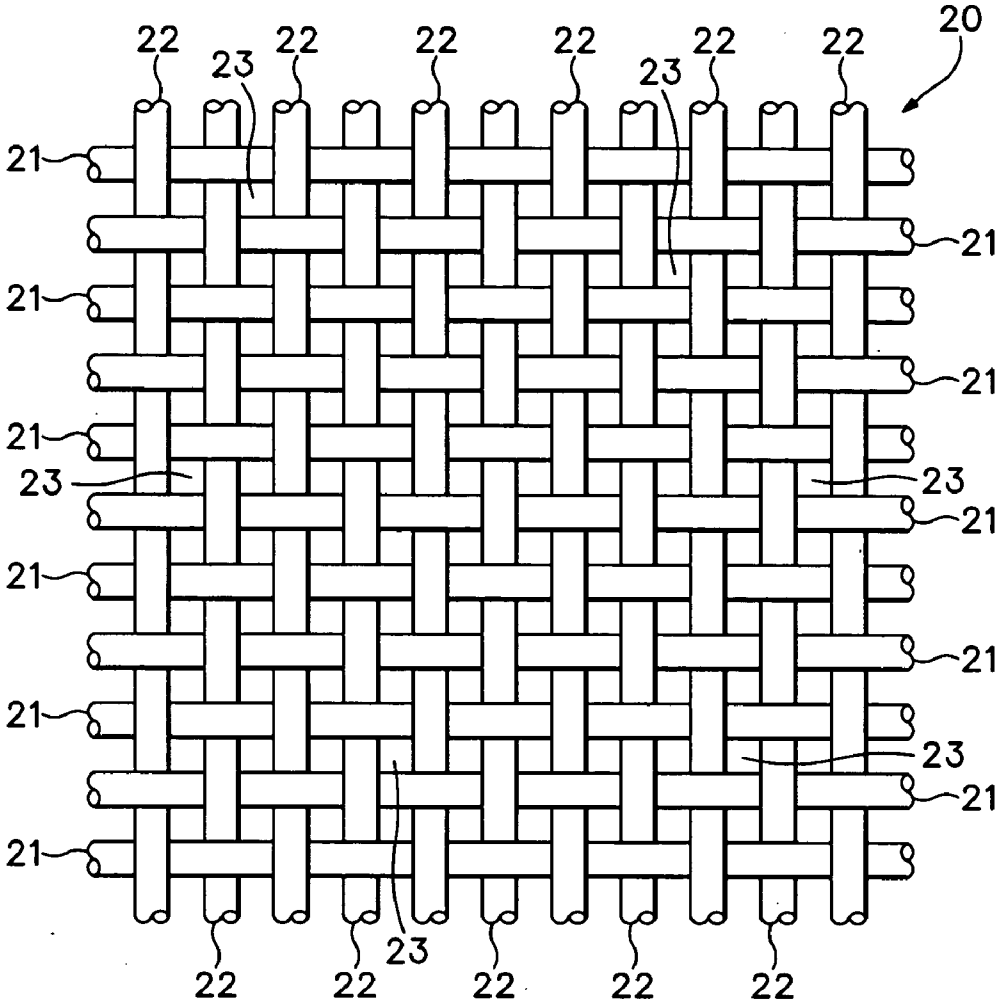


Figure 2



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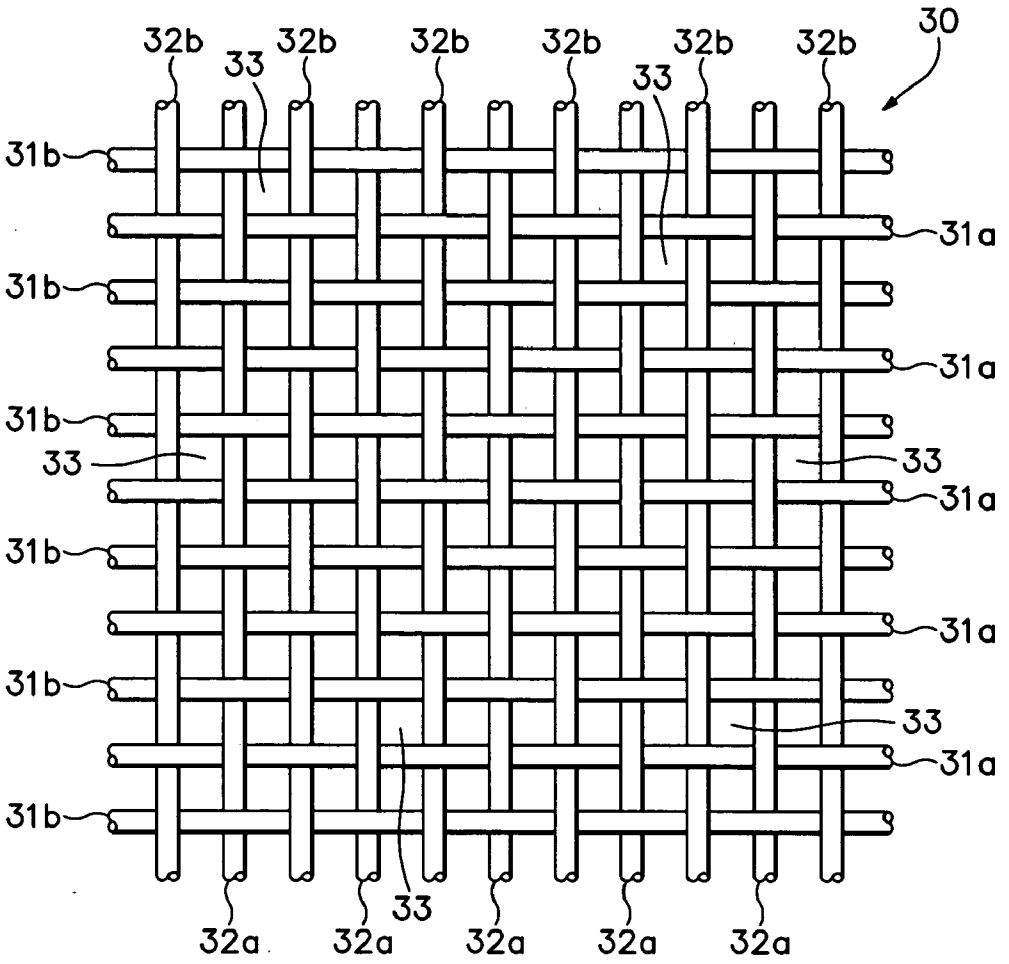
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Figure 4

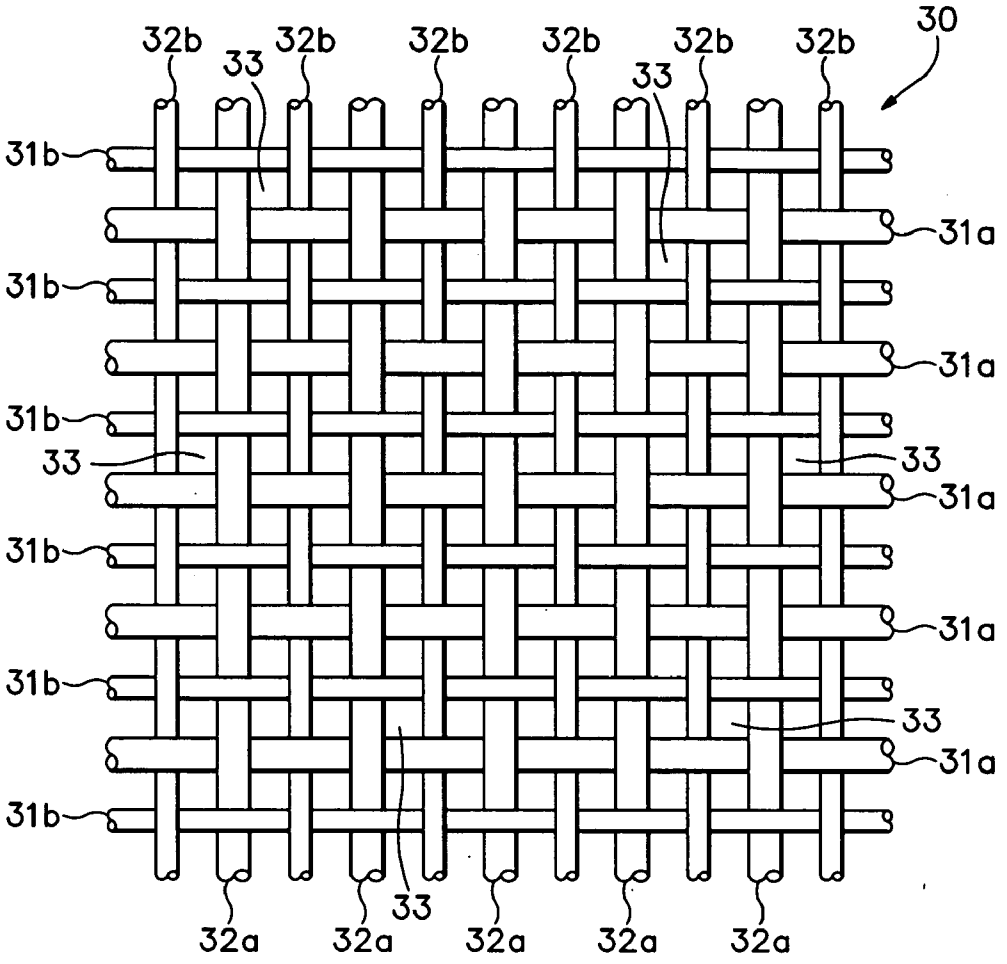
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Figure 5

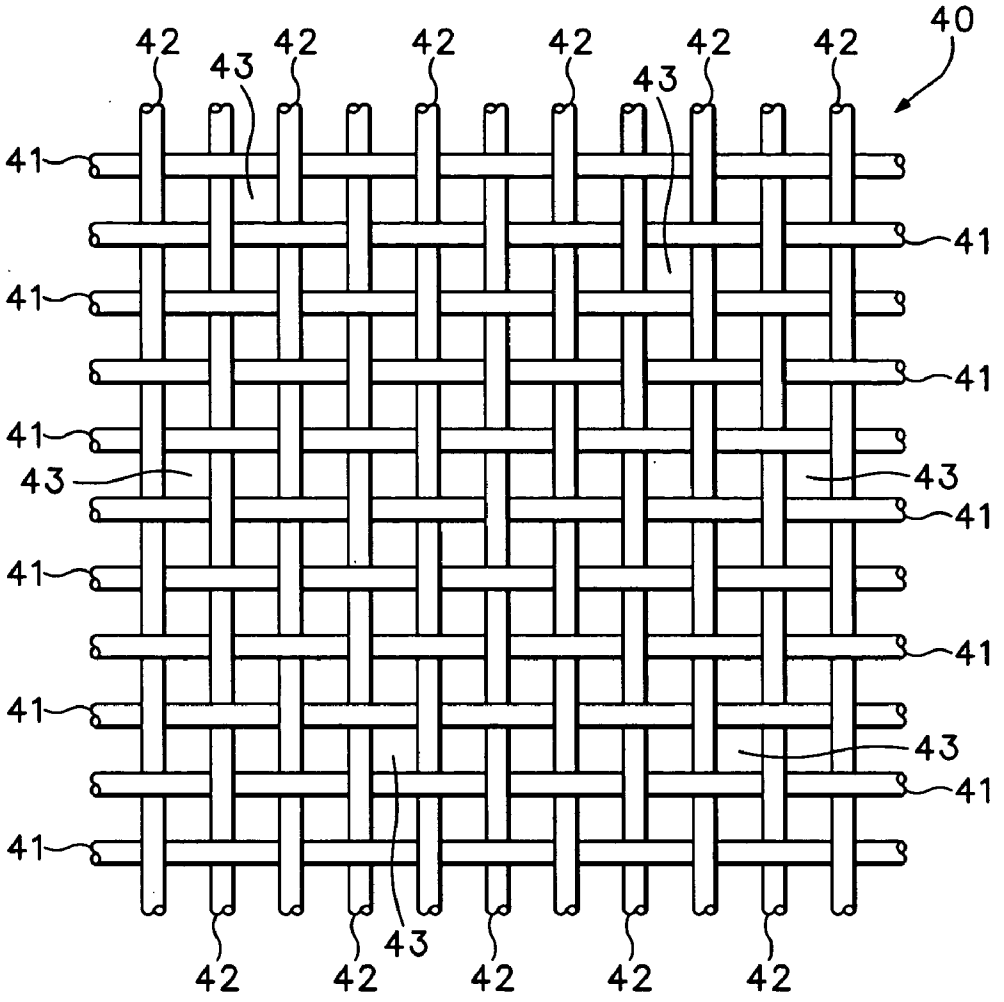
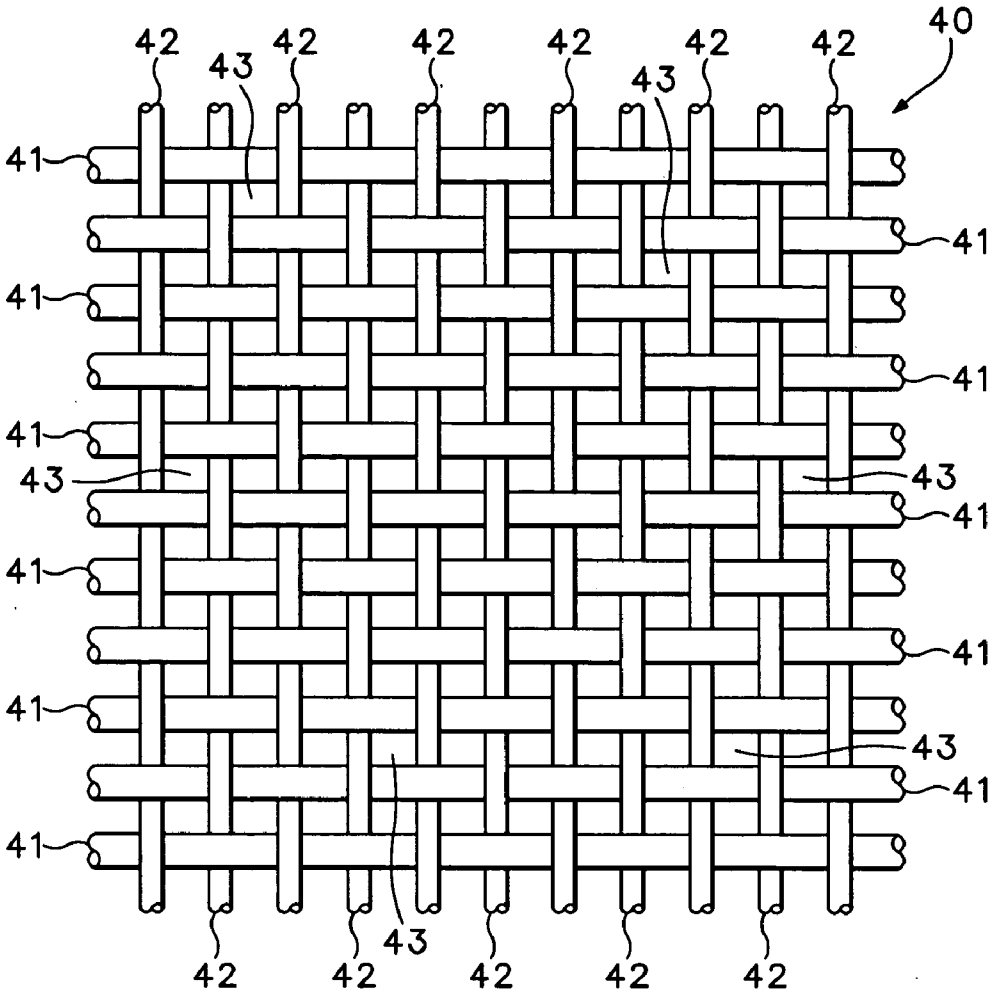


Figure 6



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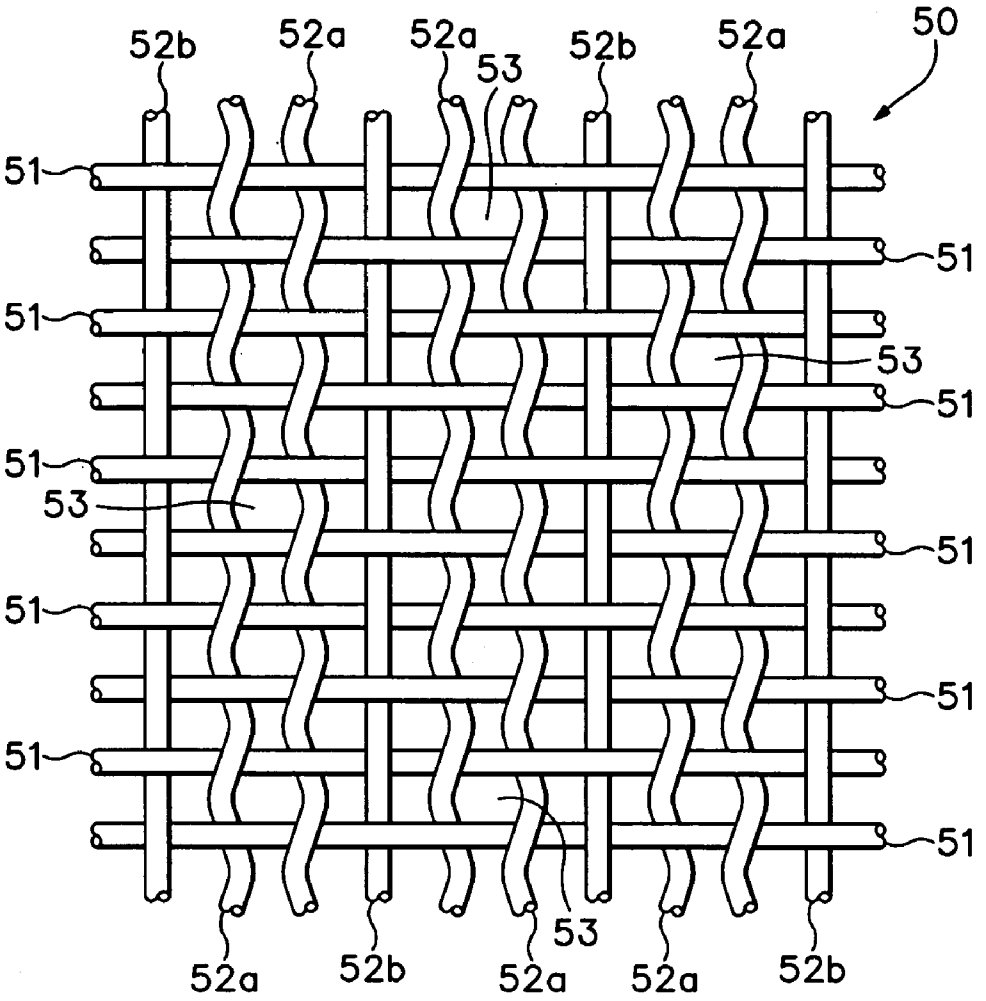
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Figure 8

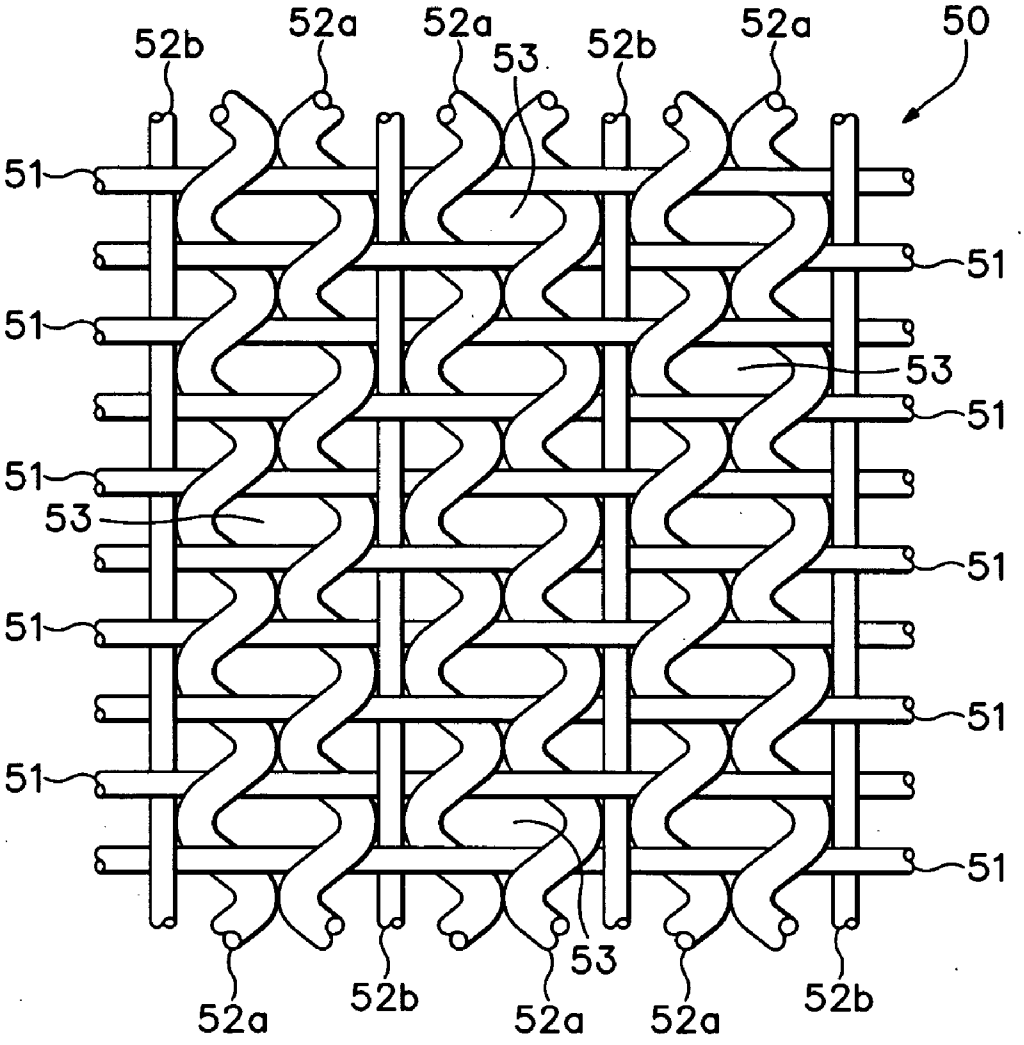
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Figure 9

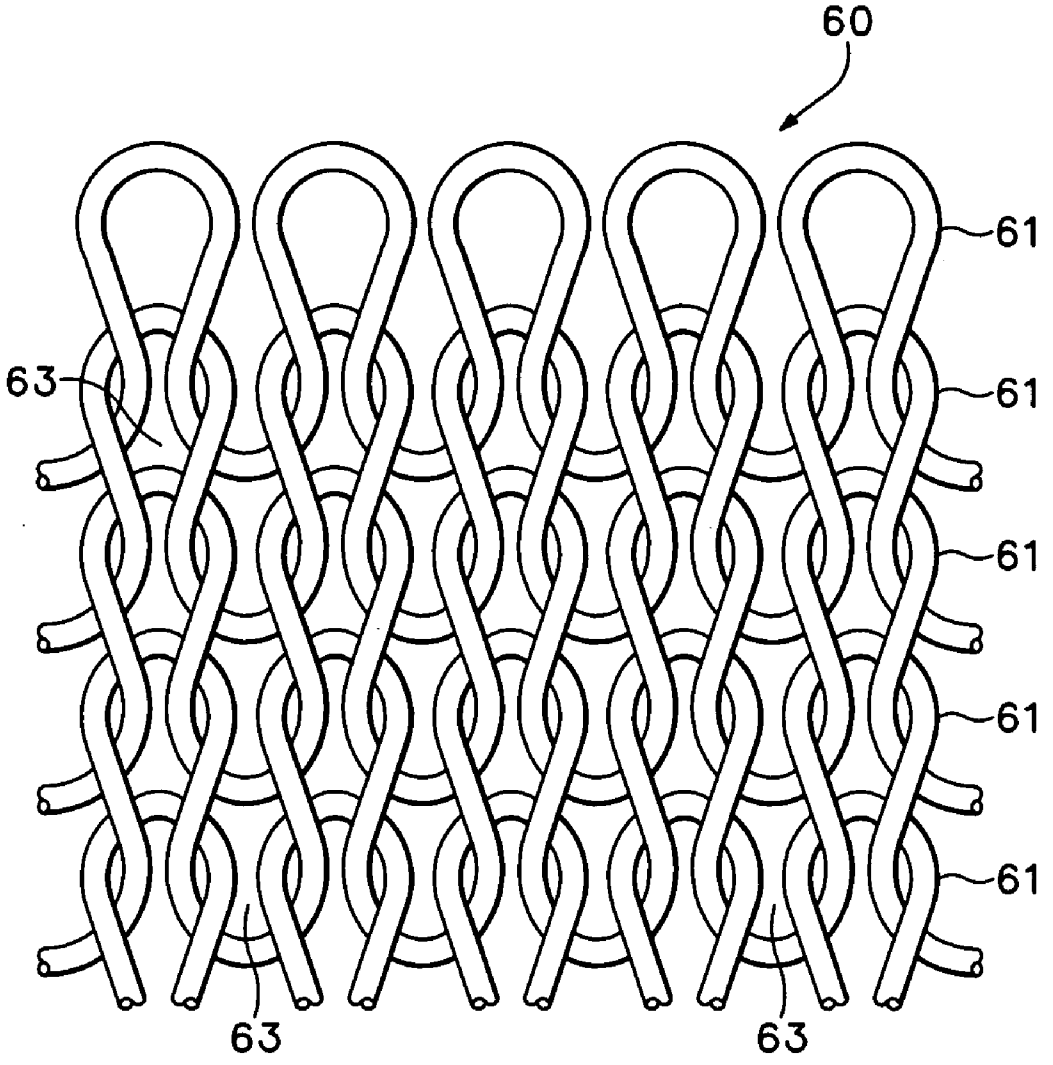

Figure 10

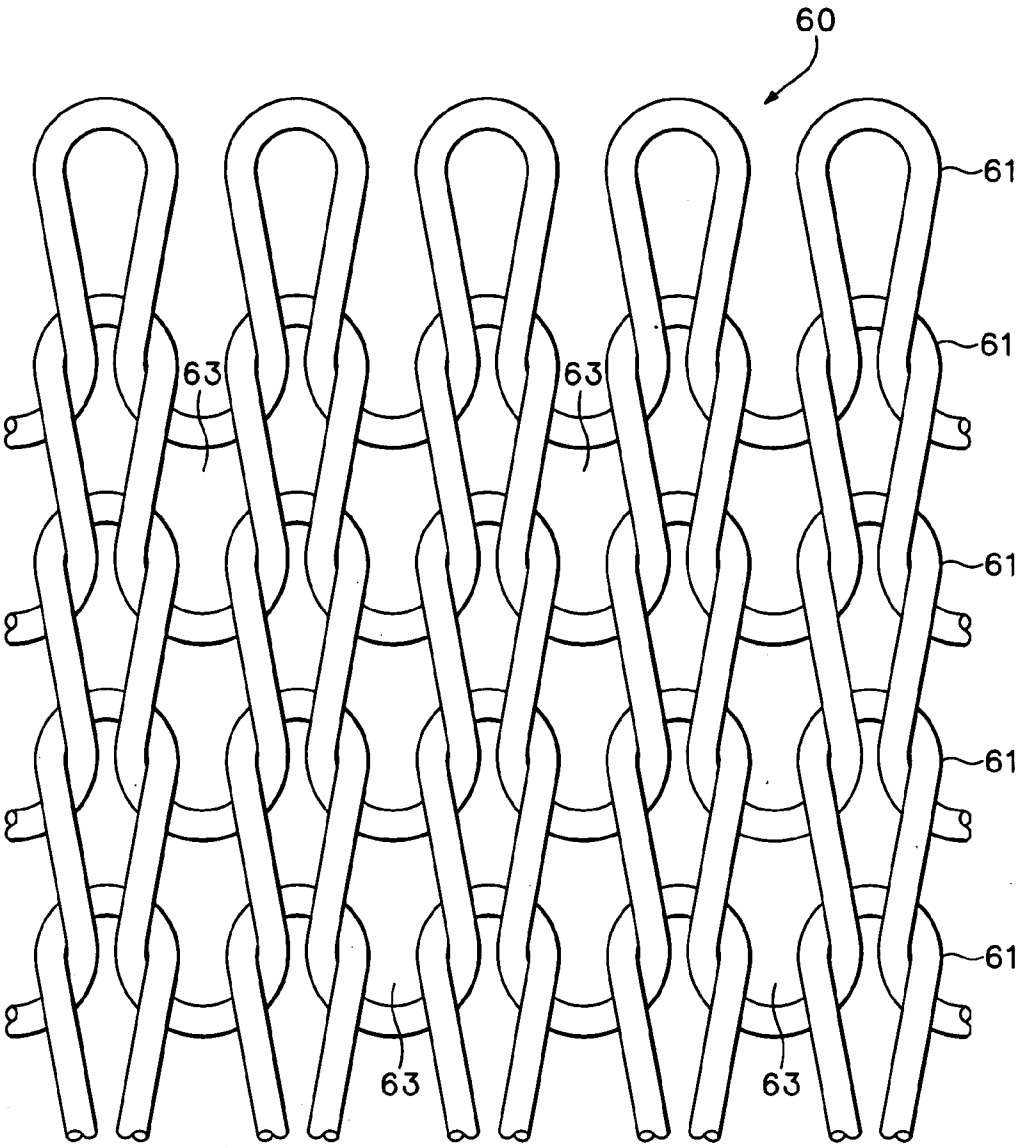

Figure 11

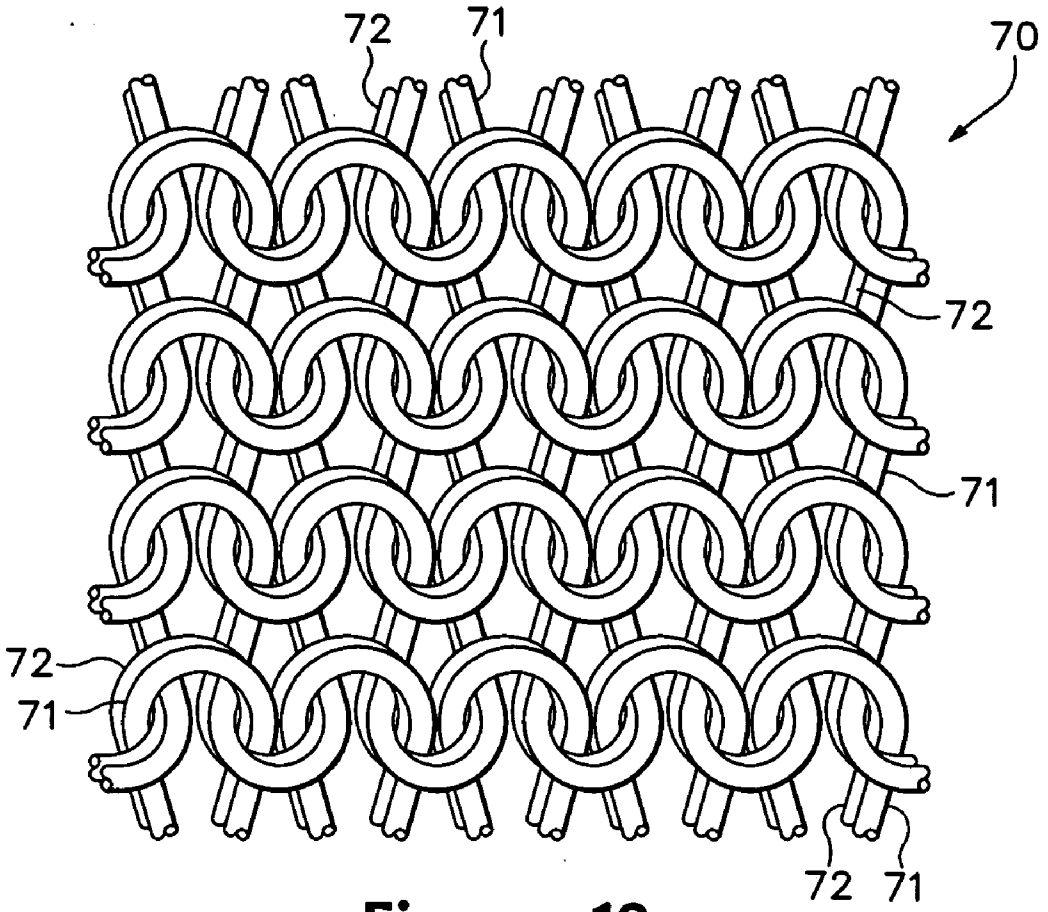

Figure 12

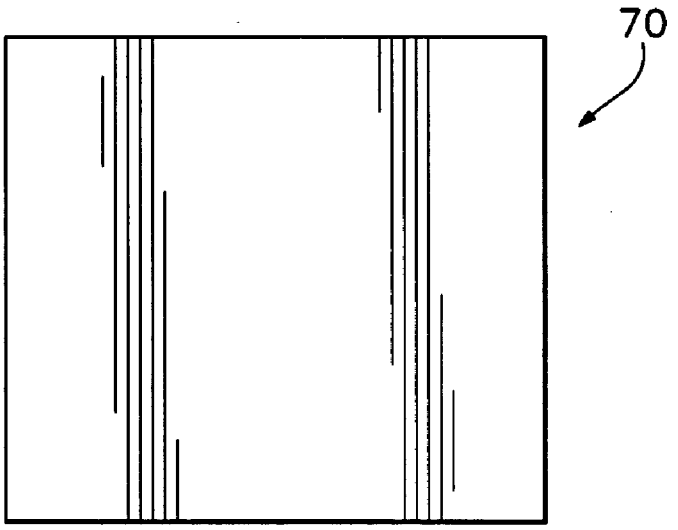

Figure 13

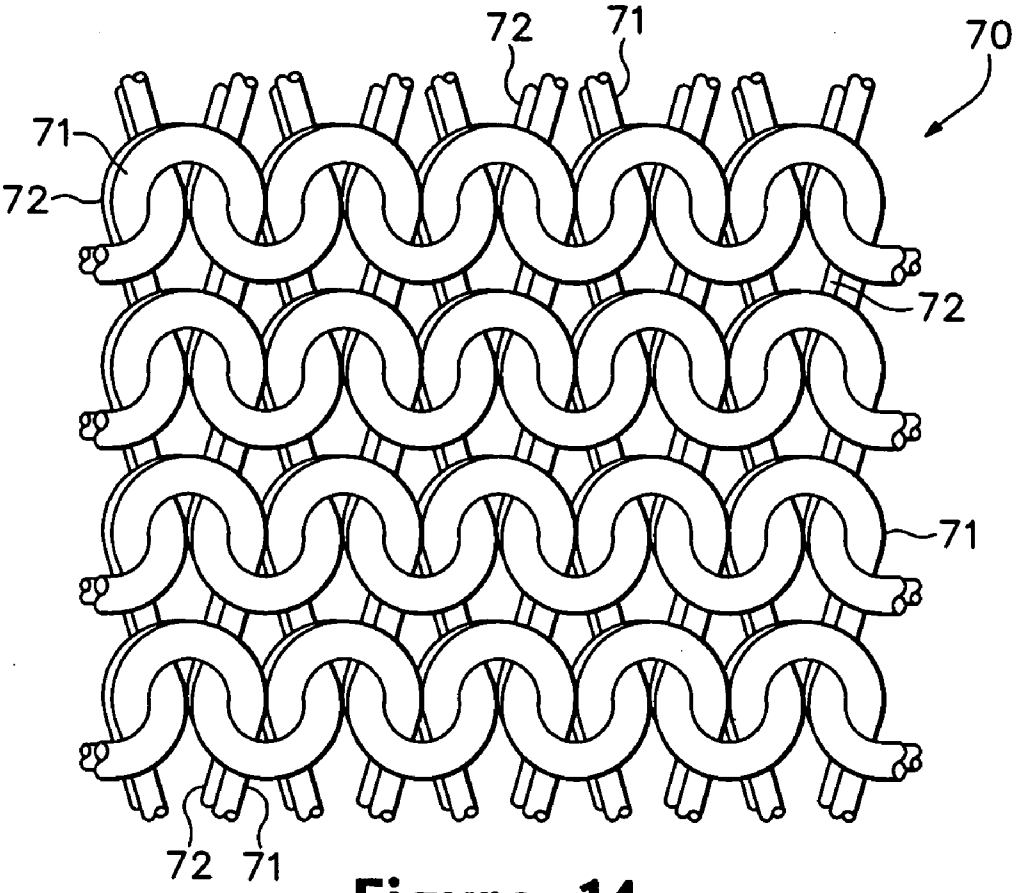

Figure 14

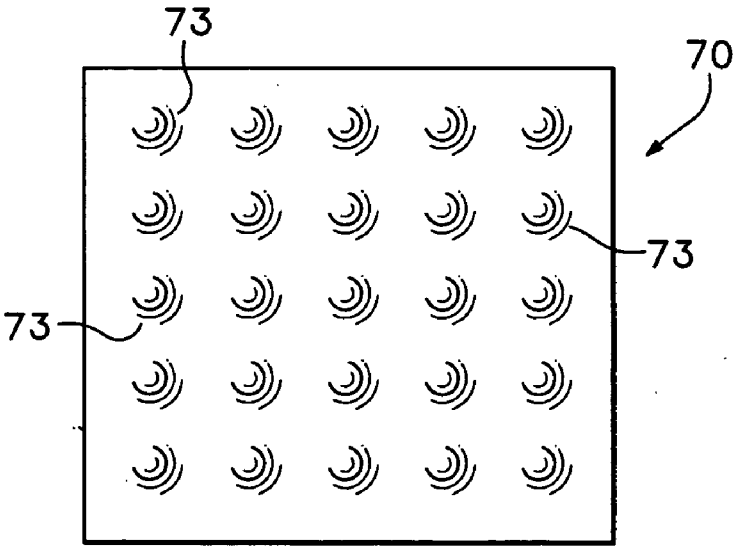

Figure 15

ARTICLE OF APPAREL INCORPORATING A MODIFIABLE TEXTILE STRUCTURE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to apparel. The invention concerns, more particularly, an article of apparel that incorporates a textile with a structure that changes or is otherwise modified by a physical stimulus, such as the presence of water, to modify a property of the textile. The invention has application, for example, to articles of apparel intended for use during athletic activities.

[0003] 2. Description of Background Art

[0004] Articles of apparel designed for use during athletic activities generally exhibit characteristics that enhance the performance or comfort of an individual. For example, apparel may incorporate an elastic textile that provides a relatively tight fit, thereby imparting the individual with a lower profile that minimizes wind resistance. Apparel may also be formed from a textile that wicks moisture away from the individual in order to reduce the quantity of perspiration that accumulates adjacent to the skin. Furthermore, apparel may incorporate materials that are specifically selected for particular environmental conditions.

[0005] The characteristics of the textiles that are incorporated into apparel are generally selected based upon the specific activity for which the apparel is intended to be used. A textile that minimizes wind resistance, for example, may be suitable for activities where speed is a primary concern. Similarly, a textile that reduces the quantity of perspiration that accumulates adjacent to the skin may be most appropriate for athletic activities commonly associated with a relatively high degree of exertion. Accordingly, textiles may be selected to enhance the performance or comfort of individuals engaged in specific athletic activities.

[0006] Textiles may be defined as any manufacture from fibers, filaments, or yarns characterized by flexibility, fineness, and a high ratio of length to thickness. Textiles generally fall into two categories. The first category includes textiles produced directly from webs of fibers by bonding, fusing, or interlocking to construct non-woven fabrics and felts. The second category includes textiles formed through a mechanical manipulation of yarn, thereby producing a woven fabric.

[0007] Yarn is the raw material utilized to form textiles in the second category and may be defined as an assembly having a substantial length and relatively small cross-section that is formed from at least one filament or a plurality of fibers. Fibers have a relatively short length and require spinning or twisting processes to produce a yarn of suitable length for use in textiles. Common examples of fibers are cotton and wool. Filaments, however, have an indefinite length and may merely be combined with other filaments to produce a yarn suitable for use in textiles. Modem filaments include a plurality of synthetic materials such as rayon, nylon, polyester, and polyacrylic, with silk being the primary, naturally-occurring exception. Yarn may be formed from a single filament or a plurality of individual filaments grouped together. Yarn may also include separate filaments formed from different materials, or the yarn may include filaments that are each formed from two or more different materials. Similar concepts also apply to yarns formed from fibers. Accordingly, yarns may have a variety of configurations that generally conform to the definition provided above.

[0008] The various techniques for mechanically manipulating yarn into a textile include interweaving, intertwining and twisting, and interlooping. Interweaving is the intersection of two yarns that cross and interweave at substantially right angles to each other. The yarns utilized in interweaving are conventionally referred to as warp and weft. Intertwining and twisting encompasses procedures such as braiding and knotting where yarns intertwine with each other to form a textile. Interlooping involves the formation of a plurality of columns of intermeshed loops, with knitting being the most common method of interlooping.

SUMMARY OF THE INVENTION

[0009] The present invention is an article of apparel that includes a textile with at least one property that changes upon exposure to a physical stimulus. The textile has a modifiable structure formed from yarns that exhibit a dimensional-transformation upon exposure to the physical stimulus. The yarns have a first set of dimensions when unexposed to the physical stimulus, and the yarns have a second set of dimensions when exposed to the physical stimulus. The structure of the textile is modified by exposing the textile to the physical stimulus such that the yarns transform from the first set of dimensions to the second set of dimensions and change the property of the textile. The yarns may be formed from a material that exhibits the dimensional-transformation upon exposure to water. Accordingly, the physical stimulus may be water. In some embodiments, the physical stimulus may also be heat, light, or moving air, for example.

[0010] The textile may be formed through an interweaving process wherein the yarns define openings in the textile. The openings exhibit a first area when the yarns are unexposed to the physical stimulus, and the openings exhibit a second area when the yarns are exposed to the physical stimulus. The area of the openings may determine, for example the permeability of the textile. Accordingly, when the first area is greater than the second area, the permeability of the textile is decreased upon exposure to the physical stimulus. Furthermore, when the first area is less than the second area, the permeability of the textile is increased upon exposure to the physical stimulus. In some embodiments, the yarns may exhibit an undulating configuration to increase the permeability upon exposure to the physical stimulus.

[0011] A substantial portion of the textile may be formed from the yarn. Alternately, a first portion of the yarns may exhibit the dimensional-transformation upon exposure to the physical stimulus, and a second portion of the yarns may remain dimensionally-stable upon exposure to the physical stimulus.

[0012] The textile may also be formed through an interlooping process. In some embodiments, the yarns define openings in the textile. The openings may exhibit a first area when the yarns are unexposed to the physical stimulus, and the openings may exhibit a second area when the yarns are exposed to the physical stimulus, thereby affecting the permeability of the textile. In other embodiments, the structure of the textile may exhibit a first texture when the yarns are unexposed to the physical stimulus, and the structure of

the textile may exhibit a second texture when the yarns are exposed to the physical stimulus. The first texture may be, for example, smoother than the second texture, and the second texture may include a plurality of nodes that extend outward from a surface of the textile.

[0013] The advantages and features of novelty characterizing the present 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 drawings that describe and illustrate various embodiments and concepts related to the invention.

DESCRIPTION OF THE DRAWINGS

[0014] The foregoing Summary of the Invention, as well as the following Detailed Description of the Invention, will be better understood when read in conjunction with the accompanying drawings.

[0015] **FIG. 1** is a plan view of an article of apparel incorporating a first textile structure in accordance with the present invention.

[0016] **FIG. 2** is a plan view of a portion of the first textile structure in an unexposed state.

[0017] **FIG. 3** is a plan view of the portion of the first textile structure in an exposed state.

[0018] **FIG. 4** is a plan view of a portion of a second textile structure in an unexposed state.

[0019] **FIG. 5** is a plan view of the portion of the second textile structure in an exposed state.

[0020] **FIG. 6** is a plan view of a portion of a third textile structure in an unexposed state.

[0021] **FIG. 7** is a plan view of the portion of the third textile structure in an exposed state.

[0022] **FIG. 8** is a plan view of a portion of a fourth textile structure in an unexposed state.

[0023] **FIG. 9** is a plan view of the portion of the fourth textile structure in an exposed state.

[0024] **FIG. 10** is a plan view of a portion of a fifth textile structure in an unexposed state.

[0025] **FIG. 11** is a plan view of the portion of the fifth textile structure in an exposed state.

[0026] **FIG. 12** is a plan view of a portion of a sixth textile structure in an unexposed state.

[0027] **FIG. 13** is a schematic plan view of a larger portion of the sixth textile structure in the unexposed state.

[0028] **FIG. 14** is a plan view of the portion of the sixth textile structure in an exposed state.

[0029] **FIG. 15** is a schematic plan view of the larger portion of the sixth textile structure in the exposed state.

DETAILED DESCRIPTION OF THE INVENTION

[0030] Introduction

[0031] The following discussion and accompanying figures disclose an article of apparel **10** in accordance with the present invention. Apparel **10** is depicted in **FIG. 1** as having the general configuration of a conventional short-sleeved shirt. One skilled in the relevant art will recognize, however, that the various textiles disclosed in the following material may be incorporated into articles of apparel exhibiting a variety of configurations, including long-sleeved shirts, headwear, coats, jackets, pants, underwear, gloves, socks, and footwear, for example. Accordingly, the various concepts disclosed in the following discussion and accompanying figures with respect to apparel **10** may be utilized in connection with a variety of apparel configurations.

[0032] The primary elements of apparel **10** include a torso portion **11** and two arm portions **12***a* and **12***b*. Torso portion **11** corresponds with a torso of an individual and, therefore, covers the torso when worn. Similarly, arm portions **12***a* and **12***b* respectively correspond with a right arm and a left arm of the individual and cover the arms when worn. Apparel **10** exhibits, therefore, the general configuration of a conventional long-sleeved shirt. In contrast with the conventional long-sleeved shirt, however, apparel **10** is at least partially formed from a textile with a structure that is modified by a physical stimulus, thereby changing properties of the textile. For example, the permeability or texture of the textiles may change when exposed to water, increased temperature, or moving air (i.e., wind). Accordingly, the structures of the textiles may be modified in order to provide apparel **10** with different properties. The following material discloses a variety of textiles with a structure that is modified by a physical stimulus in order to change the properties of the textile or apparel **10**.

[0033] First Textile Structure

[0034] A portion of a textile **20** that is suitable for apparel **10** is disclosed in **FIGS. 2 and 3**. Textile **20** has the structure of an interwoven material that includes a plurality of weft yarns **21** and a plurality of warp yarns **22**. Textile **20** may be formed, therefore, by mechanically manipulating yarns **21** and **22** thorough an interweaving process, which involves crossing and interweaving yarns **21** and **22** at substantially right angles to each other. The process of crossing and interweaving yarns **21** and **22** at substantially right angles to each other forms a plurality of discrete openings **23** that are located between the various yarns **21** and **22**.

[0035] Each of yarns **21** and **22** are formed from one or more filaments or fibers that experience a dimensional-transformation when exposed to a specific physical stimulus. In other words, the dimensions (i.e., length and thickness, for example) of yarns **21** and **22** change when textile **20** is in the presence of the physical stimulus. The dimensional-transformation of yarns **21** and **22** has an effect upon the structure of textile **20**. More particularly, the dimensional-transformation of yarns **21** and **22** modifies the structure of textile **20**, thereby changing the properties of textile **20**. Accordingly, exposing textile **20** to the physical stimulus has the effect of changing the properties of textile **20**, thereby changing the properties of apparel **10**.

[0036] The manner in which exposing textile **20** to a physical stimulus has an effect upon the properties of textile **20** will now be discussed. With reference to **FIG. 2**, textile **20** is depicted in an unexposed state, in which yarns **21** and **22** are not exposed to the physical stimulus. With reference to **FIG. 3**, however, textile **20** is depicted in an exposed state, in which yarns **21** and **22** are exposed to the physical

stimulus. In the unexposed state, yarns **21** and **22** exhibit dimensions with a relatively narrow thickness such that the area of each opening **23** is relatively large. In the exposed state, however, yarns **21** and **22** exhibit a greater thickness, which decreases the area of each opening **23**. That is, exposing yarns **21** and **22** to the physical stimulus causes yarns **21** and **22** to increase in thickness, which decreases the area of each opening **23** and modifies the structure of textile **20**.

[**0037**] The modification in the structure of textile **20** (i.e., decreasing the area of openings **23**) changes the properties of textile **20**. In the unexposed state, each opening **23** is relatively large. In the exposed state, however, the area of each opening **23** is decreased, which decreases the overall permeability of textile **20** to water, light, and moving air, for example. That is, the smaller area of each opening **23** in the exposed state decreases the ease with which water, light, and moving air may penetrate or otherwise extend through textile **20**. Accordingly, exposing textile **20** to a physical stimulus changes the permeability properties of textile **20**, thereby changing the permeability properties of apparel **10**.

[**0038**] Various physical stimuli may induce a dimensional-transformation of yarns **21** and **22**, including the presence of water (whether in a liquid or gaseous state), increased temperature, or moving air, for example. With regard to water, many materials exhibit a tendency to absorb water and swell or otherwise transform dimensionally. The dimensional-transformation may occur relatively rapidly due to immersion or contact with liquid water. In addition, the dimensional-transformation may occur relatively slowly due to a prolonged exposure to air with a relative humidity that is greater than 75 percent, for example. Textile **20**, and particularly yarns **21** and **22**, may be formed from one or more of these materials that exhibit a tendency to transform dimensionally in the presence of a physical stimulus such as water. Furthermore, yarns **21** and **22** may be formed from materials that transform dimensionally due to temperature increases or moving air.

[**0039**] Yarns **21** and **22**, as discussed above, may be formed from a variety of materials that transform dimensionally in the presence of water. For example, at least a portion of the filaments or fibers in yarns **21** and **22** may be formed of a moisture-absorptive polyester material, such as the various moisture-absorptive polyester materials manufactured by Tejin Fibers Limited of Japan. In some embodiments, yarns **21** and **22** may be a 75 denier, 72 filament semi-dull textured polyester yarn, and suitable formulations for the fiber or filament contents of yarns **21** and **22** include: (i) 70 percent generally non-absorptive polyester and 30 percent moisture-absorptive polyester; (ii) 76 percent generally non-absorptive polyester and 24 percent moisture-absorptive polyester; (iii) 80 percent generally non-absorptive polyester and 20 percent moisture-absorptive polyester; or (iv) 84 percent cationic-dyeable polyester that is also generally non-absorptive and 16 percent moisture-absorptive polyester. Accordingly, the percentage of the fibers or filaments formed from moisture-absorptive polyester may vary considerably within the scope of the present invention, and may also range from 5 percent to 100 percent in some embodiments. In each of the examples above, a non-absorptive or otherwise dimensionally-stable polyester fibers or filaments are combined with a moisture-absorptive polyester fibers or filaments. Other non-absorptive polymer fibers or filaments may also be utilized, such as rayon, nylon, and polyacrylic. In addition, silk, cotton, or wool may be utilized in yarns **21** and **22**. Accordingly, a wide range of materials are suitable for the various yarns **21** and **22**.

[**0040**] When incorporated into article of apparel **10**, textile **20** may be utilized to protect or otherwise insulate the individual from specific environmental conditions. As discussed above, one physical stimulus that induces a dimensional-transformation in yarns **21** and **22** is water, such as rain. When rain or another source of water (i.e., the physical stimulus) is not present, textile **20** is in the unexposed state and exhibits a relatively high permeability that permits air to freely enter and exit apparel **10**, thereby cooling the individual. When significant quantities of water contact apparel **10**, thereby placing textile **20** in the exposed state, textile **20** exhibits a relatively low permeability that inhibits the movement of water through textile **20**. More specifically, water in the form of rain that contacts apparel **10** will cause openings **23** to decrease in area and limit the quantity of water that enters apparel **10**. When yarns **21** and **22** are formed from a material that transforms dimensionally in the presence of heat, sunlight or other heat sources induce openings **23** to decrease in area and limit the quantity of solar radiation that enters apparel **10**. In addition, moving air in the form of wind may induce openings **23** to decrease in area to limit the quantity of air that passes through apparel **10**. Accordingly, forming textile **20** from yarns **21** and **22** that transform dimensionally in the presence of one or more physical stimuli may be utilized to effectively insulate the individual from specific environmental conditions, such as rain, sunlight, or wind.

[**0041**] Based upon the above discussion, textile **20** may be formed from various yarns **21** and **22** that transform dimensionally in the presence of a physical stimulus. The dimensional-transformation of yarns **21** and **22** modify the structure of textile **20**, thereby inducing a change in the properties of textile **20**. When incorporated into apparel **10**, the change in the properties of textile **20** when exposed to the physical stimulus may be utilized to insulate the individual from specific environmental conditions, such as rain, sunlight, or wind. Accordingly, textile **20** effectively adapts to changing environmental conditions in order to enhance the comfort of the individual wearing apparel **10**.

[**0042**] Second Textile Structure

[**0043**] With respect to textile **20**, both of yarns **21** and **22** are at least partially formed from materials that transform dimensionally in the presence of a physical stimulus. In some embodiments, however, various yarns may be entirely formed from a material that does not dimensionally transform to a significant degree in the presence of a physical stimulus. That is, some of the yarns forming the textile of apparel **10** may be formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus.

[**0044**] A textile **30** is depicted in **FIGS. 4 and 5** that includes a plurality of weft yarns **31***a*, a plurality of other weft yarns **31***b*, a plurality of warp yarns **32***a*, and a plurality of other warp yarns **32***b* that define various openings **33**. Whereas yarns **31***a* and **32***a* are formed from a material that dimensionally transforms in the presence of a physical stimulus, yarns **31***b* and **32***b* are formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus.

[0045] The manner in which exposing textile **30** to a physical stimulus has an effect upon the properties of textile **30** will now be discussed. With reference to **FIG. 4**, textile **30** is depicted in an unexposed state, in which yarns **31***a*, **31***b*, **32***a*, and **32***b* are not exposed to the physical stimulus. With reference to **FIG. 5**, however, textile **30** is depicted in an exposed state, in which yarns **31***a*, **31***b*, **32***a*, and **32***b* are exposed to the physical stimulus. In the unexposed state, each of yarns **31***a*, **31***b*, **32***a*, and **32***b* exhibit dimensions with a relatively narrow thickness such that the area of each opening **33** is relatively large. In the exposed state, however, yarns **31***a* and **32***a* exhibit a greater thickness, which decreases the area of each opening **33**. That is, exposing yarns **31***a* and **32***a* to the physical stimulus causes yarns **31***a* and **32***a* to increase in thickness, which decreases the area of each opening **33** and modifies the structure of textile **30**. As discussed above, yarns **31***b* and **32***b* are formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus. Accordingly, **31***b* and **32***b* do not transform dimensionally when exposed to the physical stimulus.

[0046] The modification in the structure of textile **30** (i.e., decreasing the area of openings **33**) changes the properties of textile **30**. In the unexposed state, each opening **33** is relatively large. In the exposed state, however, the area of each opening **33** is decreased, which decreases the overall permeability of textile **30** to water, light, and moving air, for example. That is, the smaller area of each opening **33** in the exposed state decreases the ease with which water, light, and moving air may penetrate through textile **30**. Accordingly, exposing textile **30** to a physical stimulus changes the permeability properties of textile **30**. Given that textile **30** may replace textile **20** in apparel **10**, exposing textile **30** to a physical stimulus may be utilized to effectively change the permeability properties of apparel **10**.

[0047] An advantage of forming yarns **31***b* and **32***b* from a dimensionally-stable yarn that is not significantly affected by the physical stimulus relates to the dimensional stability of textile **30**. Yarns **31***b* and **32***b* form a web in textile **30** that does not significantly change dimensions when exposed to the physical stimulus. Whereas yarns **31***a* and **32***a* transform dimensionally, yarns **31***b* and **32***b* remain dimensionally-stable (i.e., in their original dimensions). Accordingly, yarns **31***b* and **32***b* may be utilized to ensure that the shape and dimensions of textile **30** are retained, despite the dimensional-transformation of yarns **31***a* and **32***a*.

[0048] Third Textile Structure

[0049] Another potential configuration for the textile that forms at least a portion of apparel **10** is disclosed in **FIGS. 6 and 7**, in which a plurality of weft yarns **41** and a plurality of warp yarns **42** define various openings **43**. Whereas weft yarns **41** are formed from a material that dimensionally transforms in the presence of a physical stimulus, warp yarns **42** are formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus. Accordingly, weft yarns **41** do not substantially change dimensions when exposed to the physical stimulus.

[0050] Exposing textile **40** to a physical stimulus modifies the structure of textile **40**, which has an effect upon the properties of textile **40**. With reference to **FIG. 6**, textile **40** is depicted in an unexposed state, in which yarns **41** and **42** are not exposed to the physical stimulus. With reference to **FIG. 7**, however, textile **40** is depicted in an exposed state, in which yarns **41** and **42** are exposed to the physical stimulus. As with textiles **20** and **30**, exposing yarns **41** and **42** to the physical stimulus causes yarns **41** to increase in thickness, which decreases the area of each opening **43** and modifies the structure of textile **40**. The modification in the structure of textile **40** (i.e., decreasing the area of openings **43**) changes the properties of textile **40**. In the unexposed state, each opening **33** is relatively large. In the exposed state, however, the area of each opening **33** is decreased, which decreases the overall permeability of textile **30** to water, light, and moving air, for example. Given that textile **40** may replace textile **20** in apparel **10**, exposing textile **40** to a physical stimulus may be utilized to effectively change the permeability properties of apparel **10**. As with textile **30**, forming warp yarns **42** from a dimensionally-stable yarn that is not significantly affected by the physical stimulus ensures that the shape and dimensions of textile **40** are retained, despite the dimensional-transformation of weft yarns **41**.

[0051] Fourth Textile Structure

[0052] The configurations of textiles **20**, **30**, and **40** may be utilized to protect or otherwise insulate the individual from specific environmental conditions. As discussed above, the dimensional-transformation of various yarns induces the openings between the yarns to decrease in area. The decrease in area decreases the permeability of textiles **20**, **30**, and **40**, thereby permitting less rain, sunlight, or wind to enter apparel **10**. It may be desirable in some situations, however, to increase the permeability of the textile forming apparel **10**. For example, increasing the permeability may be utilized to increase air flow through the textile forming apparel **10**, thereby enhancing the removal of perspiration from the individual.

[0053] A textile **50** with the structure of an interwoven material that includes a plurality of weft yarns **51**, a plurality of warp yarns **52***a*, and a plurality of warp yarns **52***b* is depicted in **FIGS. 8 and 9**. Textile **50** may be formed, therefore, by mechanically manipulating yarns **51**, **52***a*, and **52***b* thorough an interweaving process, which involves crossing and interweaving weft yarns **51** at substantially right angles to yarns **52***a* and **52***b*. The process of crossing and interweaving weft yarns **51** at substantially right angles to yarns **52***a* and **52***b* forms a plurality of discrete openings **53**.

[0054] Whereas yarns **52***a* are formed from a material that dimensionally transforms in the presence of a physical stimulus, yarns **51** and **52***b* are formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus. In addition, warp yarns **52***a* exhibit an undulating or otherwise wavy configuration, whereas yarns **51** and **52***b* are relatively straight.

[0055] The manner in which exposing textile **50** to a physical stimulus has an effect upon the properties of textile **50** will now be discussed. With reference to **FIG. 8**, textile **50** is depicted in an unexposed state, in which yarns **51**, **52***a*, and **52***b* are not exposed to the physical stimulus. With reference to **FIG. 9**, however, textile **50** is depicted in an exposed state, in which yarns **51**, **52***a*, and **52***b* are exposed to the physical stimulus. In the unexposed state, yarns **51**, **52***a*, and **52***b* exhibit dimensions with a relatively narrow thickness such that the area of each opening **53** is relatively small. In the exposed state, however, warp yarns **52***a* exhibit

a greater thickness and a greater degree of undulation, which increases the area of each opening **53**. That is, exposing yarns **51**, **52***a*, and **52***b* to the physical stimulus causes warp yarns **52***a* to increase in thickness and degree of undulation, which increases the area of each opening **53** and modifies the structure of textile **50**.

[**0056**] The modification in the structure of textile **50** (i.e., increasing the area of openings **53**) changes the properties of textile **50**. In the unexposed state, each opening **53** is relatively small. In the exposed state, however, the area of each opening **53** is increased, which increases the overall permeability of textile **50** to water, light, and moving air, for example. That is, the greater area of each opening **53** in the exposed state increases the ease with which water, light, and moving air may penetrate through textile **50**. Accordingly, exposing textile **50** to a physical stimulus increases the permeability properties of textile **50**, thereby increasing the permeability properties of apparel **10**.

[**0057**] When incorporated into article of apparel **10**, textile **50** may be utilized to cool the individual and remove perspiration from the individual, for example. Based upon the above discussion, therefore, textile **50** may be formed from various warp yarns **52***a* that transform dimensionally and in degree of undulation in the presence of a physical stimulus. The dimensional-transformation of warp yarns **52***a* modifies the structure of textile **50**, thereby inducing a change in the properties of textile **50**. When incorporated into apparel **10**, the change in the properties of textile **50** when exposed to the physical stimulus may be utilized to cool the individual and remove perspiration from the individual. Accordingly, textile **50** effectively adapts to changing perspiration levels of the individual in order to enhance the comfort of the individual wearing apparel **10**.

[**0058**] Fifth Textile Structure

[**0059**] Each of textiles **20**, **30**, **40**, and **50** are formed thorough an interweaving process, which involves crossing and interweaving weft yarns and warp yarns at substantially right angles to each other. A textile that adapts to changing perspiration levels of the individual, for example, in order to enhance the comfort of the individual may also be formed through other methods of mechanically-manipulating yarns. Referring to FIGS. **10** and **11**, a textile **60** that is formed through an interlooping process is disclosed. Interlooping involves the formation of a plurality of columns of intermeshed loops, with knitting being the most common method of interlooping. Textile **60** includes a plurality of courses (i.e., a row of needle loops produced by adjacent needles during the knitting cycle) and a plurality of wales (i.e., a column of intermeshed needle loops generally produced by the same needle the knits at successive knitting cycles) that are formed from a yarn **61**.

[**0060**] Yarn **61** is formed from a material that dimensionally transforms in the presence of a physical stimulus. More particularly, the dimensions of yarn **61** (i.e., length and thickness, for example) may increase in the presence of the physical stimulus. When exposed to a physical stimulus, yarn **61** dimensionally-transforms in both length and thickness. Although an increase thickness would appear to decrease the area of each opening **62**, the associated increase in length separates the various portions of yarn **61** to a greater degree and actually increases the area of each opening **63**. That is, the increase in thickness has a greater effect upon the area of openings **63** than the increase in thickness, thereby increasing the overall area of each opening **63**. When exposed to the physical stimulus, therefore, the permeability of textile **60** may increase.

[**0061**] The manner in which exposing textile **60** to a physical stimulus has an effect upon the properties of textile **60** will now be discussed in greater detail. With reference to **FIG. 10**, textile **60** is depicted in an unexposed state, in which yarn **61** is not exposed to the physical stimulus. With reference to **FIG. 11**, however, textile **60** is depicted in an exposed state, in which yarn **61** is exposed to the physical stimulus. In the unexposed state, the area of each opening **63** is relatively small. In the exposed state, however, yarn **61** exhibits a greater thickness and a greater length. As discussed above, the increase in length dominates the increase in thickness in order to increase the overall area of each opening **63**. That is, exposing yarn **60** to the physical stimulus causes yarn **60** to increase in length, which increases the area of each opening **63** and modifies the structure of textile **60**.

[**0062**] The modification in the structure of textile **60** (i.e., increasing the area of openings **63**) changes the properties of textile **60**. In the unexposed state, each opening **63** is relatively small. In the exposed state, however, the area of each opening **63** is increased, which increases the overall permeability of textile **60** to water, light, and moving air, for example. That is, the greater area of each opening **63** in the exposed state increases the ease with which water, light, and moving air may penetrate through textile **60**. Accordingly, exposing textile **60** to a physical stimulus increases the permeability properties of textile **60**, thereby increasing the permeability properties of apparel **10**.

[**0063**] When incorporated into article of apparel **10**, textile **60** may be utilized to cool the individual and remove perspiration from the individual, for example. Based upon the above discussion, therefore, textile **60** may be formed from yarn **61**, which transforms dimensionally and in degree of undulation in the presence of a physical stimulus. The dimensional-transformation of yarn **61** modifies the structure of textile **60**, thereby inducing a change in the properties of textile **60**. When incorporated into apparel **10**, the change in the properties of textile **60** when exposed to the physical stimulus may be utilized to cool the individual and remove perspiration from the individual. Accordingly, textile **60** effectively adapts to changing perspiration levels of the individual in order to enhance the comfort of the individual wearing apparel **10**.

[**0064**] Sixth Textile Structure

[**0065**] Increasing or decreasing the area of openings between the various yarns that form a textile is one manner in which the structure of the textile may be modified in order to change the properties (i.e., permeability) of the textile. In some embodiments, the texture of the textile may also be modified in order to change the properties of the textile. Referring to **FIGS. 12-15**, a textile **70** is disclosed. Textile **70** is formed from a yarn **71** and a yarn **72** through an interlooping process. As will be described in greater detail below, the texture of textile **70** changes from being relatively smooth to having a plurality of nodes **73** that form a separation between the individual and textile **70**. Nodes **73** effectively hold textile **70** away from the individual and permit air to flow between textile **70** and the individual,

thereby increasing removal of perspiration. In order to form textile **70**, yarns **71** and **72** are mechanically-manipulated through a circular knitting process to form textile **70** with a double knit structure. In some embodiments, three or more yarns may be utilized to form textile **70**, and a variety of other knit structures in addition to the double knit structure may be utilized.

[**0066**] Whereas yarn **71** is formed from a material that dimensionally transforms in the presence of a physical stimulus, yarn **72** is formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus. Accordingly, yarn **71** substantially changes dimensions when exposed to the physical stimulus. Yarn **71** extends through the structure formed by yarn **72** and is primarily positioned on one side of textile **70**. That is, the position of yarn **71** is concentrated on one side of textile **70**. When exposed to the physical stimulus, yarn **71** transforms dimensionally, whereas yarn **72** remains dimensionally-stable. The dimensions of yarn **71** increase when exposed to the physical stimulus and form a plurality of nodes **73** on one side of textile **70**. That is, the concentrated areas of yarn **71** expand when exposed to the physical stimulus and form nodes **73**.

[**0067**] With reference to **FIG. 12** and **13**, textile **70** is depicted in an unexposed state, in which yarns **71** and **72** are not exposed to the physical stimulus. With reference to **FIGS. 14 and 15**, however, textile **70** is depicted in an exposed state, in which yarns **71** and **72** are exposed to the physical stimulus. In the unexposed state, textile **70** exhibits a relatively smooth texture. In the exposed state, however, textile **70** exhibits greater texture due to the presence of the plurality of nodes **73**. That is, exposing yarn **71** to the physical stimulus forms nodes **73** on one side of textile **70** and causes textile **70** to increase in texture, which modifies the structure of textile **70**.

[**0068**] The modification in the structure of textile **70** changes the properties of textile **70**. In the unexposed state, textile **70** is relatively smooth and significantly contacts the individual. In the exposed state, however, the texture of textile **70** is increased through the formation of nodes **73**, which forms a separation between the individual and textile **70**. That is, nodes **73** effectively hold textile **70** away from the individual and permit air to flow between textile **70** and the individual, thereby increasing the rate at which perspiration is removed. Exposing textile **70** to a physical stimulus increases the texture of textile **70**, thereby increasing the texture properties of apparel **10**. Accordingly, textile **70** effectively adapts to changing perspiration levels of the individual in order to enhance the comfort of the individual wearing apparel **10**.

CONCLUSION

[**0069**] Based upon the above discussion, various textiles may be formed from yarns that transform dimensionally in the presence of a physical stimulus. The dimensional-transformation of the yarns modifies the structures of the textiles, thereby inducing a change in the properties of textiles. When incorporated into an article of apparel, the change in the properties of the textiles when exposed to the physical stimulus may be utilized to insulate the individual from specific environmental conditions or adapts to changing perspiration levels of the individual, for example. Accordingly, the present invention relates to textiles that effectively adapt to enhance the comfort of the individual wearing the apparel.

[**0070**] The present invention is disclosed above and in the accompanying drawings with reference to a variety of embodiments. 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 embodiments described above without departing from the scope of the present invention, as defined by the appended claims.

That which is claimed is:

1. An article of apparel comprising a textile with at least one property that changes upon exposure to a physical stimulus, the textile having a modifiable structure formed from yarns that exhibit a dimensional-transformation upon exposure to the physical stimulus, the yarns having a first set of dimensions when unexposed to the physical stimulus, and the yarns having a second set of dimensions when exposed to the physical stimulus, the structure of the textile being modified by exposing the textile to the physical stimulus such that the yarns transform from the first set of dimensions to the second set of dimensions and change the property of the textile.

2. The article of apparel recited in claim 1, wherein the physical stimulus is water.

3. The article of apparel recited in claim 1, wherein the first set of dimensions is less than the second set of dimensions.

4. The article of apparel recited in claim 1, wherein the textile is formed through an interweaving process.

5. The article of apparel recited in claim 4, wherein the yarns define openings in the textile, the openings exhibiting a first area when the yarns are unexposed to the physical stimulus, and the openings exhibiting a second area when the yarns are exposed to the physical stimulus.

6. The article of apparel recited in claim 5, wherein the property of the textile is permeability of the textile.

7. The article of apparel recited in claim 6, wherein the first area is greater than the second area to decrease the permeability of the textile when the yarns are exposed to the physical stimulus.

8. The article of apparel recited in claim 6, wherein the first area is less than the second area to increase the permeability of the textile when the yarns are exposed to the physical stimulus.

9. The article of apparel recited in claim 8, wherein at least a portion of the yarns exhibit an undulating configuration.

10. The article of apparel recited in claim 4, wherein a substantial portion of the textile is formed from the yarn.

11. The article of apparel recited in claim 4, wherein a first portion of the yarns exhibit the dimensional-transformation upon exposure to the physical stimulus, and a second portion of the yarns remain dimensionally-stable upon exposure to the physical stimulus.

12. The article of apparel recited in claim 11, wherein the first portion of the yarns are both weft yarns and warp yarns, and the second portion of the yarns are both weft yarns and warp yarns.

13. The article of apparel recited in claim 11, wherein the first portion of the yarns are one of weft yarns and warp yarns, and the second portion of the yarns are another of weft yarns and warp yarns.

14. The article of apparel recited in claim 1, wherein the textile is formed through an interlooping process.

15. The article of apparel recited in claim 14, wherein the yarns define openings in the textile, the openings exhibiting a first area when the yarns are unexposed to the physical stimulus, and the openings exhibiting a second area when the yarns are exposed to the physical stimulus.

16. The article of apparel recited in claim 1, wherein the first area is less than the second area to increase the permeability when the yarns are exposed to the physical stimulus.

17. The article of apparel recited in claim 1, wherein the structure of the textile exhibits a first texture when the yarns are unexposed to the physical stimulus, and the structure of the textile exhibits a second texture when the yarns are exposed to the physical stimulus.

18. The article of apparel recited in claim 17, wherein the first texture is smoother than the second texture.

19. The article of apparel recited in claim 17, wherein the second texture includes a plurality of nodes that extend outward from a surface of the textile.

20. An article of apparel comprising a textile with a permeability that changes upon exposure to a physical stimulus, the textile having a plurality of openings defined between yarns that exhibit a dimensional-transformation upon exposure to the physical stimulus, the yarns having a first set of dimensions when unexposed to the physical stimulus, and the yarns having a second set of dimensions when exposed to the physical stimulus, the structure of the textile being modified by exposing the textile to the physical stimulus such that the yarns transform from the first set of dimensions to the second set of dimensions and change the permeability of the textile.

21. The article of apparel recited in claim 20, wherein the physical stimulus is water.

22. The article of apparel recited in claim 20, wherein the textile is formed through an interweaving process.

23. The article of apparel recited in claim 22, wherein the openings decrease in area to decrease the permeability of the textile when the yarns are exposed to the physical stimulus.

24. The article of apparel recited in claim 22, wherein the openings increase in area to increase the permeability of the textile when the yarns are exposed to the physical stimulus.

25. The article of apparel recited in claim 24, wherein at least a portion of the yarns exhibit an undulating configuration.

26. The article of apparel recited in claim 20, wherein a substantial portion of the textile is formed from the yarn.

27. The article of apparel recited in claim 20, wherein a first portion of the yarns exhibit the dimensional-transformation upon exposure to the physical stimulus, and a second portion of the yarns remain dimensionally-stable upon exposure to the physical stimulus.

28. The article of apparel recited in claim 20, wherein the textile is formed through an interlooping process.

29. The article of apparel recited in claim 20, wherein the textile exhibits a first texture when the yarns are unexposed to the physical stimulus, and the textile exhibits a second texture when the yarns are exposed to the physical stimulus.

30. The article of apparel recited in claim 29, wherein the first texture is smoother than the second texture.

31. The article of apparel recited in claim 29, wherein the second texture includes a plurality of nodes that extend outward from a surface of the textile.

32. An article of apparel at least partially formed from an interwoven textile, the textile comprising:

a first yarn that exhibits a dimensional-transformation upon exposure to water; and

a second yarn that is substantially dimensionally-stable upon exposure to the water, wherein the textile is formed by mechanically-manipulating the first yarn and the second yarn, the textile exhibiting a first structure when unexposed to the water, and the textile exhibiting the second structure when exposed to the water due to the dimensional-transformation of the first yarn.

33. The article of apparel recited in claim 32, wherein the dimensional-transformation of the first yarn increases dimensions of the first yarn.

34. The article of apparel recited in claim 32, wherein the first yarn and the second yarn define openings in the textile, the openings exhibiting a first area when the first yarn and the second yarn are unexposed to the water, and the openings exhibiting a second area when the first yarn and the second yarn are exposed to the water to modify the structure of the textile.

35. The article of apparel recited in claim 34, wherein the first area is greater than the second area to decrease a permeability of the textile when the first yarn and the second yarn are exposed to the water.

36. The article of apparel recited in claim 34, wherein the first area is less than the second area to increase a permeability of the textile when the first yarn and the second yarn are exposed to the water.

37. The article of apparel recited in claim 36, wherein at least a portion of the yarns exhibit an undulating configuration.

38. The article of apparel recited in claim 32, wherein the first yarn is both weft yarns and warp yarns, and the second yarn is both weft yarns and warp yarns.

39. The article of apparel recited in claim 32, wherein the first yarn is one of weft yarns and warp yarns, and the second yarn is another of weft yarns and warp yarns.

40. An article of apparel at least partially formed from an interlooped textile, the textile comprising a yarn that exhibits a dimensional-transformation upon exposure to water, the yarn having a first set of dimensions when unexposed to the water, and the yarn having a second set of dimensions when exposed to the water, a structure of the textile being modified by exposing the textile to the water such that the yarns transform from the first set of dimensions to the second set of dimensions and change a permeability of the textile.

41. The article of apparel recited in claim 40, wherein the yarn defines openings in the textile, the openings exhibiting a first area when the yarn is unexposed to the water, and the openings exhibiting a second area when the yarn is exposed to the water to modify the structure of the textile.

42. The article of apparel recited in claim 41, wherein the first area is less than the second area to increase the permeability of the textile when the yarns are exposed to the water.

43. The article of apparel recited in claim 40, wherein the structure of the textile exhibits a first texture when the yarn is unexposed to the water, and the structure of the textile exhibits a second texture when the yarn is exposed to the water to modify the structure of the textile.

44. The article of apparel recited in claim 43, wherein the first texture is smoother than the second texture.

45. The article of apparel recited in claim 43, wherein the second texture includes a plurality of nodes that extend outward from a surface of the textile.

46. An article of apparel at least partially formed from an interlooped textile, the textile comprising:

a first yarn that exhibits a dimensional-transformation upon exposure to water, the first yarn having a first set of dimensions when unexposed to the water, and the first yarn having a second set of dimensions when exposed to the water; and

a second yarn that is substantially dimensionally-stable upon exposure to the water, the textile having a first surface and an opposite second surface, the first yarn being substantially concentrated at the first surface, a structure of the textile being modified by exposing the textile to the water such that the first yarn transform from the first set of dimensions to the second set of dimensions to form a plurality of nodes on the first surface.

47. The article of apparel recited in claim 46, wherein the first yarn and the second yarn are mechanically-manipulated to form a double knit structure.

48. The article of apparel recited in claim 46, wherein the second texture includes a plurality of nodes that extend outward from a surface of the textile.

49. The article of apparel recited in claim 46, wherein the nodes impart a texture to the textile on the first surface.

50. An article of apparel at least partially formed from an interwoven textile, the textile comprising:

a first yarn that exhibits an increasing dimensional-transformation upon exposure to water; and

a second yarn that is substantially dimensionally-stable upon exposure to the water, wherein the textile is formed by mechanically-manipulating the yarns to form a plurality of openings between the yarns, the openings having a first area when the yarns are unexposed to the water, and the openings having a second area when the yarns are exposed to the water due to the dimensional-transformation of the first yarn, the second area being greater than the first area to increase a permeability of the textile.

51. The article of apparel recited in claim 50, wherein at least a portion of the yarns exhibit an undulating configuration.

52. The article of apparel recited in claim 50, wherein the first yarn is both weft yarns and warp yarns, and the second yarn is both weft yarns and warp yarns.

53. The article of apparel recited in claim 50, wherein the first yarn is one of weft yarns and warp yarns, and the second yarn is another of weft yarns and warp yarns.

54. A method of manufacturing an article of apparel from a textile, the method comprising steps of:

selecting a first yarn with a first degree of water absorbency and a first degree of dimensional-transformation upon exposure to water;

selecting a second yarn with a second degree of water absorbency and a second degree of dimensional-transformation upon exposure to the water;

mechanically-manipulating the first yarn and the second yarn to form a textile with a structure that is modified from a first structure to a second structure upon exposure to the water to change a property of the textile.

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