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(54) **QUILTED INSULATING DIVING GLOVE**

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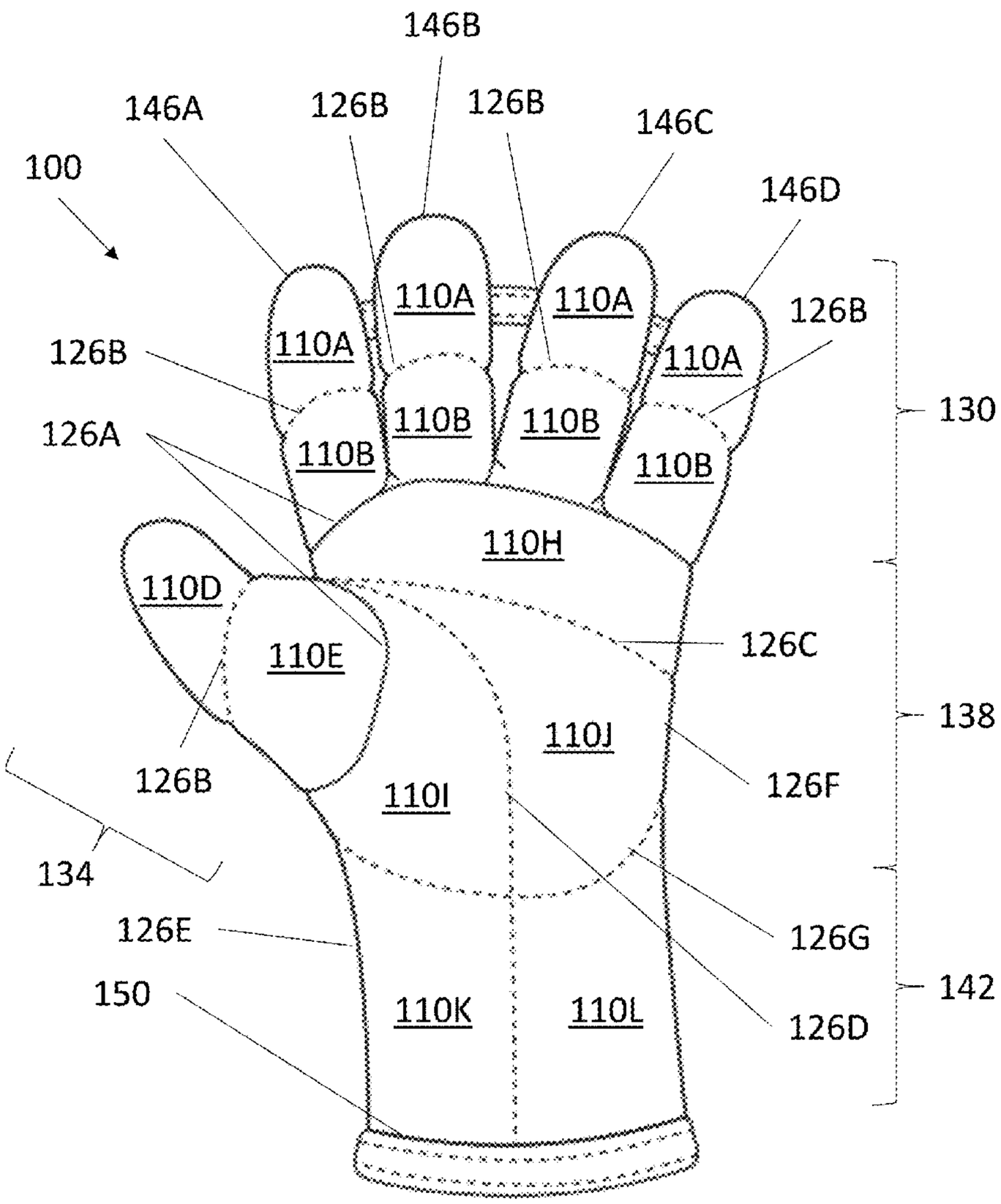
(57) **ABSTRACT**

A diving glove includes quilted material defining a plurality of pockets. Each of the pockets is filled with aerogel beads. The glove may be worn underneath a waterproof layer in a dry diving suit. The glove includes multiple seams dividing the pockets. The seams are located to maintain a distribution of beads across the glove that effectively insulates the wearer's hand and prevents the beads from impeding the wearer's manual dexterity. The glove includes a web portion extending across a back side of the fingers. The web portion can be used to create an enclosed space for insulating the wearer's fingers.



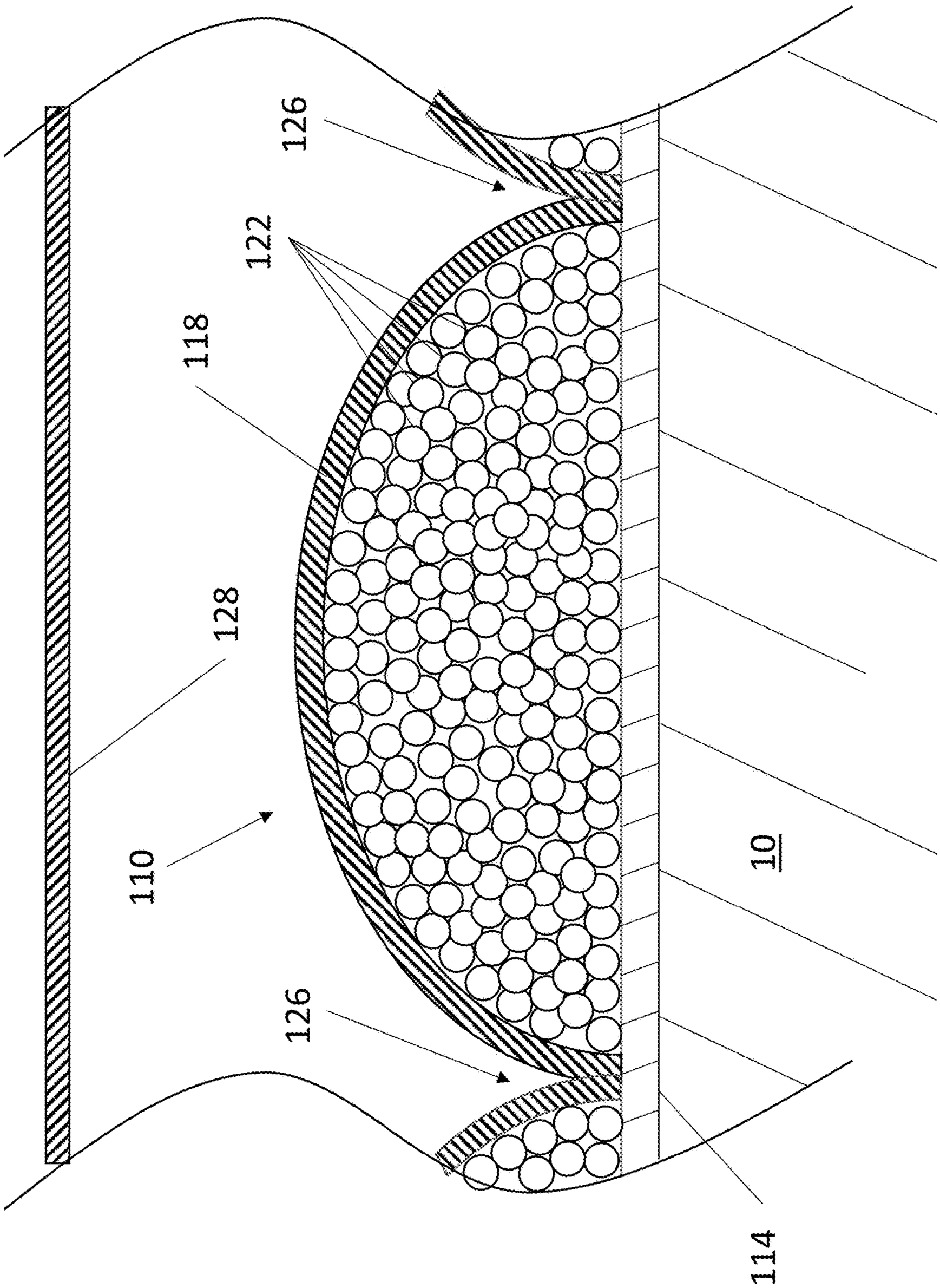


FIG. 1

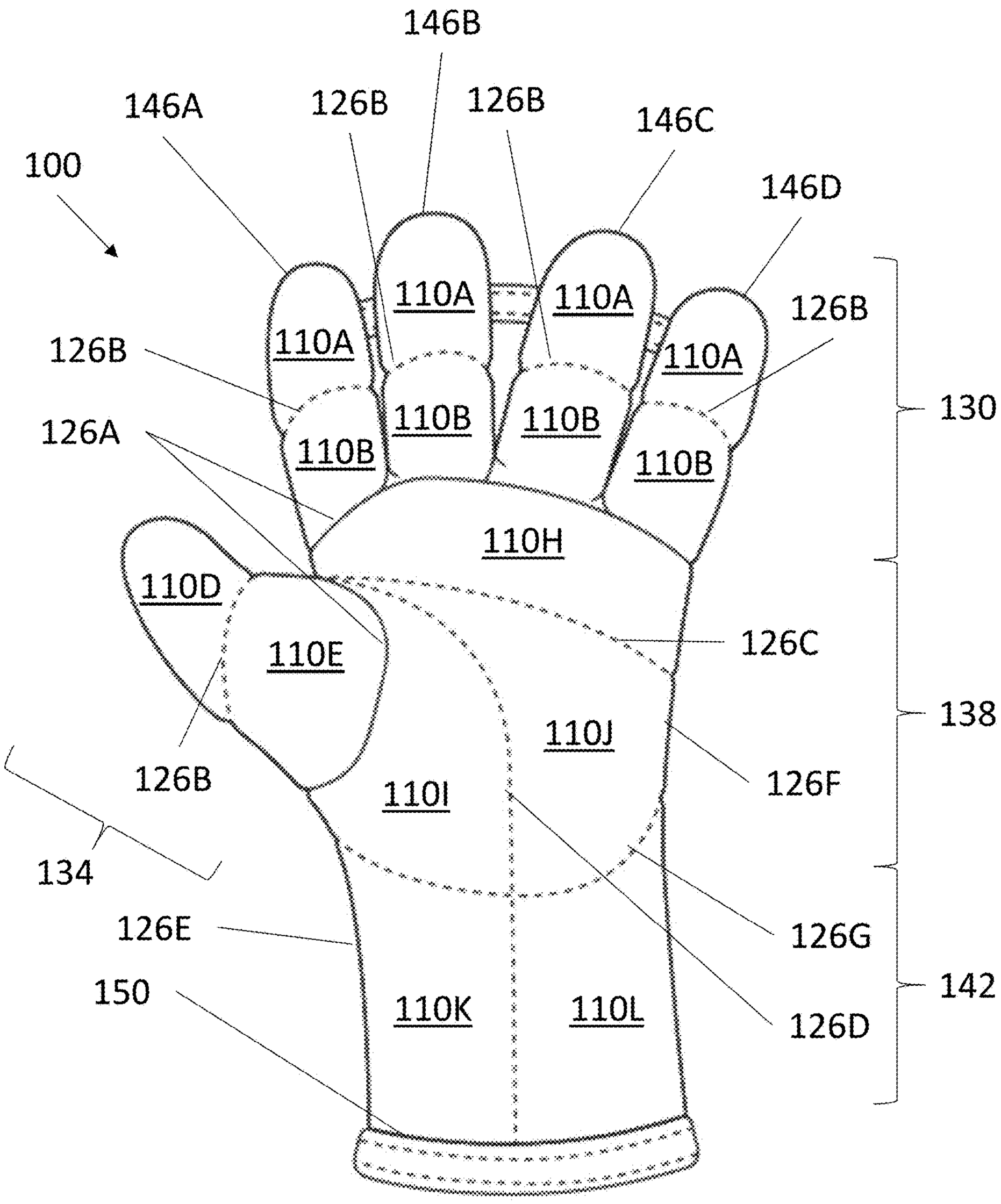

146B
146A
126B
126B
146C
100
146D
110A
110A
126B
110A
110A
126B
110B
110B
126A
110B
110B
110H
110D
126C
110E
138
110J
126F
126B
110I
134
126E
126G
150
110K
110L
126D
142
130

FIG. 2A

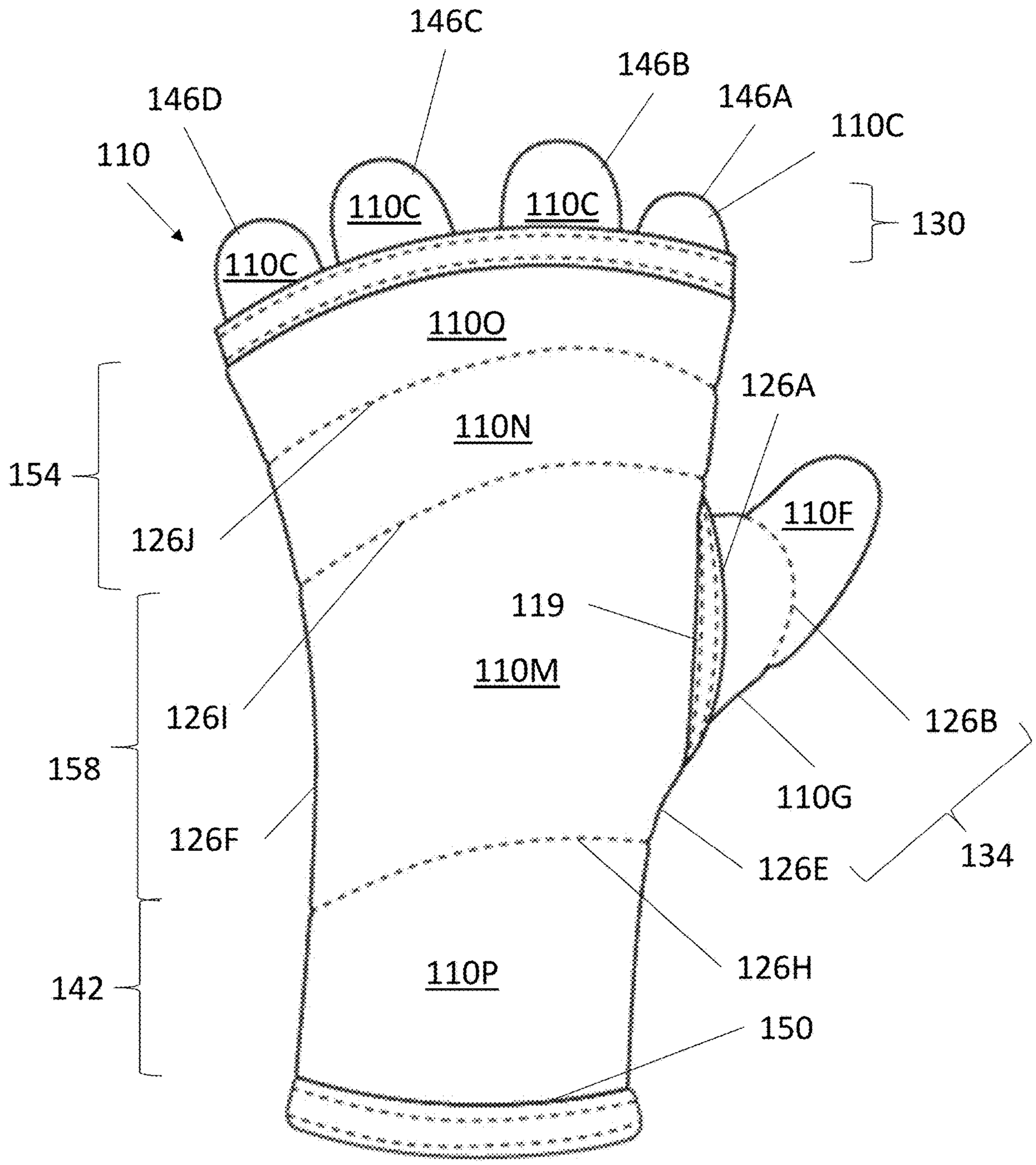

146C
146B
146D
146A
110C
110
110C
110C
130
110C
110O
110N
154
126A
126J
110F
119
110M
126I
126B
158
110G
126F
126E
134
110P
126H
142
150

FIG. 2B

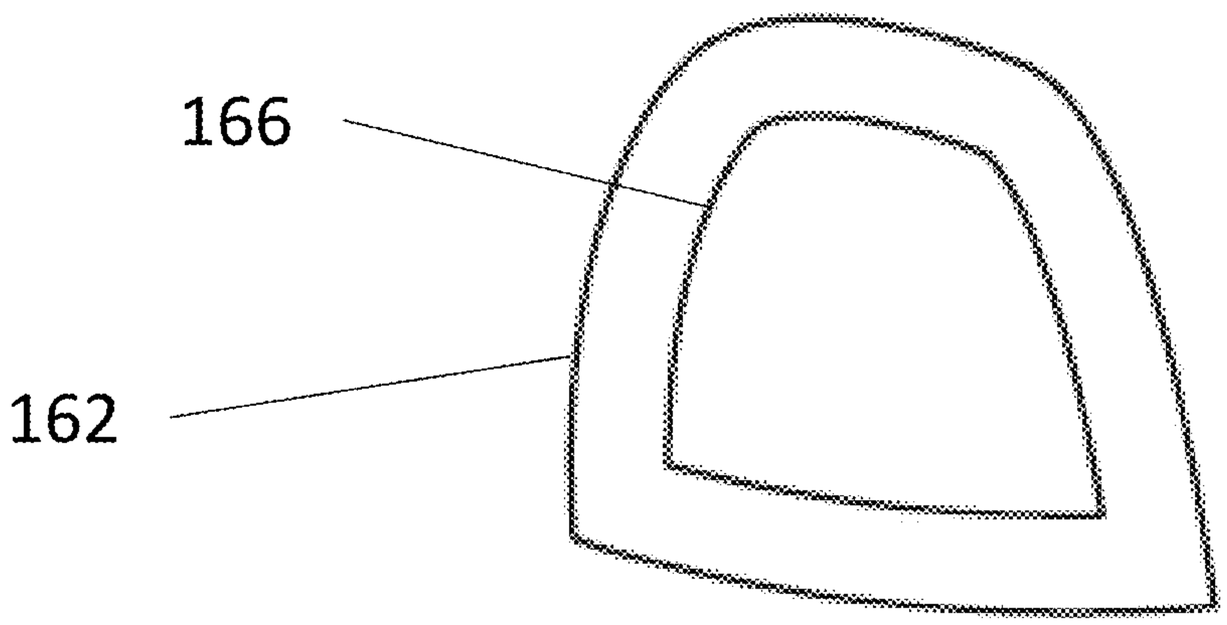


FIG. 3A

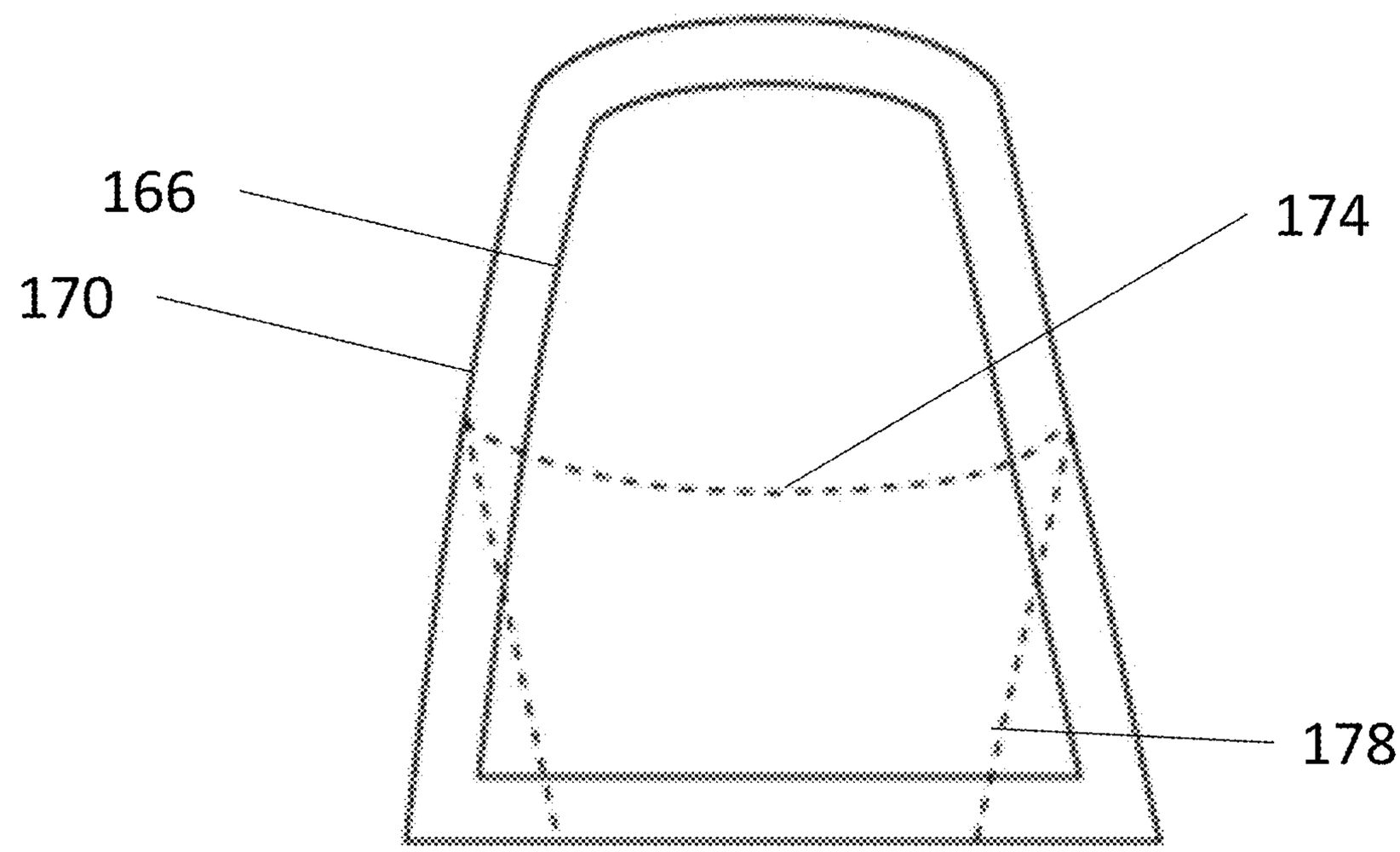


FIG. 3B

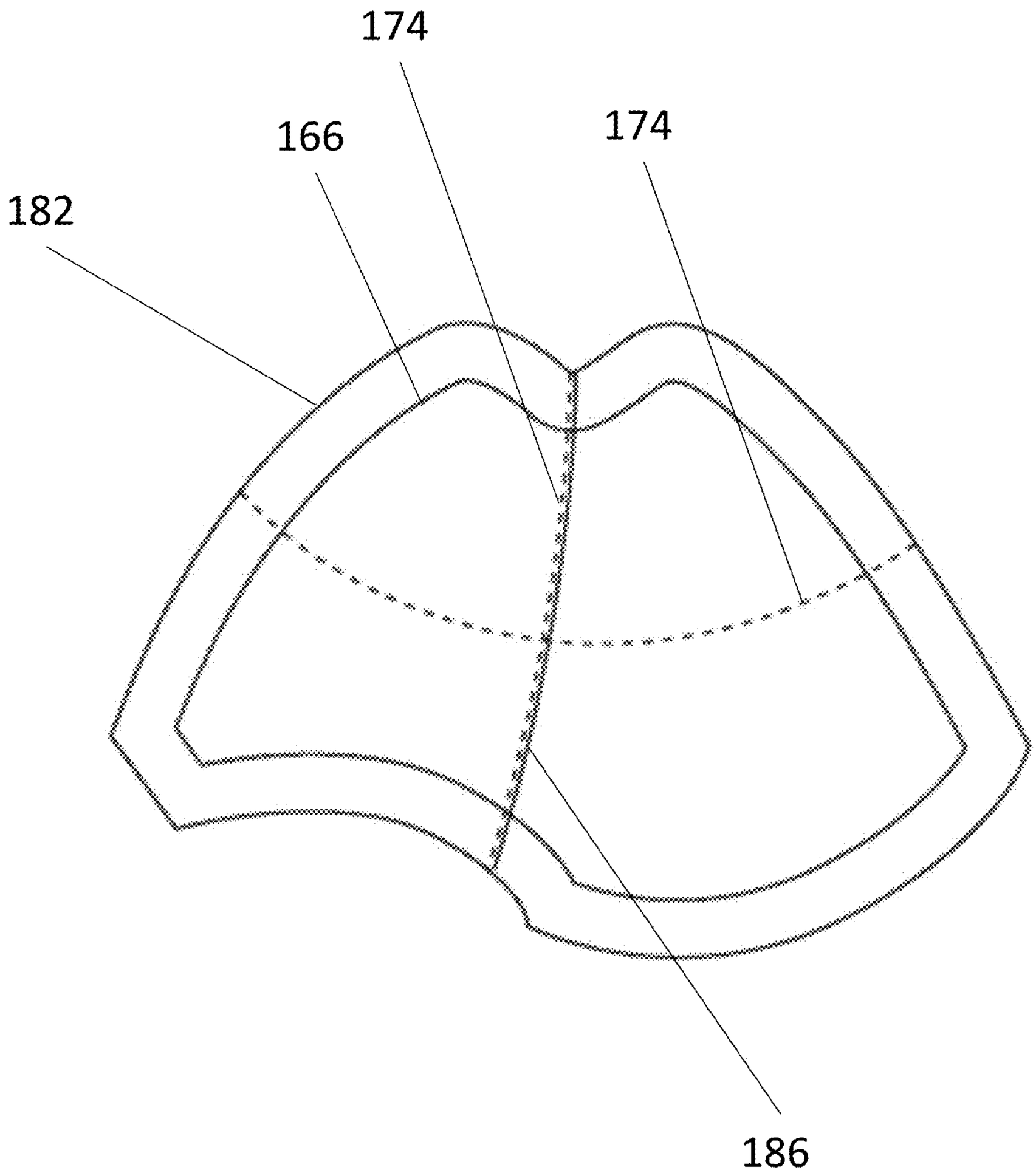


FIG. 3C

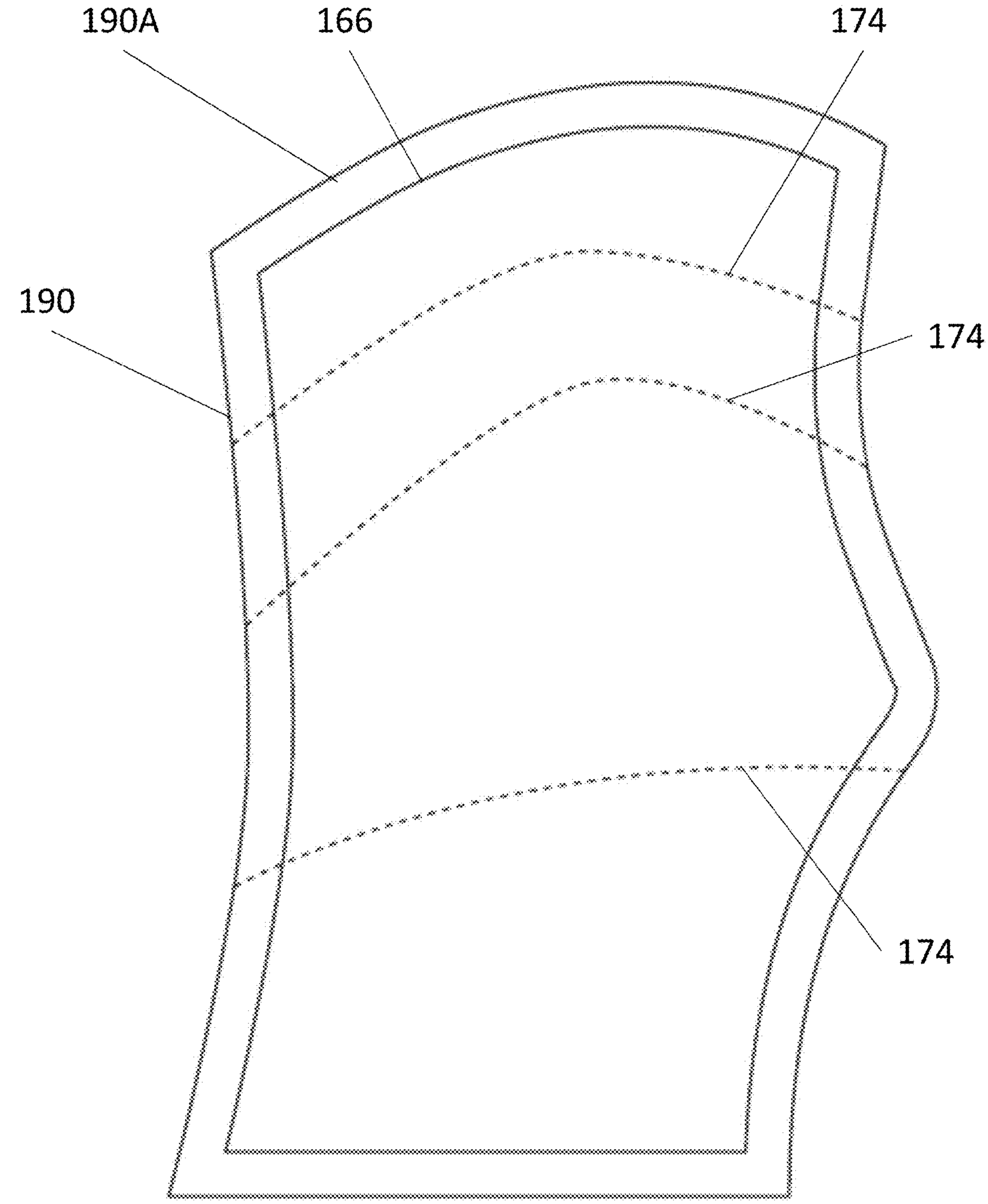


FIG. 3D

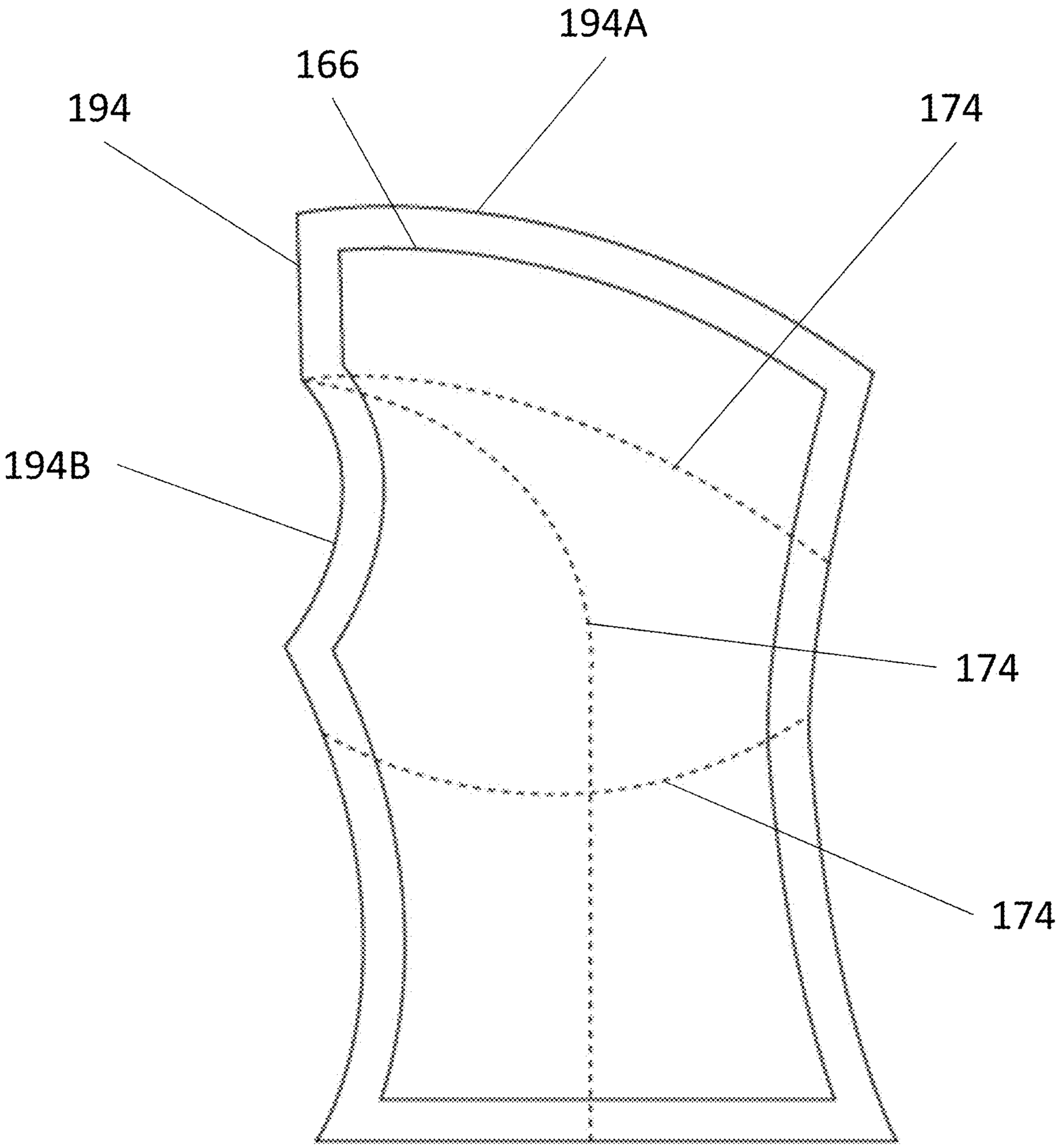


FIG. 3E

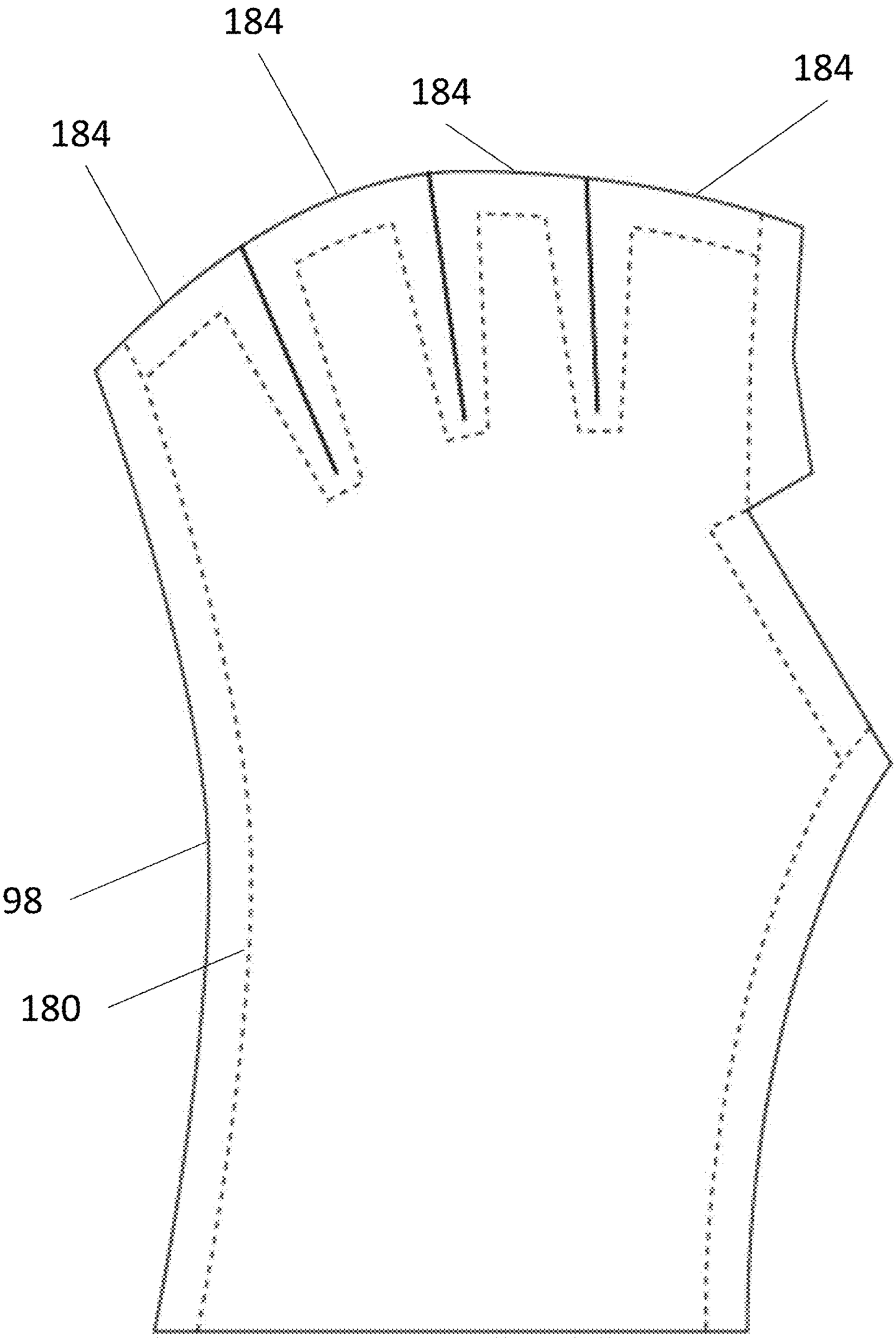


FIG. 3F

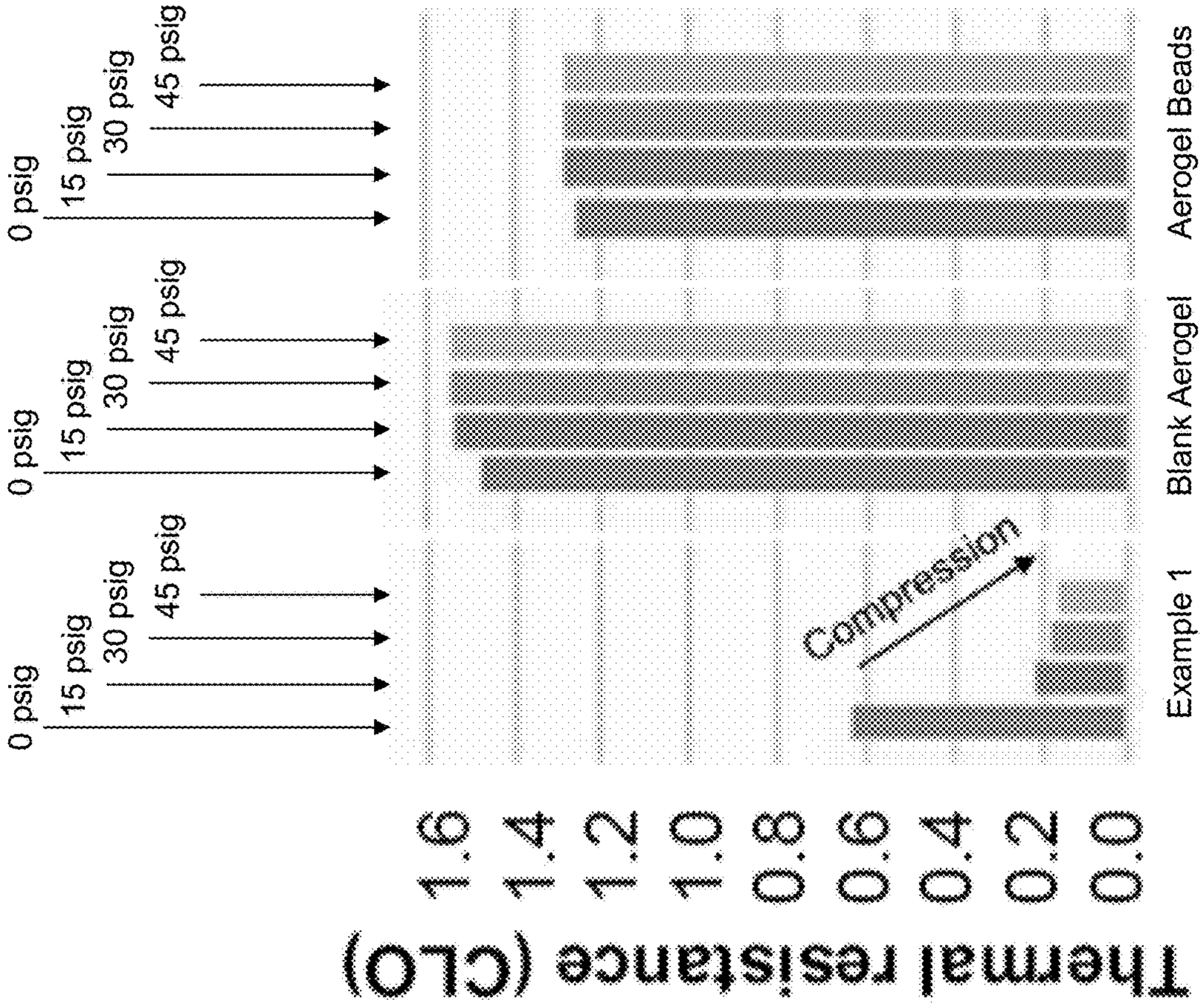

Thermal resistance (CLO)
0
2
4
6
8
0
2
4
6
Example 1
Blank Aerogel
Aerogel Beads
Compression
0 psig
15 psig
30 psig
45 psig
0 psig
15 psig
30 psig
45 psig
0 psig
15 psig
30 psig
45 psig

FIG. 4A

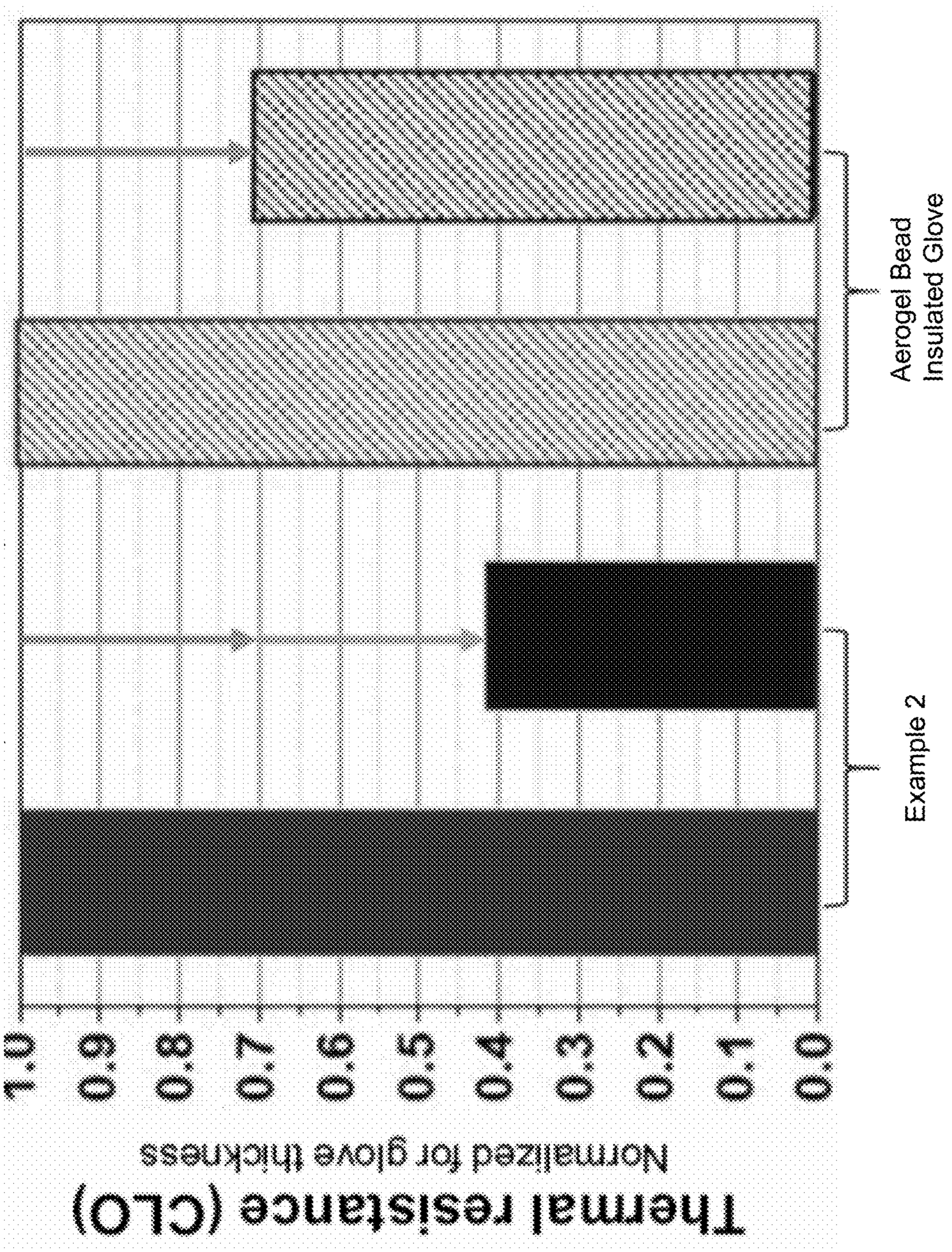

Aerogel Bead
Insulated Glove
Example 2
Thermal resistance (CLO)
Normalized for glove thickness
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

FIG. 4B

QUILTED INSULATING DIVING GLOVE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of prior-filed co-pending U.S. Provisional Application Ser. No. 63/316,970, filed Mar. 5, 2022, the content of which is herein incorporated by reference in its entirety.

STATEMENT OF GOVERNMENTAL INTEREST

[0002] This invention was made with Government support under contract number N00024-13-D-6400 awarded by the Naval Sea Systems Command (NAVSEA). The Government has certain rights in the invention.

BACKGROUND

[0003] Diving suits exist in both wet suit and dry suit varieties. Wet suits are so called because they are constructed of water permeable material that allows water to reach a wearer's skin. Wet suits are therefore tend to be suitable for relatively shallow, warm water. On the other hand, dry suits, which include a waterproof layer to prevent water from reaching the wearer's skin, are typically used for dives in colder water.

[0004] In addition to the waterproof layer, when wearing dry suits the user can include insulating articles underneath the waterproof layer to keep the wearer warm. Such insulating articles can be constructed similarly to typical winter coats, meaning they can be constructed of porous fabric configured to hold air stationary near the wearer's body.

[0005] Diving in particularly deep water can expose a dry diving suit to significant pressure. The insulating articles in a dry diving suit can become very thin under the pressures typical of deep sea diving, leaving little air trapped between the wearer's skin and the waterproof layer. The wearer's skin can lose heat quickly to water flowing across the waterproof layer under such conditions. These difficulties in insulating a diver are readily apparent to the diver's hands, which are located further from the diver's core and may therefore be likely to become numb and cold relatively quickly. Moreover, the use of thick or inflexible insulating material to cover a diver's hands can compromise a diver's manual dexterity, potentially making the diver's tasks difficult to complete.

SUMMARY

[0006] There exists a need for articles that can insulate a diver's hands under pressures typical of deep sea diving without unduly hampering the diver's dexterity and movement.

[0007] According to some aspects of the present disclosure, an insulating glove may be constructed from a quilted material defining pockets filled with beads. The beads may be made of aerogel material. The pockets may be divided by seams that prevent the beads from flowing between pockets. The seams may be distributed across the glove to maintain a distribution of beads across the glove that is effective for insulating the hand without unduly hampering the wearer's manual dexterity. The seams may be placed to align with natural lines or points of articulation of a typical wearer's hand to prevent beads from collecting where the glove is needed to bend around a relatively small radius. For example, seams may be placed on the glove to approximately align with the thenar (e.g., the ball of the thumb), transverse, and digital creases of a typical wearer's hand. The glove may also be provided with a web extending across a back side of some or all of the fingers. The web may be insulated so that the wearer can enclose the fingers and thumb within an insulated space surrounded by the web portion and the back of the glove by closing the hand into a fist. Various portions of the glove may include beads in certain ratios relative to one another to provide adequate insulation with minimal reduction of manual dexterity.

[0008] According to another aspect, a glove may include quilted material defining a plurality of pockets and shaped to receive a hand of a wearer and aerogel beads filling each pocket in the plurality of pockets.

[0009] In some arrangements according to any of the foregoing, the plurality of pockets may collectively extends across at least 75% of the exterior of the glove and the exterior of the glove is configured to enclose an entirety of the wearer's hand distal of the wearer's wrist.

[0010] In some arrangements according to any of the foregoing, the glove may include four fingers configured to receive the wearer's index finger, middle finger, ring finger, and little finger. The glove may also include a web portion extending across a back side of the fingers.

[0011] In some arrangements according to any of the foregoing, the web portion may include at least one of pocket among the plurality of pockets.

[0012] In some arrangements according to any of the foregoing, each finger of the glove may have a front side opposite the web portion, and a sum total quantity of the aerogel beads contained in the front sides of the fingers is less than two thirds the quantity of the aerogel beads contained in the web portion.

[0013] In some arrangements according to any of the foregoing, the glove may include a back portion configured to cover a back of the wearer's hand, a wrist portion located proximally of the back portion and the palm portion and configured to enclose the wearer's wrist, and a thumb portion configured to receive the wearer's thumb. A sum total quantity of the aerogel beads contained in the back portion and the web portion may be more than half of a sum total quantity of the aerogel beads contained by the glove outside of the thumb portion and distally of the wrist portion.

[0014] In some arrangements according to any of the foregoing, the glove may contain between 110 and 130 grams of the aerogel beads outside of the thumb portion and distally of the wrist portion.

[0015] In some arrangements according to any of the foregoing, any one or any combination of the fingers of the glove may extend distally beyond a distal end of the web portion.

[0016] In some arrangements according to any of the foregoing, each of the four fingers may be defined at least partially by a respective piece of quilted material attached to the web portion.

[0017] In some arrangements according to any of the foregoing, the glove may include a palm portion configured to cover a palm of the wearer. The palm portion may include multiple pockets among the plurality of pockets.

[0018] In some arrangements according to any of the foregoing, the glove may include thumb portion enclosing a cavity configured to receive the wearer's thumb, a digital seam separating the thumb portion from the palm portion, and a thenar seam. The thenar seam may extend in an arc

across the palm portion from a point located at a medial edge of the palm portion distal of the cavity to a proximal edge of the palm portion and separating at least one of the pockets of the palm portion from another of the pockets of the palm portion.

[0019] In some arrangements according to any of the foregoing, the glove may include a transverse seam extending from the point to a lateral edge of the palm portion and separating at least one of the pockets of the palm portion from another of the pockets of the palm portion.

[0020] In some arrangements according to any of the foregoing, the glove may include a palm portion configured to cover a palm of the wearer's hand and including at least one pocket among the plurality of pockets. The glove may also include fingers each including at least one pocket among the plurality of pockets and configured to receive a respective one of the wearer's index finger, middle finger, ring finger, and little finger. The glove may also include a thumb portion configured to receive the wearer's thumb and including at least one pocket among the plurality of pockets. The glove may also include a first digital seam separating the at least one pocket of the thumb portion from the at least one pocket of the palm portion. The glove may also include at least a second digital seam separating the pockets of the fingers from the at least one pocket of the palm portion.

[0021] In some arrangements according to any of the foregoing, any one or any combination of the thumb portion and the fingers of the glove may include at least a proximal pocket and a distal pocket separated by an intradigital seam located distally of one of the digital seams.

[0022] In another aspect, a diving suit may include a first glove. The first glove may include quilted material defining a plurality of pockets and be shaped to receive a hand of a wearer. The first glove may also include aerogel beads filling each pocket in the plurality of pockets. The diving suit may also include a second, waterproof glove enclosing the first glove.

[0023] In another arrangement according to any of the foregoing, the diving suit may include multiple quilted articles defining additional pockets, and each of the additional pockets may be filled with additional aerogel beads.

[0024] In another aspect, a glove may include a palm portion configured to cover a palm of a wearer's hand, a back portion configured to cover a back of the wearer's hand, fingers extending distally of the palm portion and the back portion and configured to receive fingers of the wearer, and a web portion extending distally of the back portion and across a back side of the fingers. The palm portion, back portion, fingers, and web portion may all be constructed of quilted material defining pockets filled with beads.

[0025] In some arrangements according to any of the foregoing, the glove may include a waterproof layer outside of the quilted material.

[0026] In some arrangements according to any of the foregoing, the glove may include a wrist portion extending proximally from the palm portion and the back portion. The wrist portion may be configured to enclose a wrist of the wearer and constructed of quilted material defining wrist portion pockets filled with beads. The wrist portion pockets may be separated from the pockets of the palm portion and the back portion such that beads are prevented from travelling to the wrist portion from the palm portion or the back portion.

[0027] In some arrangements according to any of the foregoing, the beads may be aerogel beads.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The accompanying drawings are incorporated herein and form a part of the specification.

[0029] FIG. **1** is a cross-section of a pocket filled with aerogel beads according to some embodiments of the present disclosure.

[0030] FIG. **2**A is a plan view of a palm side of a glove according to some embodiments of the present disclosure.

[0031] FIG. **2**B is a plan view of a back side of a glove according to some embodiments of the present disclosure.

[0032] FIGS. **3**A-**3**F are plan views of individual panels of material from which a glove may be constructed according to some embodiments of the present disclosure.

[0033] FIG. **4**A shows insulation efficacy test results of a portion of an insulating article according to some embodiments of the present disclosure compared to other insulating materials.

[0034] FIG. **4**B shows insulation efficacy test results of an insulating article according to some embodiments of the present disclosure compared to another insulating article.

[0035] In the drawings, like reference numbers generally indicate identical or similar elements.

DETAILED DESCRIPTION

[0036] In some embodiments "distal" can refer to anatomical features further from an individual's heart, while "proximal" refers to features nearer to the individual's heart. For example, when applied to portions of articles, the terms "distal" and "proximal" can refer to features designed to cover portions of the wearer further from or nearer to, respectively, the wearer's heart. In one aspect, in the specific context of hands or articles designed for hands, "medial" can refer to the thumb side of the hand, while "lateral" can refer to the side of the hand opposite from the thumb side. In some embodiments, the terms "quilt" and "quilted" can refer to articles having an inner layer and an outer layer connected together to define one or more separate pockets. "Quilted material" can refer to a structure of two layers of material joined together to define pockets, regardless of whether the two layers are of the same or different materials.

[0037] FIG. **1** is a cross-section of a pocket **110**, according to some embodiments of the present disclosure. For example, FIG. **1** may illustrate a pocket **110** filled with beads **122**, e.g., aerosol beads, which may be used to insulate an article, e.g., a glove, garment, etc.

[0038] In some embodiments, pocket **110** is defined between an inner material layer **114** and an outer material layer **118**. The edges of pocket **110** may be defined by seams **126** where outer material layer **118** is connected to inner material layer **114**. Though seams **126** are visible at two opposite edges of pocket **110** in FIG. **1**, seams **126** may completely surround pocket **110** and separate pocket **110** from adjacent pockets in the same article. Seams **126** may be where outer material layer **118** sewn, welded, adhesively bonded, connected by a bridging material, or in any other way joined to inner material layer **114**.

[0039] In some embodiments, an article that includes pocket **110** may optionally be worn under a waterproof material **128**. For example, where the article that includes pocket **110** is a glove for a dry diving suit, the inner material

layer **114** and outer material layer **118** may be fleece, LYCRA®, or any other type of material suitable for making articles without necessarily being waterproof while waterproof material **128** is an overlying glove made of rubber or another waterproof material usable for constructing waterproof diving suits. Inner material layer **114**, outer material layer **118**, and beads **122** may therefore cooperate to insulate a space **10** within the article that includes pocket **110** without necessarily being waterproof while waterproof layer **128** prevents water from reaching the space **10**. In some examples, space **10** may be occupied by the wearer when the article is worn.

[0040] In some embodiments, pocket **110** is filled with beads **122**, e.g., insulating beads. Beads **122** can be loose within pocket **110**, meaning beads **122** can be unattached to inner material layer **114**, outer material layer **118**, and one another. Beads **122** may therefore move across one another within pocket **110** so that pocket **110** may assume different shapes as the article containing pocket **110** deforms. Beads **122** may be of any shape or material and of any size that enables beads **122** to move within pocket **110**. In some examples, beads **122** may be cubic, spherical, or hemispherical, though beads **122** may be of any shape. For example, beads **122** within a single pocket **110** may optionally be either all of the same shape or of different shapes. Though beads **122** may be of any shape, rounder shapes tend to leave beads **122** relatively free to roll and move across one another within pocket **110**. Further, the beads **122** may be sized such that a longest distance between any two points on a single bead **122** is, according to various examples, 4 mm or less, 3 mm or less, 2 mm or less, or 1 mm or less, though beads **122** in other examples may be larger than any of the foregoing sizes. In some examples according to any of the foregoing, the beads **122** may optionally all have a minimum size of at least 0.1 mm across in at least one dimension.

[0041] In some examples, beads **122** may be made of aerogel. Though all aerogels are contemplated, the aerogels mentioned in co-pending U.S. application Ser. No. 16/940,628, filed Jul. 28, 2020, which is incorporated herein by reference in its entirety, are examples of materials from which beads **122** may be constructed. However, beads **122** may be made from any type of aerogel. Some specific examples include polymer aerogels, including polymer aerogel structures of about 95% air by volume or more and average pore sizes of about 20 μm or less than or equal to 100 μm across. In some aspects, aerogel beads may be made by cryogenic (cryo) milling larger blanks of aerogel material, thereby breaking the blanks into smaller particles while maintaining the original internal porous structure. In further examples, aerogel beads may be made by breaking larger blanks of aerogel material into beads using machines such as plastic shredders, granulators, grinders, or comminutors such as those used to prepare bulk polymer for recycling. In a more specific example, a blade-based comminutor may be used to break aerogel blanks into beads. Aerogel beads prepared by using a bench-scale comminutor according to some of the foregoing examples were tested for thermal resistance, and no significant loss of thermal resistance compared to aerogel in blank form was found to result from the comminution.

[0042] In some aspects, aerogel beads can also be made by combining monomeric polyamic acid backbone precursors. These may be, for example, combinations of dianhydrides with diamines, diisocyanates, or combinations of dianydrides with both diamins and diisocyantes. These can include, for example, a mixture of dimethylbenzidine and biphenyl tetracarboxylic dianhydride, with a medium, such as triethylamine, In one aspect, a syringe or other type of nozzle can be used to dispense individual drops of the slurry into an emulsion bath containing a cross-linking catalyst, such as 1,3,5-triaminophenoxybenzene, 2,4,6-tris(4-aminophenyl)pyridine, octa(aminophenoxy)-silsesquioxane, or 1,3,5-benzenetricarbonyl trichloride. In some aspects, passing through the surface tension of the bath will form the slurry into sphere shapes, and the polarity discrepancy in the bath will maintain the sphere shape throughout polymerization. In some aspects, supercritical fluid extraction can then be used to convert the polymerized spheres to aerogel beads. In other examples, beads **122** may be made of solid polymers, such as, for example, nylon, or any other type of polymer suitable for forming a small, rigid bead **122**.

[0043] In some embodiments, aerogels can provide significant thermal insulation in addition to being lightweight and resistant to deforming under compressive loads. Filling pocket **110** with aerogel beads **122** can therefore create significant resistance to the transfer of heat across pocket **110** and can prevent pocket **110** from losing a significant amount of thickness when exposed to pressures typical of even deep sea diving. In some aspects, because beads **122** are free to move within pocket **110**, beads **122** will allow pocket **110** to deform so that an article quilted with pockets **110** will remain flexible.

[0044] FIGS. **2**A and **2**B are plan views of a palm side and back side, respectively, of a glove **100** according to some embodiments of the present disclosure. For example, a glove **100** includes pockets **110** similar to pocket **110** of FIG. **1**. It is to be appreciated that FIGS. **2**A-**2**B, and FIGS. **3**A-**3**F, are individually illustrated to scale, but may not be illustrated to scale with respect to one another. In some embodiments, glove **100** may be constructed to deviate from the proportions of any of the elements of FIGS. **2**A-**2**B and **3**A-**3**F.

[0045] In some embodiments, a surface of glove **100** can be quilted over with pockets **110** so pockets **110** cooperate to thermally insulate a wearer's hand. Pockets **110** of glove **100** can be filled with beads **122** in the same manner as described above with respect to pocket **110** of FIG. **1**, making glove **100** suitable for insulating a wearer's hand during underwater diving.

[0046] In some embodiments, glove **100** may be a water permeable glove made of water permeable materials, such as, for example, fleece, LYCRA®, or any other water permeable materials from which articles may be constructed, to be worn under a waterproof glove in a dry diving suit. In other examples, glove **100** may be made from intrinsically waterproof material, or may be water permeable and adapted for use with a wet suit.

[0047] In the illustrated example, pockets **110** extend across substantially an entire surface area of an exterior of glove **100**. In various other examples, pockets **110** may extend across at least 50%, at least 60%, at least 75%, at least 90%, or at least 95% of the surface area of the exterior of glove **100**. Glove **100** of the illustrated example is configured to enclose an entirety of a wearer's hand distal of the wearer's wrist, though the concepts of the present disclosure are also applicable to gloves that partially cover the wearer's hand.

[0048] In the illustrated example, pockets **110** are distributed across glove **100** with respective sizes and locations to

provide effective insulation to a wearer's hand with minimal impact to the wearer's manual dexterity. For that purpose, seams **126** defining the pockets **110** may be placed to maintain an intended distribution of beads **122** (not visible in FIGS. **2**A and **2**B) across the front and back of glove **100**. Beads **122** can therefore be prevented from collecting at one end of glove **100**, which could lead to poor insulation where too few beads **122** remain and hamper flexibility and dexterity where too many beads **122** accumulate.

[0049] In the illustrated example, seams **126** divide glove **100** into a finger portion **130** that includes glove's **100** fingers **146**A, **146**B, **146**C, **146**D, a thumb portion **134** that is configured to receive a wearer's thumb, a palm portion **138** that is configured to cover a wearer's palm, a back portion **158** that is configured to cover a back of a wearer's hand, a wrist portion **142** that is configured to enclose and cover a wearer's wrist, and a web portion **154** that extends across the back of fingers **146**A, **146**B, **146**C, **146**D. Fingers **146**A, **146**B, **146**C, **146**D of the illustrated example are each configured to separately receive an individual one of the wearer's fingers and to be movable relative to one another. Each finger **146**A, **146**B, **146**C, **146**D individually extends distally beyond a distal edge of web portion **154**, which can improve the wearer's manual dexterity by giving the tips of fingers **146**A, **146**B, **146**C, **146**D relative to move relative to one another, but in other examples the length of web portion **154** relative to fingers **146**A, **146**B, **146**C, **146**D may vary.

[0050] Here, reference to anatomical features with respect to portions of glove **100** generally indicates the anatomical features of the wearer that the respective portions of glove **100** are configured to cover and receive or enclose. Thus, within the illustrated example, index finger **146**A is configured to receive the wearer's index finger, middle finger **146**B is configured to receive the wearer's middle finger, ring finger **146**C is configured to receive the wearer's ring finger, and little finger **146**D is configured to receive the wearer's little finger. An exception to the foregoing nomenclature applicable to the illustrated example is web portion **154**, which extends across the back of fingers **146**A, **146**B, **146**C, **146**D as noted above, and finger portion **130**, which receives and partially covers the wearer's fingers but specifically does not include web portion **154**. Thus, the portion of the exterior of glove **100** of the illustrated example included by finger portion **130** is the front and tips of the exteriors of fingers **146**A, **146**B, **146**C, **146**D. Finger portion **130** of the illustrated example therefore includes all of the pockets **110** that cover fingers **146**A, **146**B, **146**C, **146**D except for the pockets **110** of web portion **154**. Specifically, finger portion **130** of the illustrated example includes all front distal pockets **110**A, front proximal pockets **110**B, and back distal pockets **110**C of fingers **146**A, **146**B, **146**C, **146**D. However, gloves **100** according to other arrangements may lack a web portion **154**, and finger portions **130** of gloves **100** according to such other arrangements may include pockets **110** covering the back of fingers **146**A, **146**B, **146**C, **146**D. In such other arrangements, each of the fingers **146**A, **146**B, **146**C, **146**D may have an arrangement of pockets **110** similar that of thumb portion **134** of the illustrated example. In further arrangements, finger portion **130** may be divided into fewer than four fingers, with any combination of adjacent fingers grouped together into individual appendages, such as in "lobster claw" or mitten style hand coverings.

[0051] In some embodiments, each of the above listed portions **130**, **134**, **138**, **142**, **154**, **158** of glove include pockets **110** may be filled with beads **122**, with the arrangement and distribution of pockets **110** according to some examples being illustrated in FIGS. **2**A and **2**B and described below. However, the arrangement of pockets **110** within the foregoing portions of glove **100** and the relative proportions of the portions can differ in other embodiments.

[0052] In the illustrated example, seams **126** may be placed to approximately align with the joints and natural folding points of a wearer's hand. In addition to being usable to maintain a distribution of beads **122** that insulates the wearer's hand well, such seam placement can be conducive to the wearer's manual dexterity because it leads to fewer beads **122** and a lower thickness of the glove **100** at locations where the wearer's hand will bend or fold over in natural grasping motions. In such embodiments, glove **100** may be able to bend around a relatively small radius along any seams **126**, meaning placement of seams **126** on the palm side of glove **100** may minimize resistance to grasping motions.

[0053] Although the seams **126** in the illustrated example form irregular patterns (that is, the pockets **110** are shaped differently from each other), in other example embodiments the seams **126** may form regular or repeating patterns. For example, in one embodiment, the seams **126** may for a series of square, rectangular, and/or diamond-shaped pockets **110**, although alternative example embodiments are not limited thereto.

[0054] Referring still to FIGS. **2**A and **2**B, one or more digital seams **126**A may separate pockets **110** in the finger portion **130** and thumb portion **134** of glove **100** from pockets **110** in the palm portion **138** of glove **100**. In such embodiments, digital seams **126**A may be approximately aligned with the digital creases of the wearer's hand when glove **100** is worn. This placement of digital seams **126**A may prevent beads **122** from escaping the finger portion **130** and thumb portion **134** of glove **100** and keeps the finger portion **130** and thumb portion **134** movable relative to the palm portion **138**.

[0055] In the illustrated example, an intradigital seam **126**B may be located about halfway along each finger **146**A, **146**B, **146**C, **146**D and the thumb portion **134** of glove **100**. The intradigical seams may provide flexibility and maintain a favorable distribution of beads **122** within each finger **146**A, **146**B, **146**C, **146**D and the thumb portion **134** of glove **100**. Each digit of glove **100** may therefore have at least one proximal and one distal pocket. In the illustrated example, a front distal pocket **110**A, a front proximal pocket **110**B, and a back distal pocket **110**C are defined on each finger **146**A, **146**B, **146**C, **146**D of glove. Similarly, a front distal pocket **110**D, a front proximal pocket **110**E, a back distal pocket **110**F, and a back proximal pocket **110**G cooperate to cover the thumb portion **134** of glove **100** in the illustrated example. Finger portion **130** of the illustrated example **130** may therefore include front distal pockets **110**A, front proximal pockets **110**B, and back distal pockets **110**C, while thumb portion **134** includes front distal pocket **110**D, front proximal pocket **110**E, back distal pocket **110**F, and back proximal pocket **110**G. However, in other examples, the number of intradigital seams **126**B on any one or any combination of the digits **146**A, **146**B, **146**C, **146**D, **134** of glove **134** could be zero or any plural number, meaning any digit could have any number of pockets **110** along its length. Additionally, in some examples, any one or any combination of the pockets **110** on one or any combi-

nation of the digits **146**A, **146**B, **146**C, **146**D, **134** may extend around an entire circumference of the respective digit, while in further examples any one or any combination of the digits **146**A, **146**B, **146**C, **146**D, **134** may have three or more pockets **110** at a given axial location therealong.

[0056] The illustrated example also includes a transverse seam **126**C and thenar seam **126**D that similarly maintain the intended distribution of beads **122** and promote flexibility resembling the mobility of a typical human hand within palm portion **138**. Transverse seam **126**C may extend across palm portion **138** to be approximately aligned over the wearer's proximal and distal transverse creases and thenar seam **126**D may extend across palm portion **138** to be approximately aligned over the wearer's thenar crease. The transverse seam **126**C and thenar seam **126**D may thereby cooperate to maintain an intended distribution of beads **122** across palm portion **138** and to facilitate palm portion **138**'s flexibility in a manner consistent with the natural movement of the wearer's hand. That is, palm portion **138** may tend to fold at transverse seam **126**C and thenar seam **126**D in a way that resembles the folding motion of a typical human hand about the transverse and thenar creases. In the illustrated example, transverse seam **126**C extends from a medial end of transverse seam **126**C to a lateral edge of palm portion **138**, while thenar seam **126**D extends in an arc from a medial end of thenar seam **126**D to a center of a proximal end of palm portion **138**. The exact positions of the medial ends of transverse seam **126**C and thenar seam **134** may vary, and in various examples the medial ends of transverse seam **126**C and thenar seam **126**D may be located at a medial edge of palm portion **138** and distally of a cavity in glove **100** configured for receiving the wearer's thumb, at a distal edge of the digital seam **126**A separating thumb portion **134** from palm portion **138**, or generally within or distal of a distal half of a transitional area between a portion of glove **100** that covers the wearer's thumb and a portion of glove **100** that covers the wearer's palm. Either or both of the transverse seam **126**C and the thenar seam **126**D may include a medial end that meets a distal point on the digital seam **126**A located between thumb portion **134** and palm portion **138**. In other examples, the end points and curvatures of the transverse and thenar seams **126**C, **126**D could differ from those illustrated and described herein in other examples.

[0057] In the illustrated example, a medial seam **126**E runs along a medial edge of glove **100** while a lateral seam **126**F runs along a lateral edge of glove **100**. Medial seam **126**E and lateral seam **126**F may each be either a single continuous seam or a group of discontinuous seams acting together. Regardless, the medial seam **126**E and the lateral seam **126**F of the illustrated example may separate any pockets visible in FIG. **2**A from any pockets visible in FIG. **2**B. Thus, palm portion **138** of the illustrated example includes a distal pocket **110**H defined between transverse seam **126**C and the digital seam **126**A at the base of finger portion **130**, a medial pocket **110**I defined between thenar seam **126**D, medial seam **126**E, and a front wrist seam **126**G, and a lateral pocket **110**J defined between transverse seam **126**C, thenar seam **126**D, and front wrist seam **126**G. The arc of thenar seam **126**D according to the illustrated example is such that the edge of medial pocket **110**I facing lateral pocket **110**J is convex and the edge of lateral pocket **110**J facing medial pocket **110**I is concave. Nonetheless, in other examples, palm portion **138** may include more or fewer pockets **110**, some pockets in common with a back portion **158** of glove **100**, or pockets **110** of different shapes than those illustrated in FIG. **2**A.

[0058] In some embodiments, front wrist seam **126**G and a back wrist seam **126**H separate palm portion **138** and back portion **158**, respectively, from wrist portion **142**. While a distal end of wrist portion **142** may be defined by front wrist seam **126**G and back wrist seam **126**H, a proximal end of wrist portion **142** may be defined by a cuff **150**. Cuff **150** may be the proximal terminal end of glove **100** and is therefore the point where glove **100** is joined to an arm portion of a larger article, such as, for example, a dive suit. Cuff may be a seam encircling a portion of the glove **100** intended to extend over a portion of a wearer's forearm or may further include a distinct panel of material forming a distinct ring encircling glove's **100** proximal opening. In the illustrated example, thenar seam **126**D extends across front wrist seam **126**G to cuff **150**. Wrist portion **142** of the illustrated example therefore includes a medial pocket **110**K defined between thenar seam **126**D, medial seam **126**E, front wrist seam **126**G, and cuff **150**, a lateral pocket **110**L defined between thenar seam **126**D, lateral seam **126**F, front wrist seam **126**G, and cuff **150**, and a back pocket **110**P defined between back wrist seam **126**H, medial seam **126**E, lateral seam **126**F, and cuff **150**. However, in various other examples, any one or any combination of thenar seam **126**D, medial seam **126**E, and lateral seam **126**F may not extend into wrist portion **142**, and wrist portion **142** may include other seams creating any number of pockets **110** within wrist portion. In further examples, wrist portion **142** may include pockets **110** in common with pockets **110** of palm portion **138** or back portion **158**.

[0059] In the illustrated example, back portion **158** extends across a portion of glove **100** intended to cover a back of the wearer's hand. Back portion **158** includes a single back pocket **110**M defined between medial seam **126**E, lateral seam **126**F, back wrist seam **126**H, a proximal web seam **126**I, and the digital seam **126**A that separates back portion **158** from thumb portion **134**. In some embodiments, the digital seam **126**A that separates back portion **158** from thumb portion **134** of the illustrated example is a collection of seams that connect a panel **119** of additional material to the joint between thumb portion **134** and back portion **158**. However, panel **119** is optional, and the digital seam **126**A between thumb portion **134** and back portion **158** may be a single continuous seam in other examples. Though back portion **158** of the illustrated example includes the single back pocket **110**M, back portion **158** of other examples may be subdivided into any number of pockets **110**.

[0060] In the illustrated example, web portion **154** includes a proximal pocket **110**N, which is defined between proximal web seam **126**I, medial seam **126**E, lateral seam **126**F, and distal web seam **126**I, and a distal pocket **110**O, which is defined between distal web seam **126**I, medial seam **126**E, lateral seam **126**F, and a distal end of web portion **154**. Including both proximal pocket **110**N and distal pocket **110**O on web portion **154** may contribute to keeping the wearer's fingers evenly insulated, though, as noted above with regard to other portions of glove **100**, the pockets within web portion **154** may be arranged differently or provided in different quantity in other examples.

[0061] Because web portion **154** of the illustrated example extends across a back side of the wearer's fingers, web

portion **154** may not need to be able to fold to as narrow a radius of curvature as front portions of the glove to accommodate the mechanics of a typical wearer's hand. Pockets **110**N, **110**O of web portion **154** may therefore be filled with a relatively large quantity of beads **122**. Moreover, provision of web portion **154** across the back of fingers **146**A, **146**B, **146**C, **146**D may enable the wearer to enclose their fingers and thumb within web portion **154** by balling the hand wearing glove **100** into a fist. The ability to enclose the wearer's fingers and thumb in the web portion **154** and the freedom to fill the pockets **110**N, **110**O of web portion **154** with a relatively large quantity of beads **122** may both contribute to conserving heat in the wearer's fingers and thumb with minimal impact on the wearer's manual dexterity. These effects of web portion **154** may therefore compensate for the relative speed with which extremities such as fingers and thumbs can lose heat and the difficulty in adding insulation to the thumb portion **134** or the pockets **110**A, **110**B on the front of fingers **146**A, **146**B, **146**C, **146**D with relatively little reduction to manual dexterity. Web portion **154** may therefore enable pockets **110**A, **110**B, **110**C within finger portion **130** of glove **100** to be filled with relatively small amounts of beads **122** to preserve manual dexterity.

[0062] In some embodiments, distributions of beads conforming to certain mathematical relationships may provide satisfactory balances between insulation and manual dexterity. For the purposes of the following mathematical relationships, two quantities being "about equal" or "approximately equal" means that one quantity is from 90% to 110% of the other quantity. The following mathematical relationships are contemplated as applying where quantities of beads **122** are measured by number or where quantities of beads **122** are measured by weight. Web portion **154**, back portion **158**, and palm portion **138** may all include equal or about equal total quantities of beads **122** within their respective pockets **110**. That is, the sum total quantity of beads **122** in pockets **110**N, **110**O together may be equal to or about equal to the number of beads **122** in pocket **110**M individually and equal to or about equal to the number of beads in pockets **110**I, **110**J, **110**H together.

[0063] In some embodiments, a total quantity of beads **122** in the finger portion **130** may be less than or equal to, or about equal to, the total quantity of beads **122** in the web portion **154**, the total quantity of beads **122** in the back portion **158**, or the total quantity of beads **122** in the palm portion **138**. In some embodiments, a total quantity of beads **122** in the thumb portion **134** may be between two times and three times the total quantity of beads **122** in the front distal pocket **110**A, front proximal pocket **110**B, and back distal pocket **110**C of any one of the fingers **146**A, **146**B, **146**C, **146**D. In further examples, the total number of beads **122** in thumb portion **134** maybe equal to or about equal to half the total number of beads **122** in finger portion **130**. The total quantity of beads **122** in the little finger **146**D may be less than or equal to the total quantity of beads **122** in any one of the index finger **146**A, the middle finger **146**B, or ring finger **146**C. The total quantity of beads **122** in wrist portion **142** may, in various examples, be between one and a half and two times the total quantity of beads **122** in the web portion **154**, the total quantity of beads **122** in the back portion **158**, or the total quantity of beads **122** in the palm portion **138**. In further examples, the total quantity of beads **122** in wrist portion **142** may be equal to or about equal to twice the total number of beads **122** in finger portion **130**. In various examples, the pockets **110** in each portion **130**, **134**, **138**, **142**, **154**, **158** may have equal to, about equal to, or up to 150% as many beads **122** as all other pockets **110** within the same portion **130**, **134**, **138**, **142**, **154**, **158**. The total quantity of beads **122** in glove **100** may have a mass of between about 150 g and about 200 g or between about 160 g and about 190 g.

[0064] In some embodiments, because a back side of glove **100**, referring generally to back portion **158** and web portion **154**, may not need to fold across a small radius at any specific point to accommodate the mechanics of a typical wearer's hand and because web portion **154** enables a wearer to enclose and insulate the fingers and palm of the wearer's hand by forming a fist, filling relatively large quantities of beads **122** into back portion **158** and web portion **154** and relatively small quantities of beads **122** into finger portion **130** and palm portion **138** may enable glove **100** to insulate the wearer's hand well with relatively little compromise to the wearer's manual dexterity. Certain ratios of bead **122** fill between portions of the back and front sides of glove **100** may balance insulation and dexterity well. For example, the total quantity of beads **122** contained in pockets **110** covering front sides of the fingers **146**A, **146**B, **146**C, **146**D, which would be front distal pockets **110**A and front proximal pockets **110**B in the illustrated example, may be less than two thirds of the quantity of beads **122** contained in web portion **154**. Back portion **158** and web portion **154** together may contain more than half of a sum total quantity of beads **122** contained by glove **100** outside of thumb portion **134** and distally of wrist portion **142**. The sum total quantity of beads **122** contained by glove **100** outside of thumb portion **134** and distally of wrist portion **142** may have a mass of between 110 and 130 g.

[0065] According to various arrangements, articles **100** can be made that deviate from any one or any combination of the foregoing mathematical relationships. That is, in various arrangements, any one or any combination of the foregoing mathematical relationships may be true, and in further arrangements, any one or any combination of the foregoing mathematical relationships may be false. The total weight of beads **122** may also vary depending on the material from which beads **122** are constructed and the size of the glove **100**.

[0066] FIGS. **3**A-**3**F are plan views of individual panels of material from which an article **100** may be constructed according to some embodiments of the present disclosure. Specifically, FIG. **3**A is a plan view of a back finger panel **162** according to some embodiments of the present disclosure, FIG. **3**B is a plan view of a front finger panel **170** according to some embodiments of the present disclosure, FIG. **3**C is a plan view of a thumb panel **182** according to some embodiments of the present disclosure, FIG. **3**D is a plan view of a back and web panel **190** according to some embodiments of the present disclosure, FIG. **3**E is a plan view of a palm panel **194**, and FIG. **3**F is a plan view of a back liner **198** according to some embodiments of the present disclosure.

[0067] In some embodiments, back finger panel **162**, front finger panel **170**, thumb panel **182**, back and web panel **190**, and palm panel **194** may all include two layers of material between which a cavity **166** is formed. The perimeter of each cavity **166** may be defined by a seam, which may be similar to the seams **126** described above, joining the two layers of the respective panel together. Marks **174** indicate where

seams **126** can be sewn or otherwise created across cavities **166** to divide cavities **166** into the pockets **110** of glove **100**. Additional seams can optionally be placed at marks **178** to join proximal portions of adjacent fingers **146** to one another.

[0068] In some embodiments, the panels of FIGS. **3**A-**3**F can be stitched or otherwise connected together to form a glove as article **100**. Four back finger panels **162** may be sewn to corresponding distal projections **184** of back liner **198**. Then, back finger panels **162** may each be connected to a respective front finger panel **170**. Adjacent front finger panels **170** may then optionally be joined at marks **178** before front finger panels **170** are connected to a distal end **194**A of palm panel **194**. Then thumb panel **182** may be connected to thumb edge **194**B of palm panel **194** and thumb edge **198**B of back liner **198**. Following connection of thumb panel **182** to palm panel **194**, and optionally before or after connection of thumb panel **182** to back liner **198**, front finger panels **170** may each be connected to a respective distal projection **184** of back liner **198**. After being connected to palm panel **194** and back liner **198**, thumb panel **182** may be folded at fold line **186** and sewn shut or otherwise closed to form thumb portion **134**. Edges of palm panel **194**, back liner **198**, and back and web panel **190** may then be joined and a cuff **150** may be formed to create glove **100** as shown in FIGS. **2**A and **2**B. A distal end **190**A of back and web panel **190** may be connected to back finger panels **162** at any stage. Marks **174** on back liner **198** indicate where back panel **180** may be connected to back and web panel **190**. Each of the foregoing connections can be any of the processes or structures suitable for creating seams **126** as described above, such as sewing, welding, or adhesive bonding. Optionally, the layers of material can be connected to form cavities **166**, then seams **126** can be placed along marks **174** to divide cavities **166** into pockets **110**, before the panels are attached to one another. Pockets **110** can be filled with beads **122** at any subsequent stage of forming glove **100**.

[0069] The foregoing panels and processes for joining them are some examples of how glove **100** may be constructed. In other examples, glove **100** may be formed by connecting portions of material in a different order than the order described above or by joining panels of material that differ in number and shape from the panels shown in FIGS. **3**A-**3**F.

[0070] Glove **100** is one example of an insulating article that can be worn under a waterproof layer of a dry diving suit. Any other article worn under the waterproof layer of a dry diving suit may be similarly constructed of quilted layers defining pockets filled with beads of aerogel or other insulating materials. Thus, an entire body suit of quilted material defining pockets filled with beads of aerogel or other insulating materials may be worn under a waterproof layer to form a dry diving suit. In further examples, a body suit of quilted material defining pockets filled with beads of aerogel or other insulating materials may be constructed such that the inner layer, the outer layer, or both is waterproof, or a body suit of quilted material defining pockets filled with beads of aerogel or other insulating materials may be worn without a waterproof layer as a wet suit. In any of the foregoing examples, seams may separate the pockets to maintain a distribution of beads across the wearer that results in effective insulation and avoids restricting the wearer's movement. In any of the foregoing examples, glove **100** and any other quilted insulating articles may be constructed to provide effective insulation for dives at 700 feet below sea level, or at 45 psig.

[0071] FIG. **4**A shows thermal resistance test results of aerogel beads according to some embodiments of the present disclosure in comparison with other materials at different hydrostatic pressures. The results are expressed in CLO units.

[0072] For each material, a 2" square sample or coupon of the material was tested for thermal efficacy at 0 psig, 15 psig, 30 psig, and 45 psig of hydrostatic pressure. The Example 1 coupon, which lacked aerogel beads and was made from insulating fabric material alike to the material marketed under the trade name THINSULATE®, is shown to have lost most of its insulating capability at 15 psig, which compressed the sample and thus prevented it from holding an insulating layer of air. By contrast, a solid aerogel blank was observed to have nearly constant insulating capability across all pressures tested. The coupon in the form of a pocket filled with aerogel beads, which was alike to the pockets **110** of beads **122** described with respect to some examples related to FIGS. **1**A-**3**F, exhibited good insulation efficacy in general and the most consistent insulation efficacy across all tested hydrostatic pressures without loss.

[0073] FIG. **4**B shows a comparison of thermal resistance between the Example 2 glove, which was made from the same material as the Example 1 coupon described above, and an aerogel bead containing glove alike to some of the example articles and gloves **100** discussed above with respect to FIGS. **1**A-**3**F in CLO units, normalized for material thickness. For each article, the left bar shows the thermal resistance in air, while the right bar shows the thermal resistance under water. The thermal resistance under water was normalized to the thermal resistance in air. After normalizing, each article achieved **1** CLO unit in air, but the Example 2 glove lost about twice as great a proportion of its original thermal resistance as the aerogel bead glove under water. This difference in the amount of thermal resistance lost at higher pressure is attributable to the greater compressibility of the padded insulated materials than of aerogel beads.

[0074] It is to be appreciated that the Detailed Description section, and not any other section, is intended to be used to interpret the claims. Other sections can set forth one or more but not all exemplary embodiments as contemplated by the inventor(s), and thus, are not intended to limit this disclosure or the appended claims in any way.

[0075] While this disclosure describes exemplary embodiments for exemplary fields and applications, it should be understood that the disclosure is not limited thereto. Other embodiments and modifications thereto are possible, and are within the scope and spirit of this disclosure. For example, and without limiting the generality of this paragraph, embodiments are not limited to the software, hardware, firmware, and/or entities illustrated in the figures and/or described herein. Further, embodiments (whether or not explicitly described herein) have significant utility to fields and applications beyond the examples described herein.

[0076] Embodiments have been described herein with the aid of functional building blocks illustrating the implementation of specified functions and relationships thereof. The boundaries of these functional building blocks have been arbitrarily defined herein for the convenience of the description. Alternate boundaries can be defined as long as the

specified functions and relationships (or equivalents thereof) are appropriately performed. Also, alternative embodiments can perform functional blocks, steps, operations, methods, etc. using orderings different than those described herein.

[0077] References herein to "one embodiment," "an embodiment," "an example embodiment," or similar phrases, indicate that the embodiment described can include a particular feature, structure, or characteristic, but every embodiment can not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it would be within the knowledge of persons skilled in the relevant art(s) to incorporate such feature, structure, or characteristic into other embodiments whether or not explicitly mentioned or described herein. Additionally, some embodiments can be described using the expression "coupled" and "connected" along with their derivatives. These terms are not necessarily intended as synonyms for each other. For example, some embodiments can be described using the terms "connected" and/or "coupled" to indicate that two or more elements are in direct physical or electrical contact with each other. The term "coupled," however, can also mean that two or more elements are not in direct contact with each other, but yet still co-operate or interact with each other.

[0078] The breadth and scope of this disclosure should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

What is claimed is:

1. A glove comprising:

quilted material defining a plurality of pockets and shaped to receive a hand of a wearer; and

aerogel beads filling each pocket in the plurality of pockets.

2. The glove of claim **1**, wherein:

the plurality of pockets collectively extends across at least 75% of an exterior of the glove, and

the exterior of the glove is configured to enclose an entirety of the hand of the wearer distal of a wrist of the wearer.

3. The glove of claim **1**, comprising:

four fingers configured to receive an index finger, a middle finger, a ring finger, and a little finger of the wearer; and

a web portion extending across a back side of the four fingers.

4. The glove of claim **3**, wherein the web portion includes at least one of the pockets among the plurality of pockets.

5. The glove of claim **4**, wherein:

each of the four fingers includes a front side opposite the web portion, and

a sum total quantity of the aerogel beads contained in the front sides of the four fingers is less than two thirds the quantity of the aerogel beads contained in the web portion.

6. The glove of claim **4**, comprising:

a back portion configured to cover a back of the hand of the wearer;

a wrist portion located proximally of the back portion and a palm portion and configured to enclose a wrist of the wearer; and

a thumb portion configured to receive a thumb of the wearer;

wherein a sum total quantity of the aerogel beads contained in the back portion and the web portion is more than half of a sum total quantity of the aerogel beads contained by the glove outside of the thumb portion and distally of the wrist portion.

7. The glove of claim **6**, wherein the glove contains between 110 grams and 130 grams of the aerogel beads outside of the thumb portion and distally of the wrist portion.

8. The glove of claim **3**, wherein any one or any combination of the four fingers extend distally beyond a distal end of the web portion.

9. The glove of claim **3**, wherein each of the four fingers is defined at least partially by a respective piece of quilted material attached to the web portion.

10. The glove of claim **1**, comprising a palm portion configured to cover a palm of the wearer, the palm portion including multiple pockets among the plurality of pockets.

11. The glove of claim **10**, comprising:

a thumb portion enclosing a cavity configured to receive a thumb of the wearer;

a digital seam separating the thumb portion from the palm portion; and

a thenar seam extending in an arc across the palm portion from a point located at a medial edge of the palm portion distal of the cavity to a proximal edge of the palm portion and separating at least one of the pockets of the palm portion from another of the pockets of the palm portion.

12. The glove of claim **11**, comprising a transverse seam extending from the point to a lateral edge of the palm portion and separating at least one of the pockets of the palm portion from another of the pockets of the palm portion.

13. The glove of claim **1**, comprising:

a palm portion configured to cover a palm of the hand of the wearer and including at least one pocket among the plurality of pockets;

fingers each including at least one pocket among the plurality of pockets and configured to receive a respective one of an index finger, a middle finger, a ring finger, and a little finger of the wearer;

a thumb portion configured to receive a thumb of the wearer and including at least one pocket among the plurality of pockets;

a first digital seam separating the at least one pocket of the thumb portion from the at least one pocket of the palm portion; and

at least a second digital seam separating the pockets of the fingers from the at least one pocket of the palm portion.

14. The glove of claim **13**, wherein any one or any combination of the thumb portion and the fingers of the glove includes at least a proximal pocket and a distal pocket separated by an intradigital seam located distally of one of the digital seams.

15. A diving suit comprising:

a first glove comprising:

quilted material defining a plurality of pockets and shaped to receive a hand of a wearer;

aerogel beads filling each pocket in the plurality of pockets; and

a second, waterproof glove enclosing the first glove.

16. The diving suit of claim **15**, comprising multiple quilted articles defining additional pockets, wherein each of the additional pockets is filled with additional aerogel beads.

17. A glove comprising:

a palm portion configured to cover a palm of a wearer's hand;

a back portion configured to cover a back of the wearer's hand;

fingers extending distally of the palm portion and the back portion and configured to receive fingers of the wearer; and

a web portion extending distally of the back portion and across a back side of the fingers;

wherein the palm portion, back portion, fingers, and web portion are all constructed of quilted material defining pockets filled with beads.

18. The glove of claim **17**, further comprising a waterproof layer outside of the quilted material.

19. The glove of claim **17**, further comprising:

a wrist portion extending proximally from the palm portion and the back portion, the wrist portion:

configured to enclose a wrist of the wearer, and

constructed of quilted material defining wrist portion pockets filled with beads, the wrist portion pockets being separated from the pockets of the palm portion and the back portion such that the beads are prevented from traveling to the wrist portion from the palm portion or the back portion.

20. The glove of claim **17**, wherein the beads are aerogel beads.

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