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(54) **FOOTWEAR ARTICLE INCLUDING CIRCULAR KNIT STRUCTURES**

SCHUHWERK MIT RUNDSTRICKSTRUKTUREN

ARTICLE CHAUSSANT COMPRENANT DES STRUCTURES TRICOTÉES CIRCULAIRES

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Description**TECHNICAL FIELD**

[0001] The present disclosure relates to a footwear article that includes circular knit structures.

BACKGROUND

[0002] Conventional footwear articles have a sole and an upper attached to the sole. Footwear manufacturing has historically been a cut-sew-assembly operation that is labor intensive. Panels of upper materials are cut to size and sewn together to create the upper. The sole is attached to the upper using a number of different techniques to create the finished footwear article. Recent developments in footwear design employ knitting technology to form portions of footwear and the upper in particular. In some instances, flat bed knitting is used to form a planar knitted fabric blank. The planar knitted fabric blank is formed into a specific shape so that it can be folded or wrapped into a near completed shoe upper. Once the upper is formed, the sole component or other durable structures are attached to the knitted shoe upper consistent with conventional footwear manufacturing techniques. While some sewing is required to create the shoe upper using flat-bed knitting, fewer sewing steps are required compared to conventional shoe manufacturing. Although flat knitting may result in increased material utilization, because fabric cutting is minimized, there are design limits and production inefficiencies inherent in flat knitting. Examples are shown by US2019208862 and US2017311672.

SUMMARY

[0003] The invention is set out in the appended set of claims.

BRIEF DESCRIPTION OF THE DRAWINGS**[0004]**

Figure 1 is a side elevation view of a footwear article not in accordance with the claimed invention;

Figure 2 is an exploded view of the footwear article shown in Figure 1;

Figure 3 is a cross-sectional view of the footwear article taken along line 3-3 in Figure 1;

Figure 4 is a side view of a knitted blank used to form a component of the footwear article illustrated in Figures 1-3;

Figure 5 is a side view of an interior of the knitted blank used to form the component of the footwear

article illustrated in Figures 1 and 2, showing portion of the knitted blank removed to create an ankle portion of the footwear article; and

Figure 6 is a side elevation view of a double layer knitted footwear component formed from the knitted blank shown in Figure 4.

Figure 7 illustrates a article not in accordance with the claimed invention;

Figure 8 illustrates a footwear article comprising a lacing system not in accordance with the claimed invention;

Figure 9 illustrates a footwear article comprising a collar not in accordance with the claimed invention;

Figure 10 illustrates a footwear article comprising a plurality of features not in accordance with the claimed invention;

Figure 11 illustrates a footwear article comprising a plurality of features not in accordance with the claimed invention;

Figure 12 illustrates a footwear article comprising a lacing system not in accordance with the claimed invention;

Figure 13 illustrates a footwear article comprising a lacing system not in accordance with the claimed invention;

Figure 14 illustrates example footwear articles comprising functional layers.

DETAILED DESCRIPTION OF EMBODIMENTS

[0005] Embodiments of the present disclosure include a footwear article that includes a circular knitted fabric formed into a double-layer knitted upper of a footwear article 10. The footwear article 10 is disclosed as having a configuration suitable for walking or running. Concepts associated with the footwear may also be applied to a variety of other athletic footwear types, including baseball shoes, basketball shoes, cross-training shoes, cycling shoes, football shoes, tennis shoes, soccer shoes, sprinting shoes, and hiking boots, for example. The concepts may also be applied to footwear types that are generally considered to be non-athletic, including dress shoes, loafers, sandals, and work boots. The concepts disclosed in this application apply to a wide variety of footwear types.

[0006] Referring to Figures 1-3, a footwear article 10 includes a sole component 20 and an upper knitted component 30. For reference purposes, footwear article 10 may be divided into three general regions: a forefoot re-

gion 11, a midfoot region 12 rearward of the forefoot region, and a heel region 13. The forefoot region 11 generally includes portions of footwear article 10 corresponding with the toes and the joints connecting the metatarsals with the phalanges. The midfoot region 12 generally includes portions of footwear article 10 corresponding with an arch area of the foot. The heel region 13 generally corresponds with rear portions of the foot. The footwear article 10 also includes a medial side 14 and a lateral side 15, which extend through each of the regions 11-13 and correspond with opposite sides of footwear article 10. The lateral side 15 corresponds with an outside area of the foot, i.e. the surface that faces away from the other foot, and the medial side 14 corresponds with an inside area of the foot, i.e., the surface that faces toward the other foot. Regions 11-13 and sides 14-15 are intended to represent general areas of footwear article 10. In addition to footwear article 10, regions 11-13 and sides 14-15 may also be applied to sole component 20 and/or the upper knitted component 30.

[0007] Continuing with Figures 1-3, the sole component 20 is secured to the upper knitted component 30 and extends between the foot and the ground when footwear article 10 is worn. The sole component 20 may include a midsole, an outsole, and a liner (not shown). The midsole is secured to the upper knitted component 30, as further explained below. The mid-sole may be formed from a compressible polymer foam element, e.g., a polyurethane or ethylvinylacetate foam, that attenuates ground reaction forces and provides cushioning when compressed between the foot and the ground during walking, running, or other ambulatory activities. The outsole is secured to a lower surface of midsole and may be formed from a wear-resistant rubber material that is textured to impart traction. The structure and features of sole component 20 or any sole component utilized with upper knitted component 30 may vary considerably.

[0008] The footwear article 10 includes a plurality of tabs 22a-22d that extend upwardly from the sole component 20 along a medial side 14 and a lateral side 15 of the footwear article 10. The plurality of tabs 22a-22d include securing members 24a-24d in the form of openings, slots, and/or hooks that receive a cord 18.

[0009] Continuing with Figures 1-3, the upper knitted component 30 forms an internal void 31 within footwear article 10 for receiving and securing a foot relative to sole component 20. The void 31 is shaped to accommodate the foot and extends along the lateral side of the foot, along the medial side of the foot, over the foot, around the heel, and under the foot. Access to the void is provided by an ankle opening 32 located in at least heel region 13. A cord 18 extends through portions of upper knitted component 30, as described above, and permits the wearer to modify dimensions of the upper knitted component 30 to accommodate the proportions of the foot. The cord 18 permits the wearer to tighten the upper knitted component 30 around the foot, and cord 18 permits the wearer to loosen the upper knitted component

30 to facilitate entry and removal of the foot from the void 31 through ankle opening 32.

[0010] Continuing with Figures 1-3, the upper knitted component 30 is a double layer knitted upper having a substantially monolithic, circular knit, fabric construction. The double layer knitted upper has a foot bed 41, a toe portion 42, a mid-foot portion 44 (sometimes called an upper portion 44) continuous with the toe portion 42, a heel portion 46 adjacent and continuous with the mid-foot portion 44 and an ankle portion 48 that defines the ankle opening 32. The foot bed 41 extends from the toe portion 42 along the mid-foot portion 44 to the heel portion 46. The sole component 20 is attached to the foot bed 41. In an alternative embodiment, a liner (not shown) is positioned within the double layer knitted upper along the foot bed 41. The toe portion 42, mid-foot portion 44, heel portion 46, and ankle portion 48, and foot bed 41 refer to generally areas of the upper knitted component 30.

[0011] Referring to Figures 2 and 3, the double layer knitted upper has an outer knit layer 60 and an inner knit layer 80. The outer knit layer 60 and the inner knit layer 80 together form the toe portion 42, the mid-foot portion 44, the heel portion 46, and the ankle portion 48 of the double layer knitted upper. The outer knit layer 60, however, defines an exterior surface 50 of the double layer knitted upper and the inner knit layer defines an inner surface 52 of the double-layer knitted upper. Thus, it can be said that the outer knit layer 60 forms the exterior facing surfaces (not numbered) of the toe portion 42, the mid-foot portion 44, the heel portion 46, and the ankle portion 48. Conversely, the inner knit layer 80 defines the inward facing surfaces (not numbered) of the toe portion 42, the mid-foot portion 44, the heel portion 46, and the ankle portion 48. Furthermore, both the outer knit layer 60 and the inner knit layer 80 substantially define the foot bed 41 of the double-layer knitted upper. The outer knit layer 60 and the inner knit layer 80 may define an edge 51 along the ankle opening 32. An optional binding 54 may be disposed along the edge 51 of the ankle opening 32.

[0012] The double layer knitter upper include at least one attachment member that consolidates the outer knit layer 60 to the inner knit layer 80, thereby forming the double layer knitted upper. The attachment member may be any material that fuses the outer knit layer 60 and the inner knit layer 80 together. Because the outer and inner knit layers are circular knit structure, each layer has float yarns on side due to the different knit constructions formed in the knitted regions described below. When the double layer knitter upper is formed the floats from the outer knit layer 60 face the floats from the inner knit layer 80. The floats can create snags and deform the knit construction when the floats are pulled or the layers or otherwise deformed. The attachment members address this problem by consolidating the outer knit layer and the inner knit layer together. In particular, the attachment member bonds the yarns from the outer knit layer 60 to the yarns from the inner knit layer 80. This bonding minimizes dis-

tortion in the knit structure created in use. The attachment members also bind the outer and inner knit layers together so that the two layers do not slide relative to one another. The attachment member provides stability to the double layer knitted upper. In one example, the attachment member may comprise binding yarns. The binding yarns may comprise part of the knit stitches, may be laid-in, or plated in during knitting. When the binding yarns exposed to a desired temperature (at above glass transition temperature), the binding yarns melt, thereby consolidating the outer and inner knit layers 60, 80 together. The binding yarns may be thermoplastic polyurethane yarns. In another example, the binding yarns are low-melt thermoplastic yarns that have a lower melt temperature than the yarns used to form the outer and inner knit layers 60, 80. In an alternative embodiment, the attachment member may be a low-melt adhesive film, a low melt adhesive nonwoven web, or an adhesive coating. In still another alternative embodiment, the attachment member could be binding yarns that tack the outer layer and inner layer together.

[0013] The outer knit layer 60 has plurality of outer knit regions 62a-62f and the inner knit layer 80 has a plurality of inner knit regions 82a-82g. The outer and inner knit regions comprise selected textile structural elements. The selected textile structural elements may include specific knit stitches and/or presence of certain yarns. Furthermore, the selected textile structural elements may include the absence of certain knit stitches and/or yarns. One or more of the plurality of outer knit regions 62a-62f of the outer knit layer 60 may spatially correspond to one or more of the plurality of inner knit regions 82a-82g. In embodiments where the inner knit regions spatially correspond to the outer knit regions, the inner knit regions completely or partially underlie the outer knit regions. For example, each one of the inner knit regions 82a-82e underlie the respective outer knit regions 62a-62d. However, the outer knit layer 60 and the inner knit layer 80 may comprise different knit regions in different locations from the other.

[0014] Figure 2 illustrates the plurality of outer knit regions 62a-62f. As illustrated, the plurality of outer knit regions comprise a first outer knit region 62a along the toe portion 42 and a portion of the foot bed 41. The first outer knit region 62a may be called a forward toe knit region. A second outer knit region 62b extends across the top of the toe portion 42. The second outer knit region 62b may be called an upper toe knit region. A third outer knit region 62c extends across the top part of the mid-foot portion 44 and rearward of the toe portion 42. The third outer knit region 62c may be called an upper mid-sole knit region. A fourth outer knit region 62d extends across heel portion 46. The fourth region 62d is referred to as an outer heel region. A fifth outer knit region 62e forms the remaining areas of the outer knit layer. A sixth outer knit region 62f is located along the ankle portion 48 above the outer heel portion 46. Each outer knit region 62a through 62f may have different textile structural el-

ements, in terms of knit structure and/or yarns. Alternatively, each outer knit regions 62a-62f may have similar knit constructions, in terms of knit structure and/or yarns. In one example, the upper mid-sole knit region 62c may comprise binding yarns. Binding yarns may be, for example, thermoplastic polyurethane yarns. The binding yarns may facilitate consolidating the outer and inner knit layers 60, 80 together.

[0015] As best shown in Figures 2 and 4, the inner knit layer 80 includes a plurality of inner knit regions 82a-82g that comprise selected textile structural elements. Regions 82a-82g are not shown in Figure 2 but are illustrated in Figure 4 as part of the knitted blank 130. As illustrated, the plurality of inner knit regions include a first inner knit region 82a along the toe portion and a portion of the foot bed. The first inner knit region 82a may be called a forward toe knit region. A second inner knit region 82b extends across the top of the toe portion. The second inner knit region 82b may be called an upper toe knit region. A third inner knit region 82c extends across the top part of the mid-sole portion and rearward of the toe portion. The third inner knit region 82c may be called an upper mid-sole knit region. A fourth inner knit region 82d extends across the heel portion. The fourth region 82d is referred to as an inner heel region. A fifth inner knit region 82e forms the remaining areas of the inner knit layer 80. A sixth inner knit region 82g extends across the bottom part of the mid-sole portion and rearward of the toe portion. The sixth inner knit region 82g may be called a lower mid-sole knit region 82g. A seventh inner knit region 82f is located along the ankle portion. Each inner knit region 82a through 82g may have different textile structural elements, in terms of knit structure and/or yarns. Alternatively, each inner knit regions 82a-82g may have similar knit constructions, in terms of knit structure and/or yarns. In one example, the upper mid-sole knit region 82c and/or the lower mid-sole knit region 82g may comprise binding yarns. Binding yarns may be thermoplastic polyurethane yarns, as described above. Binding yarns may facilitate consolidating the outer and inner knit layers 60, 80 together.

[0016] The double layer knitted upper can have a variety of circular knit constructions. For instance, the double layer knitted upper may have include a single jersey knit construction, a double knit construction, rib knit construction, a terry knit construction, or other types of weft knit constructions. Furthermore, the different regions of the double layer knitted upper may comprise different knit stitches, such as float stitches, held stitches, missed stitches, and other knit stitches known to a person of skill in the art. In one example, the outer knit toe regions 62a, 82a of the outer and/or inner layer may comprise a cushioned knit construction. Likewise, the heel regions 62d, 82d of the outer and/or inner layer can have cushioned knit construction. A cushioned knit construction includes knitted terry loops.

[0017] The double layer knitted upper can be formed from any number of yarn types, such as spun yarns or

continuous filament yarns. Spun yarns may include natural fibers, synthetic fibers, or blends of natural and synthetic fibers. Natural fibers include cotton, wool, bamboo, flax, hemp, or others. Synthetic fibers may include polyethylene terephthalate (PET), polyolefin, polyamide 6, polyamide 6,6, polylactic acid (PLA) fibers, viscose rayon, acrylic, or other fiber types. Suitable thermoplastic synthetic staple fibers may be mono-component or bi-component type fibers. A variety of yarn spinning types can be used, such as ring spun, open end, air-jet, compact spinning, and the like. Continuous filament yarns may include either or both mono-component or bi-component filaments types. Continuous filament yarns can be polyethylene terephthalate, polyolefin, and/or polyamide 6, polyamide 6,6, polylactic acid filaments. Yarns used in the knit fabric can have a range of yarn counts. For instance, in one example, the knit yarn can have a count in a range between about 50 denier to about 250 denier (or higher). The yarns are not limited to the stated range of deniers. Binding yarns are used in selected regions of the outer knitted layer 60 and the inner knitted layer 80 to help consolidate the outer layer and the inner layers together. Binding yarns may be low melt thermoplastic yarns, or yarns such as thermoplastic polyurethane yarns.

[0018] Another embodiment of the present disclosure is a method for forming a footwear article 10. The method may include a knitting phase for forming a circular knitted blank 130. Following the knitting phase, the method may include an assembling phase where the circular knitted blank 130 is formed into an upper knitted component 30 and the sole component 20 is attached to foot bed 41 of the upper knitted component 30. Referring to Figures 4-6, the circular knitted blank 130 has a first knit section 160 defining the outer knit layer 60 and the second knit section 180 defining the inner knit layer 80. The circular knitted blank 130 is folded into to itself to define the double layer knitted upper so that the inner knit layer 80 forms the inner void 31 of the footwear article 10.

[0019] The knitting phase utilizes a circular knitting machine (not shown) familiar to a person of skill in the art. The circular knitting machine may be a double needle machine that includes two cylinders. Alternatively, a circular knitting machine with a cylinder and a dial may be used. The knitting process is described below using a knitting machine with two cylinders for purposes of illustration and clarity. It should be appreciated that other types of knitting machines could be used. Each cylinder has a plurality of needles disposed around the circumference of the cylinder with each needle housed in moveable tracks. A cam assembly engages the needles along each cylinder. Rotational movement of the cam assembly (or relative movement of the cylinders) causes the needles to move up and down the tracks through what is known in the art as the knitting cycle to create courses of interconnected knitted loops of yarns. The courses of knitted loops define the circular knitted fabric blank 130. By altering the knitting cycles and/or holding certain nee-

dles in place during knitting, specific knit stitches and/or patterns can be formed into the circular knitted blank 130. The circular knitting machines and the basic circular knitting process is familiar to a person of skill in the art. Various circular knit processes may be used, such as tube circular knitting, narrow tube circular knit jacquard, single knit circular knit jacquard, double knit circular knit jacquard knitting.

[0020] Referring to Figure 4, the circular knitted blank 130 has a first terminal end 132 and a second terminal end 134. The circular knitted blank 130 is formed to have a first knit section 160 that defines the first terminal end 132 and a second knit section 180 that defines the second terminal end 134. The circular knitted blank 130 is comprised of interconnected rows of knitted loops, called courses, as described above. The first "course" of the knitted blank 130 is located at the first terminal end 132. The circular knitted blank 130 is formed course-by-course, in the direction K shown in Figure 4 until the circular knitted blank 130 is complete, as shown in Figure 4. Accordingly, during the knitting phase, the first knit section 160 is knitted first, then the second knit section 180 is formed in a single monolithic fabric with the first knit section 160.

[0021] Circular knitting of the knitted blank 130 initiates with the cylinder needles knitting the first toe portion 142 of the first knit section 160. Next, the circular knitting machine knits the mid-sole portion, which includes a first upper portion 144a and the first lower portion 144b. Then, the first heel portion 146 the first knit section 160 is knit adjacent to the first lower portion 144b. During the knitting the first heel portion 146, the knitting machine can selectively drop needles to alter the direction of knitting to form the desired curve of the first heel portion 146. After the first heel portion 148 is formed, the circular knitting machine knits the first ankle portion 148 of the first knit section adjacent 160 to the first heel portion 148 and the first upper portion 144a. At this point, the first knit section 160 is substantially complete. The first knit section 160 comprises the outer knit layer 60 of the double layer knitted upper, as explained below. Accordingly, as the knitting machine forms the first knit section 160, the different knit regions 62a-62f are created in the circular knitted blank 130, as shown.

[0022] The knitting process continues to form the second knit section 180. During this phase of knitting, the second ankle portion 248 of the second knit section 180 is formed adjacent to the first heel portion 148. The circular knitting machines knits a second heel portion 246 adjacent to and continuous with the second ankle portion 248. The circular knitting machine knits a second upper portion 244a and a second lower portion 244b of the second knit section 180. The knitting process continues and forms the second toe portion 242 of the second knit section 180 adjacent to the second upper portion 244a and the second lower portion 244b. The second toe portion 242 is formed to the terminal end 134 to complete the circular knitted blank 130. As the knitting machines forms

the second knit section 180, the different knit regions 82a-82g are created in respective areas of the circular knitted blank 130. As illustrated, the formed circular knitted blank 130 is substantially a tubular structure having the shape of two crew-cut socks connected as the ankle portion.

[0023] Additional courses of yarns may be added to facilitate transition to the next knitted blank formed by the circular knitting machine. Optional cutting devices are used to cut the completed circular knitted blank 130 from the knitting machine. The circular knitted blank 130 is the ejected out of the knitting machines for later processing.

[0024] The completed circular knitted blank 130 may have toe openings 152 and 252 at toe portion 142 and toe portion 242, respectively. The toe openings 152 and 252 can be closed with seams 154 and 254 as illustrated in Figure 5. In an alternative embodiment, the circular knitted blank 103 can be formed to automatically close the toe openings 152 and 252 using bridge stitches or inlaid yarns and the like.

[0025] The circular knitted blank 130 may be cut to form the ankle opening 32 by removing a panel 156 from the circular knitted blank 130. In an alternative embodiment, the circular knitted blank 103 can be formed to define the ankle opening 32 during knitting. In such an embodiment, the circular knitted blank 130 may form a welted edges along the border of the ankle opening 32 to prevent fraying and provide a place to attach a binding 54 (Figures 1 and 6).

[0026] When the circular knitted blank 130 is completed, the second knit section 180 is folded into the first knit section 160 to form a double layer knitted upper of the footwear article. At this stage, the double layer knitted upper comprises the outer knit layer 60 defined by the first knit section 160 and the inner knit layer 80 defined by the second knit section 180. In this state, at least two of the plurality of the outer knit regions 62a-62d of the outer knit layer 60 spatially correspond to at least two of the plurality of inner knit regions. In accordance with the illustrated embodiment, the inner knit regions 82a-82e underlie the outer knit regions 62a-62e.

[0027] The method may comprise, before folding, positioning a liner component along a lower portion of the first knit section. The liner component is therefore disposed between the outer knit layer and the inner knit layer.

[0028] The method may include attaching a sole directly to the outer knit layer of the double layer knitted upper. Attaching the sole to the outer knit layer comprises positioning the double layer knitted upper over a positioning member of an injection-molding device (not shown). Then, the sole component is injection molded onto the outer knit layer of the double layer knitted upper. In addition, the method may include injection molding a plurality of tabs 22a-22d along medial and lateral sides of the double layered knitted upper. The injection molding process may melt the TPU yarns in the specific knitted regions thereby bonding the outer knit layer to the inner

knit layer to form a monolithic, double layer knitted upper.

[0029] Double layer knitted uppers that are circular knit as described herein have several advantages. A wide range of knit constructions across different regions of the upper is possible while using a single fabric construction. Specific knit structures can be designed into different regions of the footwear article as needed. In addition, complex three-dimensional shapes that better conform to the anatomy of the foot of the wearer may be formed during the knitting process. Because circular knitted uppers are made to conform to the foot of the wearer, fewer assembly steps are required prior to attaching the upper to the sole to create the finished footwear article. Fewer total components in the finished footwear article decreases supply chain complexity and increases production efficiency and output. Furthermore, circular knitted double layer uppers can be manufactured at relatively fast production rates further increasing production efficiency.

[0030] A footwear article 300 may comprise a plurality of layers or may be continuous so as to form a unitary body. The footwear article 300 may comprise a first layer 301 and a second layer 302. The first layer 301 and the second layer 302 may comprise soft materials such as fabric. The first layer 301 and the second layer 302 may be generally tubular or may comprise other shapes. The second layer 302 may comprise rigid material such as leather or plastic. The first layer 301 and the second layer 302 may be circular-knit, flat-knit or formed by other manufacturing methods or from other materials. The second layer 302 may be folded or inverted to be disposed adjacent at least a portion of the first layer 301. The second layer 302 may comprise at least a portion of the interior or the exterior of the footwear article 300. The footwear article 300 may comprise additional layers which may provide additional functionalities.

[0031] As shown in FIG. 7, the footwear article 300 may comprise the first layer 301 and the second layer 302. The first layer 301 and the second layer 302 may comprise generally tubular shapes. The first layer 301 may comprise waterproof breathable material suitable for forming at least a portion of the exterior of the footwear article 300. The first layer 301 may be coated with a spray application to provide waterproofing and may also be breathable. The second layer 302 may comprise soft material suitable for conforming to a wearer's foot and providing comfort. The second layer 302 may be or comprise a comfort liner. When the second layer 302 is folded into the first layer 301, the second layer 302 defines the interior of the footwear article 300 and the first layer 301 defines the exterior of the footwear article 300. Although reference is made to the first and second layers 301, 302 other arrangements may be used. For example, the features of each layer may be switched or combined between the layers.

[0032] One problem in conventional circular knit applications is the difficulty in sewing or bonding other materials to a circular knit upper because it has a finished 3D shape.

[0033] As an example, most heat presses and sewing machines are optimized to work with roll goods in the flat. When a circular knit upper has a 3D shape, the typical flat operations may not be suitable.

[0034] As a further example, 3D direct injection may be used to apply additive structures, cushioning, lace details, etc. to a circular knit upper. The process may be implemented on a lasted upper, which may be finished in a 3D shape.

[0035] As illustrated in FIG. 8, a footwear article 400 may comprise a plurality of layers or may be continuous so as to form a unitary body. The footwear article 400 may comprise a first layer 401 and a second layer 402. The first layer 401 and the second layer 402 may comprise soft materials such as fabric. The first layer 401 and the second layer 402 may be generally tubular or may comprise other shapes. The second layer 402 may comprise a rigid material such as leather or plastic. The first layer 401 and the second layer 402 may be circular-knit, flat-knit or formed by other manufacturing methods or from other materials. The second layer 402 may be folded or inverted to be disposed adjacent at least a portion of the first layer 401. The second layer 402 may comprise at least a portion of the interior or the exterior of the footwear article 400. The footwear article 400 may comprise additional layers which may provide additional functionalities.

[0036] As shown in FIG. 8, the footwear article 400 may comprise a first layer 401, a second layer 402 and a lacing system 403. The lacing system 403 may comprise laces, eyelets, straps, hook and loop or other types of fasteners. The lacing system 403 may be disposed adjacent a portion of the first layer 401, a portion of the second layer 402 or a portion of both layers 401, 402. The first layer 401 and the second layer 402 may comprise generally tubular shapes which may be circular-knit. The second layer 402 may be folded into the first layer 401. The second layer 402 may define the interior portion of the footwear article 400 and the first layer may define the exterior portion of the footwear article 400. As shown, the lacing system 403 may be circumferentially disposed around the second layer 402. When the second layer 402 is folded into the first layer 401, the lacing system 403 may be disposed in-between the first and second circular-knit layers 401, 402 of the footwear article 400.

[0037] As illustrated in FIG. 9, a footwear article 500 may comprise a plurality of layers or may be continuous so as to form a unitary body. The footwear article 500 may comprise a first layer 501 and a second layer 502. The first layer 501 and the second layer 502 may comprise soft materials such as fabric. The first layer 501 and the second layer 502 may be generally tubular or may comprise other shapes. The second layer 502 may comprise a rigid material such as leather or plastic. The first layer 501 and the second layer 502 may be circular-knit, flat-knit or formed by other manufacturing methods or from other materials. The second layer 502 may be folded or inverted to be disposed adjacent at least a portion of the

first layer 501. The second layer 502 may comprise at least a portion of the interior or the exterior of the footwear article 500. The footwear article 500 may comprise additional layers which may provide additional functionalities.

[0038] As shown in FIG. 9, the footwear article 500 may comprise a first layer 501, a second layer 502 and a collar portion 504. As shown, the first layer 501 may comprise a generally tubular shape. The first layer 501 may be circular-knit. The second layer 502 may comprise a planar rectangular shape. The second layer 502 may be flat knit. The second layer 502 may comprise one or more welded reinforcements 505 for securing the second layer 502 to the first layer 501. The second layer 502 may be configured for flat sewing operations 506 such as flat sewing, molding or screen printing. The second layer 502 may be configured to be folded into or around the first layer 501 to define the collar portion 504. The second layer 502 may be configured to be disposed partially circumferentially around an exterior portion of the first layer 501 to define the collar portion 504. The second layer 502 may also be disposed adjacent a midfoot, an ankle or another portion of the first layer 501 to define other features.

[0039] FIG. 10 illustrates a footwear article 600 may comprise a plurality of layers or may be continuous so as to form a unitary body. The footwear article 600 may comprise a first layer 601 and a second layer 602. The first layer 601 and the second layer 602 may comprise soft materials such as fabric. The first layer 601 and the second layer 602 may be generally tubular or may comprise other shapes. The second layer 602 may comprise a rigid material such as leather or plastic. The first layer 601 and the second layer 602 may be circular-knit, flat-knit or formed by other manufacturing methods or from other materials. The second layer 602 may be folded or inverted to be disposed adjacent at least a portion of the first layer 601. The second layer 602 may comprise at least a portion of the interior or the exterior of the footwear article 600. The footwear article 600 may comprise additional layers or features which may provide additional functionalities.

[0040] As shown in FIG. 10, the footwear article 600 may comprise a first layer 601 and a second layer 602. The first layer 601 may be generally tubular. The first layer 601 may be circular-knit. The second layer 602 may comprise hard or rigid material such as leather, rubber or plastic which are suitable for defining at least a portion of the exterior of the footwear article 600. The second layer 602 may be flat-knit. The second layer 602 may be configured to be disposed adjacent at least an exterior portion of the first layer 601. The second layer 602 may comprise reinforcement regions 610. For example, as shown, the reinforcement regions 610 may define a heel cup 610a and a toe cup 610b. The second layer 602 may comprise apertures 608 that define a lacing system 603 or other functions. The apertures 608 may comprise lace holes or eyelets configured to receive shoe laces or

straps.

[0041] The footwear article 600 may further comprise one or more venting regions 607 which provide ventilation. The venting regions 607 may be generally triangular or planar or may have other shapes. As shown, the first layer 601 and the second layer 602 may comprise a plurality of venting regions 607. The venting regions 607 of the first layer 601 may correspond with and be configured to be disposed adjacent the venting regions 607 of the second layer 602 when inverted to form the footwear article 600.

[0042] A footwear article 700 may comprise a plurality of layers or may be continuous so as to form a unitary body. The footwear article 700 may comprise a first layer 701 and a second layer 702. The first layer 701 and the second layer 702 may comprise soft materials such as fabric. The first layer 701 and the second layer 702 may be generally tubular or may comprise other shapes. The second layer 702 may comprise a rigid material such as leather or plastic. The first layer 701 and the second layer 702 may be circular-knit, flat-knit or formed by other manufacturing methods or from other materials. The second layer 702 may be folded or inverted to be disposed adjacent at least a portion of the first layer 701. The second layer 702 may comprise at least a portion of the interior or the exterior of the footwear article 700. The footwear article 700 may comprise additional layers which may provide additional functionalities.

[0043] As illustrated in FIG. 11, the footwear article 700 may comprise a first layer 701 and second layer 702. The first layer 701 and the second layer 702 may be continuous so as to define a unitary body. The second layer 702 may be configured to be inverted adjacent an exterior surface of the first layer 701. The first layer 701 and the second layer 702 may comprise one or more features. As shown, the second layer 702 may comprise a plurality of strips 709a, 709b, 709c. The strips 709a, 709b, 709c may comprise knit material, rigid material or a combination of knit and rigid materials to define different features. As shown, the first strip 709a may comprise a reinforcement region 710 which may define a heel cup 710a. The second strip 709b may comprise apertures 708 that may define a lacing system 703.

[0044] A footwear article 800 may comprise a plurality of layers or may be continuous so as to form a unitary body. The footwear article 800 may comprise a first layer 801 and a second layer 802. The first layer 801 and the second layer 802 may comprise soft materials such as fabric. The first layer 801 and the second layer 802 may be generally tubular or may comprise other shapes. The second layer 802 may comprise a rigid material such as leather or plastic. The first layer 801 and the second layer 802 may be circular-knit, flat-knit or formed by other manufacturing methods or from other materials. The second layer 802 may be folded or inverted to be disposed adjacent at least a portion of the first layer 801. The second layer 802 may comprise at least a portion of the interior or the exterior of the footwear article 800. The footwear

article 800 may comprise additional layers which may provide additional functionalities.

[0045] As illustrated in FIG. 12, the footwear article 800 may comprise a first layer 801 and a second layer 802. The first layer 801 may be generally tubular. The first layer 801 may be circular knit. The second layer 802 may comprise an irregular planar shape. The second layer 802 may be flat-knit. The footwear article 800 may further comprise a lacing system 803. As shown, the second layer 802 may comprise members 811 configured to extend through at least a portion of the first layer 801. The members 811 may be configured to be removably received in apertures 808 within the first layer 801. The members 811 may comprise loops and hooks to define a footwear article 800 with a pull through feature.

[0046] A footwear article 900 may comprise a plurality of layers or may be continuous so as to form a unitary body. The footwear article 900 may comprise a first layer 901 and a second layer 902. The first layer 901 and the second layer 902 may comprise soft materials such as fabric. The first layer 901 and the second layer 902 may be generally tubular or may comprise other shapes. The second layer 902 may comprise a rigid material such as leather or plastic. The first layer 901 and the second layer 902 may be circular-knit, flat-knit or formed by other manufacturing methods or from other materials. The second layer 902 may be folded or inverted to be disposed adjacent at least a portion of the first layer 901. The second layer 902 may comprise at least a portion of the interior or the exterior of the footwear article 900. The footwear article 900 may comprise additional layers which may provide additional functionalities.

[0047] As illustrated in FIG. 13, the footwear article 900 may comprise a first layer 901 and a second layer 902. The first layer 901 may comprise a generally tubular shape. The first layer 901 may be circular-knit. The second layer 902 may comprise a planar irregular shape. The second layer 902 may be flat knit. The second layer 902 may be inverted adjacent an exterior surface of the first layer 901. The second layer 902 may comprise a lacing system 903. As shown, the second layer 902 may comprise apertures 908 (e.g. lace holes) which define the lacing system 903. The second layer 902 may comprise reinforcement regions 910 which may define a heel cup 910a and a toe cup 910b that provide structure and integrity to the exterior of the footwear article 900.

[0048] FIG 14. illustrates footwear articles 950 - 954 which comprise functional layers 960 - 965. Functional layers 960 - 965 comprise footbeds and midsoles, the functional layers 960-965 may further comprise insulation, socks, collars and other functional features within the footwear articles 950 - 954. The functional layers are interposed between two knit layers such as using a fold over technique or other technique. The functional layer may comprise a waterproof material or membrane or a breathable waterproof membrane. The functional layer may be a pre-formed laminate or composite. The functional layer may be a spray application. The function layer

may be a 3D direct injection. The functional layer may be applied in other configurations or on other surfaces. As a non-limiting example, one problem that is being addressed by the present disclosure is that circular knit, while fast, it may be hard to sew or bond things to a circular knit upper because it is a finished 3D shape. Most heat presses and sewing machines in the state of the art are optimized to work with roll goods in the flat. As an illustrative example, 3D direct injection is one method of applying additive structures, cushioning, lace details, etc. that is optimized to work in 3D shaping. This process may be implemented on a lasted upper, as fully finished and 3D shape.

[0049] As shown, the functional layer 960 may comprise a built in footbed in the midsole of the footwear article 950. The functional layer 961 comprises a knit footbed (e.g. padding knit) within the footwear article 951. The functional layer 962 may comprise captured insulation within the footwear article 952. The functional layer 963a comprises a trapped midsole within the footwear article 953. The midsole comprises features such as outsole lugs that extend through the first and/or the second layers. The lugs are configured to engage the ground. The first layer or the second layer comprise apertures to allow the lugs from the trapped midsole to extend therethrough. Various configurations of lugs may be used such as an arrangement at the heel and an arrangement at the forefoot. The functional layer 963b may comprise a trapped foam collar within the footwear article 953. The functional layer 964 may comprise a generic upper and outsole within the footwear article 954. The functional layer 965 may comprise a custom inner sock within the footwear article 954.

Claims

1. A footwear article (950-954), comprising:

a first circular-knit layer;
a second circular-knit layer coupled to the first circular-knit layer, the second circular-knit layer configured to be disposed adjacent at least a portion of the first circular-knit layer when folded into or around the first circular-knit layer; and
a functional layer (960-965) interposed between the first circular-knit layer and the second circular-knit layer using a fold-over technique, such that, when the second circular-knit layer is folded into or around the first circular-knit layer, the functional layer is trapped between the first circular-knit layer and the second circular-knit layer and comprises a trapped midsole and a knit footbed within the footwear article, wherein the trapped midsole comprises outsole lugs that extend through the first and the second layers, and wherein the first layer or the second layer comprises apertures to allow the outsole lugs of

trapped midsole to extend therethrough.

2. The footwear article (950-954) of claim 1, wherein the functional layer (960-965) comprises one or more of a waterproof membrane, a breathable waterproof membrane, or a spray application.
3. The footwear article (950-954) of any one of claims 1-2, wherein the first circular-knit layer defines at least a portion of an exterior surface, and wherein the second circular-knit layer comprises a second circular-knit layer.
4. The footwear article (950-954) of claim 3, wherein the second circular-knit layer extends from the first circular-knit layer as a unitary body.
5. The footwear article (950-954) of any one of claims 1-4, wherein the first circular-knit layer comprises a generally tubular shape.
6. The footwear article (950-954) of any one of claims 1-5, wherein the second circular-knit layer comprises a generally tubular shape.
7. The footwear article (950-954) of any one of claims 1-6, wherein the first circular-knit layer comprises waterproof breathable material and wherein the second circular-knit layer comprises a comfort liner.
8. The footwear article (950-954) of claim 1, further comprising a lacing system disposed adjacent at least a portion of the second circular-knit layer such that at least a portion of the lacing system is interposed between the second circular-knit layer and the first circular-knit layer when the second circular-knit layer is folded into the first circular-knit layer.
9. The footwear article (950-954) of any one of claims 1-8, wherein the first circular-knit layer comprises a generally tubular shape and wherein the second circular-knit layer comprises a planar shape, wherein the second circular-knit layer is configured for flat operations prior to being folded into or around the first circular-knit layer.
10. The footwear article (950-954) of claim 9, wherein the second circular-knit layer comprises one or more welded reinforcement regions (505).
11. The footwear article (950-954) of any one of claims 9-10, wherein the first circular-knit layer comprises a collar, and wherein the second circular-knit layer is configured to be disposed at least partially circumferentially around an exterior surface of the first circular-knit layer.
12. The footwear article (950-954) of any one of claims

1-11, wherein the first circular knit layer comprises one or more venting regions (607) and wherein the second circular-knit layer is configured to be folded into or around the first circular-knit layer the first circular-knit layer to be adjacent at least a portion of the venting regions (607).

13. The footwear article (950-954) of any one of claims 1-12, wherein the second circular-knit layer comprises one or more features configured to be disposed adjacent the first circular-knit layer when the second circular-knit layer is folded into or around the first circular-knit layer, and wherein the one or more features comprises an aperture, lace holes, or a heel cup, or a combination of the same.
14. The footwear article (950-954) of any one of claims 1-13, wherein the second circular-knit layer comprises one or more features configured to be disposed adjacent first circular-knit layer when the second circular-knit layer is folded into or around the first circular-knit layer, wherein the one or more features comprises a pull through configured to extend through a portion of the first circular-knit layer.
15. The footwear article (950-954) of any one of claims 1-14, wherein the functional layer (960-965) further comprises captured insulation or a trapped foam collar.

Patentansprüche

1. Schuhartikel (950-954), umfassend:

eine erste Rundstrickschicht;
eine zweite Rundstrickschicht, die mit der ersten Rundstrickschicht verbunden ist, wobei die zweite Rundstrickschicht konfiguriert ist, um neben mindestens einem Abschnitt der ersten Rundstrickschicht angeordnet zu sein, wenn sie in oder um die erste Rundstrickschicht gefaltet ist; und
eine Funktionsschicht (960-965), die zwischen der ersten Rundstrickschicht und der zweiten Rundstrickschicht unter Verwendung einer Umfalttechnik eingefügt ist, sodass, wenn die zweite Rundstrickschicht in oder um die erste Rundstrickschicht gefaltet ist, die Funktionsschicht zwischen der ersten Rundstrickschicht und der zweiten Rundstrickschicht eingeklemmt ist und eine eingeklemmte Mittelsohle und ein gestricktes Fußbett innerhalb des Schuhartikels umfasst, wobei die eingeklemmte Mittelsohle Laufsohlenstollen umfasst, die sich durch die erste und die zweite Schicht erstrecken, und wobei die erste Schicht oder die zweite Schicht Öffnungen umfasst, um es den Laufsohlenstollen

der eingeklemmten Mittelsohle zu ermöglichen, sich dort hindurch zu erstrecken.

2. Schuhartikel (950-954) nach Anspruch 1, wobei die Funktionsschicht (960-965) eine oder mehrere einer wasserdichten Membran, einer atmungsaktiven wasserdichten Membran oder einer Sprühapplikation umfasst.
3. Schuhartikel (950-954) nach einem der Ansprüche 1 bis 2, wobei die erste Rundstrickschicht mindestens einen Abschnitt einer Außenfläche definiert und wobei die zweite Rundstrickschicht eine zweite Rundstrickschicht umfasst.
4. Schuhartikel (950-954) nach Anspruch 3, wobei sich die zweite Rundstrickschicht als einheitlicher Körper von der ersten Rundstrickschicht aus erstreckt.
5. Schuhartikel (950-954) nach einem der Ansprüche 1 bis 4, wobei die erste Rundstrickschicht eine im Allgemeinen röhrenförmige Form aufweist.
6. Schuhartikel (950-954) nach einem der Ansprüche 1 bis 5, wobei die zweite Rundstrickschicht eine im Allgemeinen röhrenförmige Form aufweist.
7. Schuhartikel (950-954) nach einem der Ansprüche 1 bis 6, wobei die erste Rundstrickschicht wasserdichtes, atmungsaktives Material umfasst und wobei die zweite Rundstrickschicht ein Komfortfutter umfasst.
8. Schuhartikel (950-954) nach Anspruch 1, ferner umfassend ein Schnürsystem, das neben mindestens einem Abschnitt der zweiten Rundstrickschicht angeordnet ist, so dass mindestens ein Abschnitt des Schnürsystems zwischen der zweiten Rundstrickschicht und der ersten Rundstrickschicht eingefügt ist, wenn die zweite Rundstrickschicht in die erste Rundstrickschicht gefaltet ist.
9. Schuhartikel (950-954) nach einem der Ansprüche 1 bis 8, wobei die erste Rundstrickschicht eine im Allgemeinen röhrenförmige Form aufweist und wobei die zweite Rundstrickschicht eine planare Form aufweist, wobei die zweite Rundstrickschicht für flache Vorgänge konfiguriert ist, bevor sie in oder um die erste Rundstrickschicht gefaltet wird.
10. Schuhartikel (950-954) nach Anspruch 9, wobei die zweite Rundstrickschicht einen oder mehrere verschweißte Verstärkungsbereiche (505) umfasst.
11. Schuhartikel (950-954) nach einem der Ansprüche 9 bis 10, wobei die erste Rundstrickschicht einen Kragen umfasst und wobei die zweite Rundstrickschicht konfiguriert ist, um mindestens teilweise eine

Außenfläche der ersten Rundstrickschicht umlaufend angeordnet zu sein.

12. Schuhartikel (950-954) nach einem der Ansprüche 1 bis 11, wobei die erste Rundstrickschicht einen oder mehrere Entlüftungsbereiche (607) umfasst und wobei die zweite Rundstrickschicht konfiguriert ist, um in oder um die erste Rundstrickschicht gefaltet zu sein, wobei die erste Rundstrickschicht neben mindestens einem Abschnitt der Entlüftungsbereiche (607) ist. 5 10
13. Schuhartikel (950-954) nach einem der Ansprüche 1 bis 12, wobei die zweite Rundstrickschicht ein oder mehrere Merkmale umfasst, die konfiguriert sind, um neben der ersten Rundstrickschicht angeordnet zu sein, wenn die zweite Rundstrickschicht in oder um die erste Rundstrickschicht gefaltet ist, und wobei das eine oder die mehreren Merkmale eine Öffnung, Schnürsenkellöcher oder eine Fersenkappe oder eine Kombination davon umfassen. 20
14. Schuhartikel (950-954) nach einem der Ansprüche 1 bis 13, wobei die zweite Rundstrickschicht ein oder mehrere Merkmale umfasst, die konfiguriert sind, um neben der ersten Rundstrickschicht angeordnet zu sein, wenn die zweite Rundstrickschicht in oder um die erste Rundstrickschicht gefaltet ist, wobei das eine oder die mehreren Merkmale einen Durchzug umfassen, der konfiguriert ist, um sich durch einen Abschnitt der ersten Rundstrickschicht zu erstrecken. 25 30
15. Schuhartikel (950-954) nach einem der Ansprüche 1 bis 14, wobei die Funktionsschicht (960-965) ferner eine inliegende Isolierung oder einen eingeklemmten Schaumstoffkragen umfasst. 35

Revendications

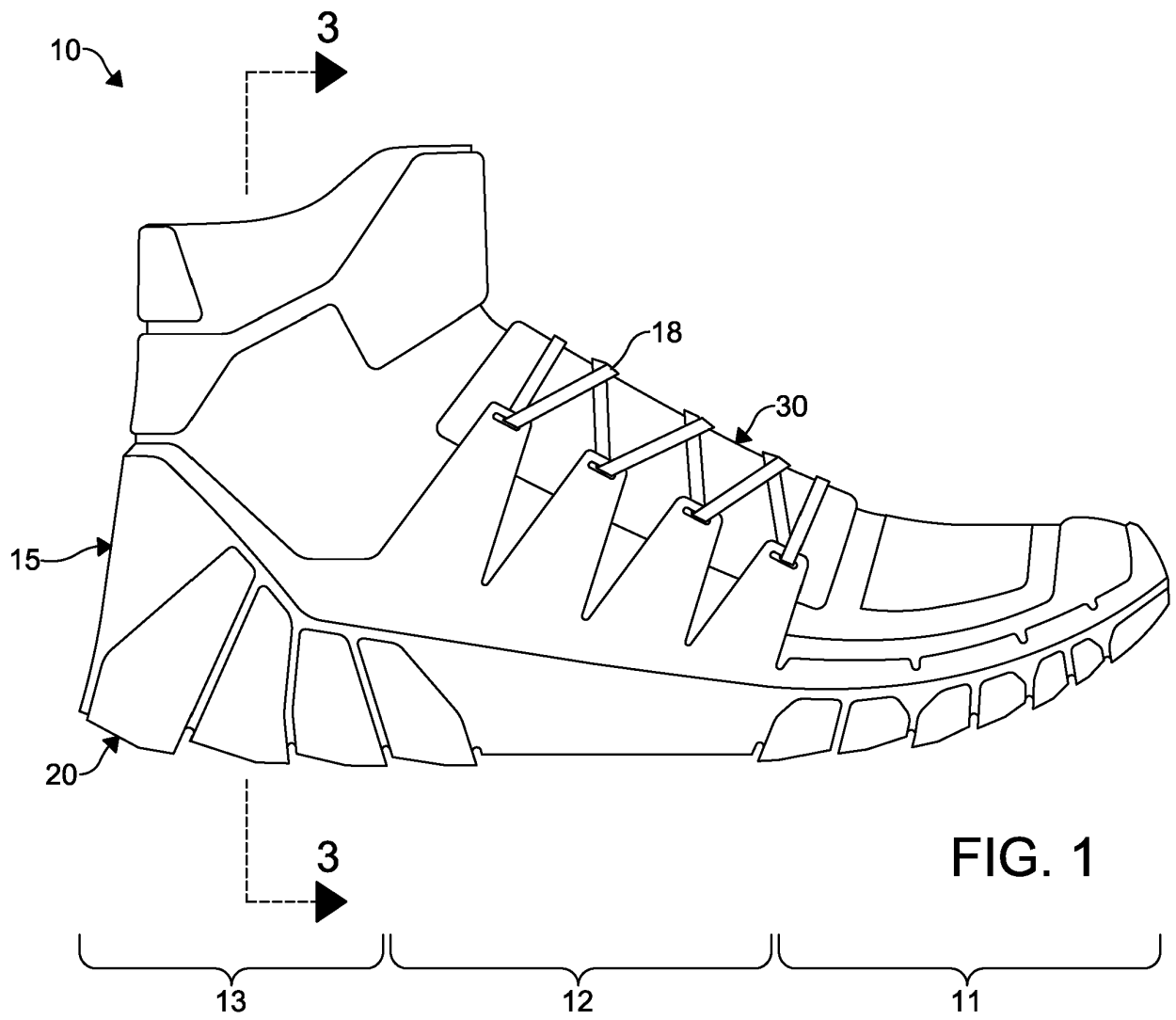
1. Article chaussant (950-954), comprenant : 40
une première couche de tricot circulaire ;
une seconde couche de tricot circulaire accouplée à la première couche de tricot circulaire, la seconde couche de tricot circulaire conçue pour être disposée adjacente à au moins une partie de la première couche de tricot circulaire lorsqu'elle est pliée dans ou autour de la première couche de tricot circulaire ; et
une couche fonctionnelle (960-965) intercalée entre la première couche de tricot circulaire et la seconde couche de tricot circulaire à l'aide d'une technique de repliage, de telle sorte que, lorsque la seconde couche de tricot circulaire est pliée dans ou autour de la première couche de tricot circulaire, la couche fonctionnelle est 45 50 55

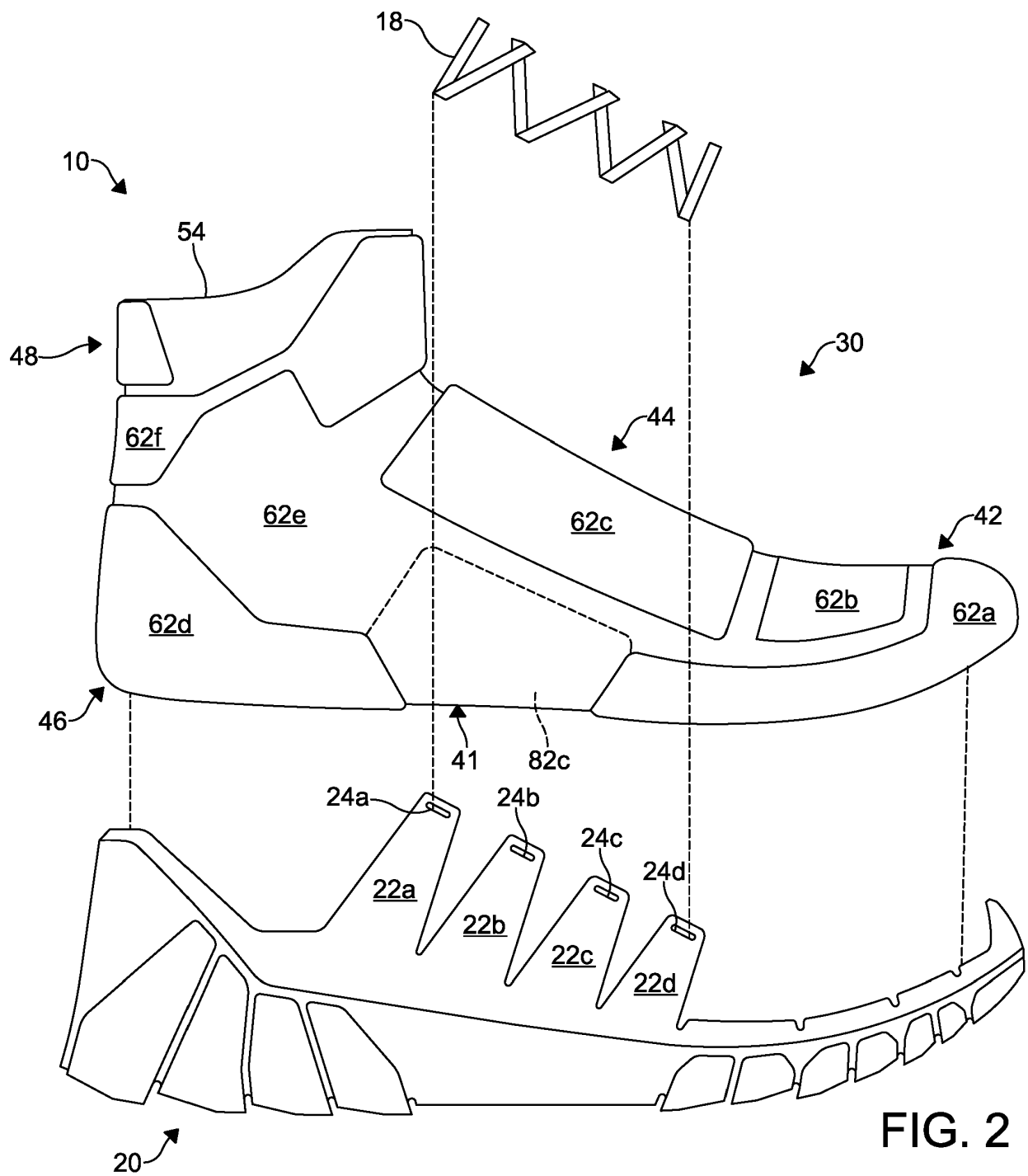
piégée entre la première couche de tricot circulaire et la seconde couche de tricot circulaire et comprend une semelle intercalaire enfermée et une semelle intérieure en tricot au sein de l'article chaussant, dans lequel la semelle intercalaire enfermée comprend des ergots de semelle extérieure qui s'étendent à travers les première et seconde couches, et dans lequel la première couche ou la seconde couche comprend des ouvertures pour permettre aux ergots de semelle extérieure de la semelle intercalaire enfermée de s'étendre à travers celle-ci.

2. Article chaussant (950-954) selon la revendication 1, dans lequel la couche fonctionnelle (960-965) comprend une ou plusieurs parmi une membrane imperméable, une membrane imperméable respirante, ou une application de pulvérisation. 15
3. Article chaussant (950-954) selon l'une quelconque des revendications 1 à 2, dans lequel la première couche de tricot circulaire définit au moins une partie d'une surface extérieure, et dans lequel la seconde couche de tricot circulaire comprend une seconde couche de tricot circulaire. 20 25
4. Article chaussant (950-954) selon la revendication 3, dans lequel la seconde couche de tricot circulaire s'étend à partir de la première couche de tricot circulaire en tant que corps d'un seul tenant. 30
5. Article chaussant (950-954) selon l'une quelconque des revendications 1 à 4, dans lequel la première couche de tricot circulaire comprend une forme généralement tubulaire. 35
6. Article chaussant (950-954) selon l'une quelconque des revendications 1 à 5, dans lequel la seconde couche de tricot circulaire comprend une forme généralement tubulaire. 40
7. Article chaussant (950-954) selon l'une quelconque des revendications 1 à 6, dans lequel la première couche de tricot circulaire comprend un matériau respirant imperméable et dans lequel la seconde couche de tricot circulaire comprend une doublure de confort. 45
8. Article chaussant (950-954) selon la revendication 1, comprenant en outre un système de laçage disposé adjacent à au moins une partie de la seconde couche de tricot circulaire de telle sorte qu'au moins une partie du système de laçage est intercalée entre la seconde couche de tricot circulaire et la première couche de tricot circulaire lorsque la seconde couche de tricot circulaire est pliée dans la première couche de tricot circulaire. 50 55

9. Article chaussant (950-954) selon l'une quelconque des revendications 1 à 8, dans lequel la première couche de tricot circulaire comprend une forme généralement tubulaire et dans lequel la seconde couche de tricot circulaire comprend une forme plane, dans lequel la seconde couche de tricot circulaire est conçue pour des opérations à plat avant d'être pliée dans ou autour de la première couche de tricot circulaire. 5
10. Article chaussant (950-954) selon la revendication 9, dans lequel la seconde couche de tricot circulaire comprend une ou plusieurs régions de renfort soudées (505). 10
11. Article chaussant (950-954) selon l'une quelconque des revendications 9 à 10, dans lequel la première couche de tricot circulaire comprend un collier, et dans lequel la seconde couche de tricot circulaire est conçue pour être disposée de façon au moins partiellement circonférentielle autour d'une surface extérieure de la première couche de tricot circulaire. 20
12. Article chaussant (950-954) selon l'une quelconque des revendications 1 à 11, dans lequel la première couche de tricot circulaire comprend une ou plusieurs régions de ventilation (607) et dans lequel la seconde couche de tricot circulaire est conçue pour être pliée dans ou autour de la première couche de tricot circulaire la première couche de tricot circulaire devant être adjacente à au moins une partie des régions de ventilation (607). 25 30
13. Article chaussant (950-954) selon l'une quelconque des revendications 1 à 12, dans lequel la seconde couche de tricot circulaire comprend une ou plusieurs caractéristiques conçues pour être disposées adjacentes à la première couche de tricot circulaire lorsque la seconde couche de tricot circulaire est pliée dans ou autour de la première couche de tricot circulaire, et dans lequel la ou les caractéristiques comprennent une ouverture, des trous de lacet ou une coque talonnière, ou une combinaison de ceux-ci. 35 40 45
14. Article chaussant (950-954) selon l'une quelconque des revendications 1 à 13, dans lequel la seconde couche de tricot circulaire comprend une ou plusieurs caractéristiques conçues pour être disposées adjacentes à la première couche de tricot circulaire lorsque la seconde couche de tricot circulaire est pliée dans ou autour de la première couche de tricot circulaire, dans lequel la ou les caractéristiques comprennent un passage traversant conçu pour s'étendre à travers une partie de la première couche de tricot circulaire. 50 55
15. Article chaussant (950-954) selon l'une quelconque

des revendications 1 à 14, dans lequel la couche fonctionnelle (960-965) comprend en outre une isolation capturée ou un collier de mousse enfermé.





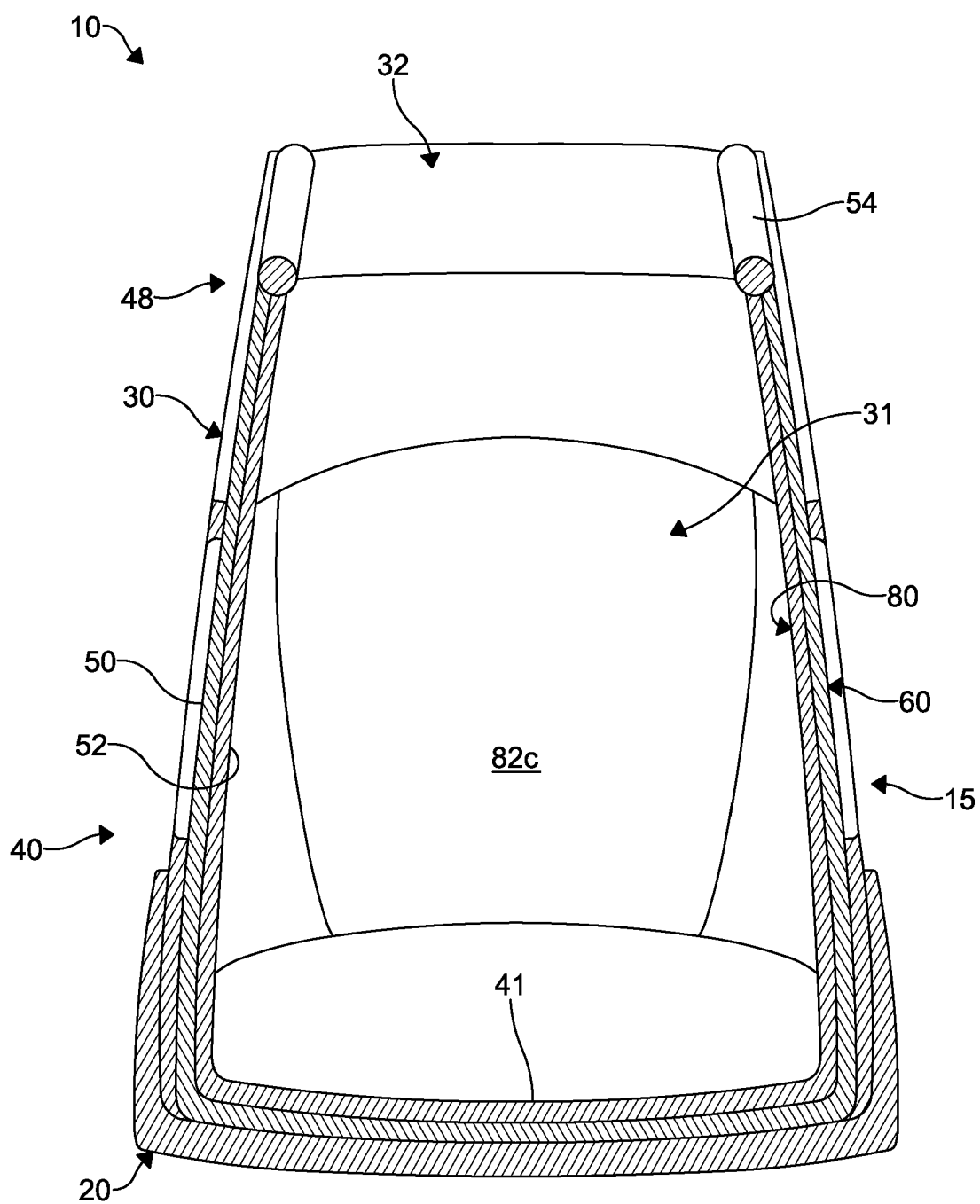


FIG. 3

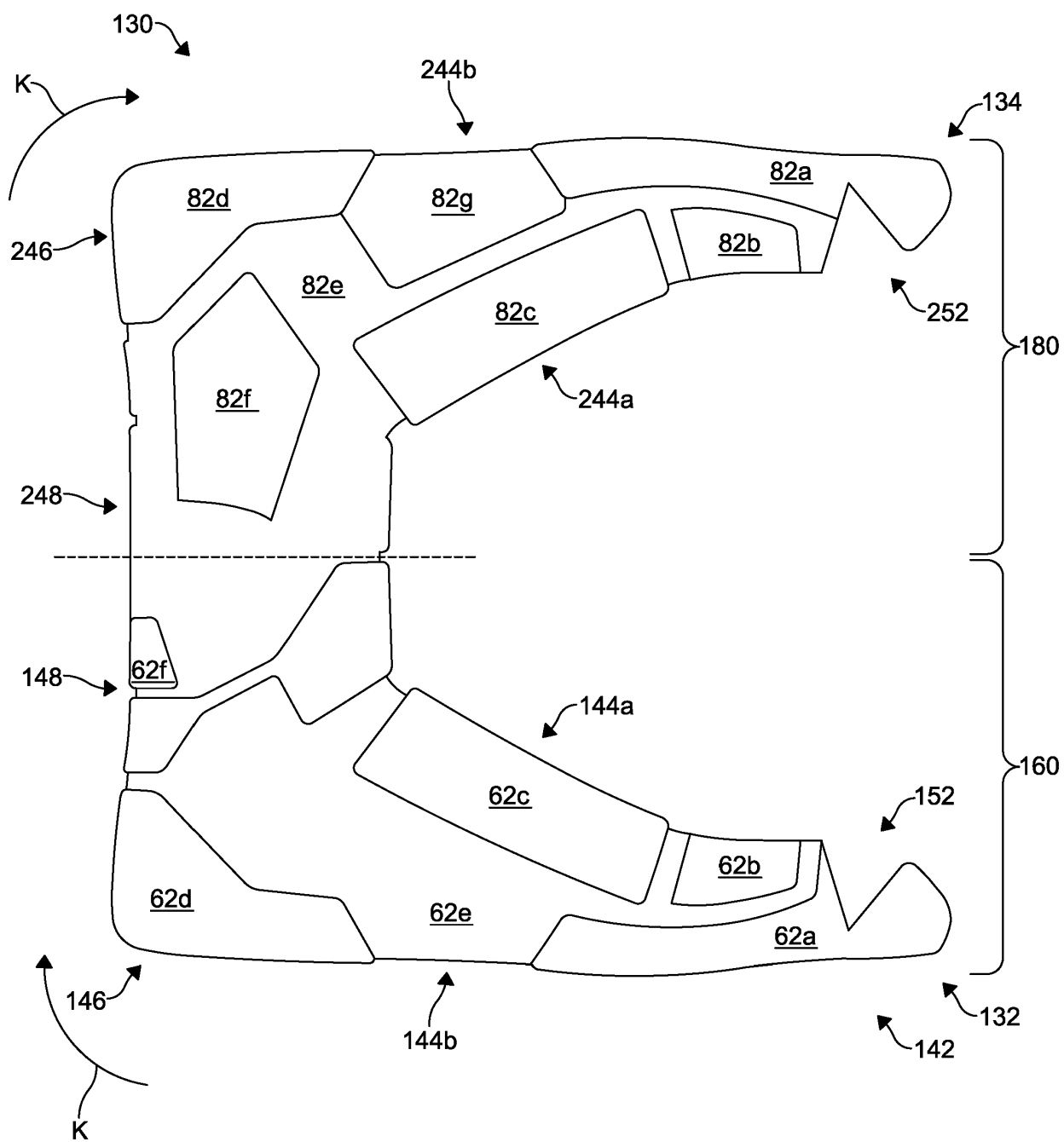


FIG. 4

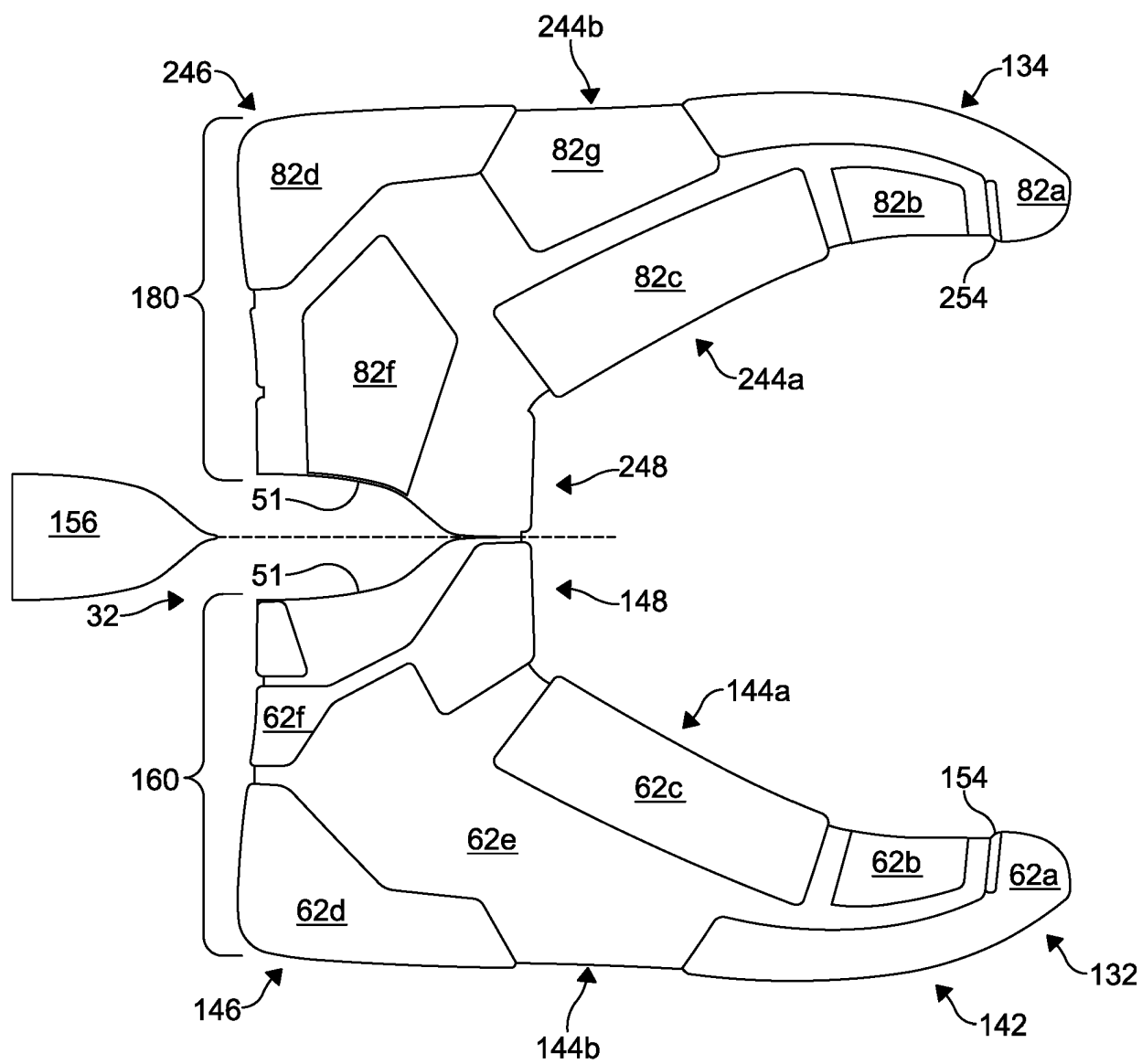


FIG. 5

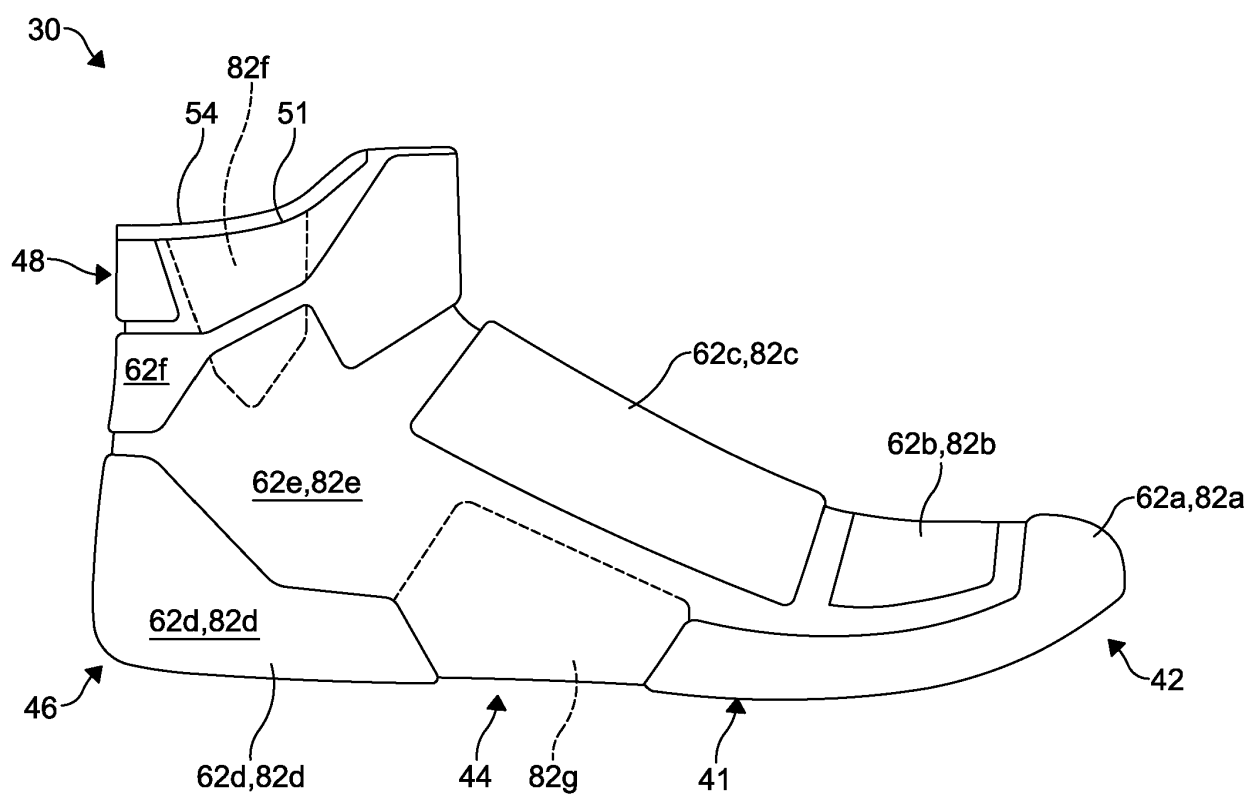
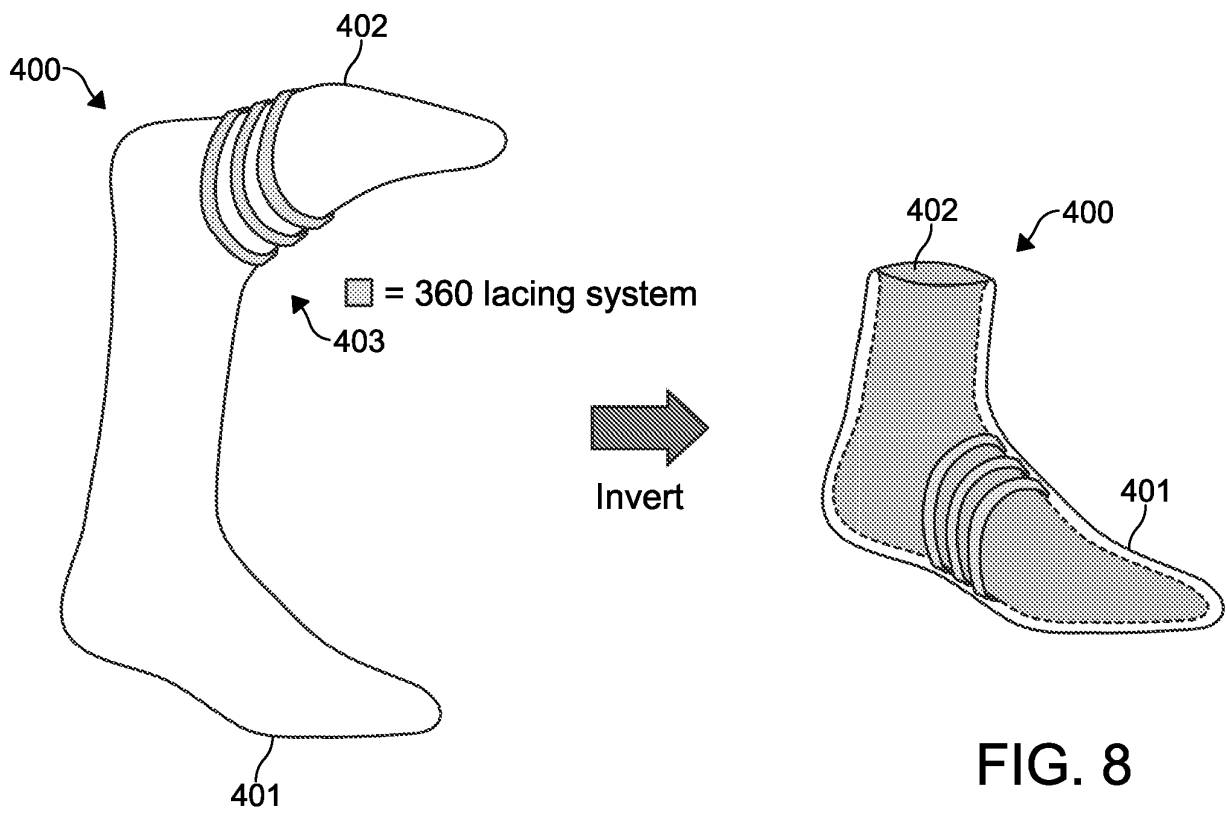
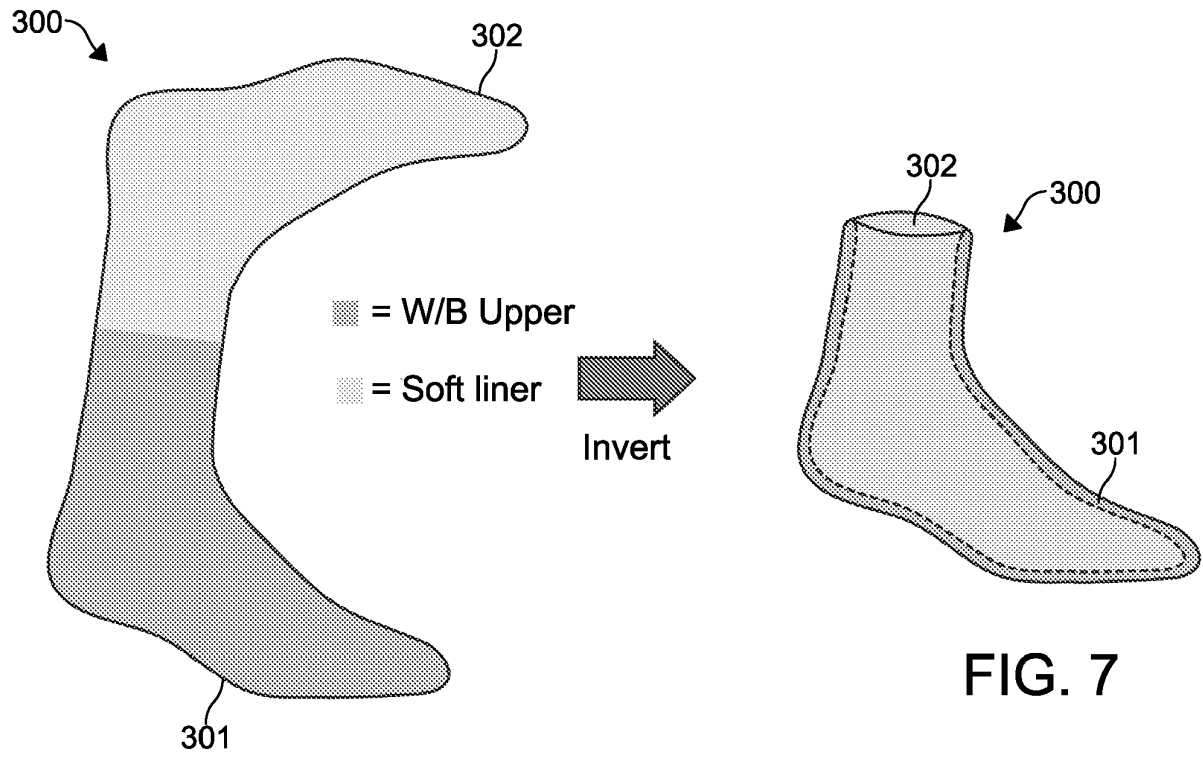
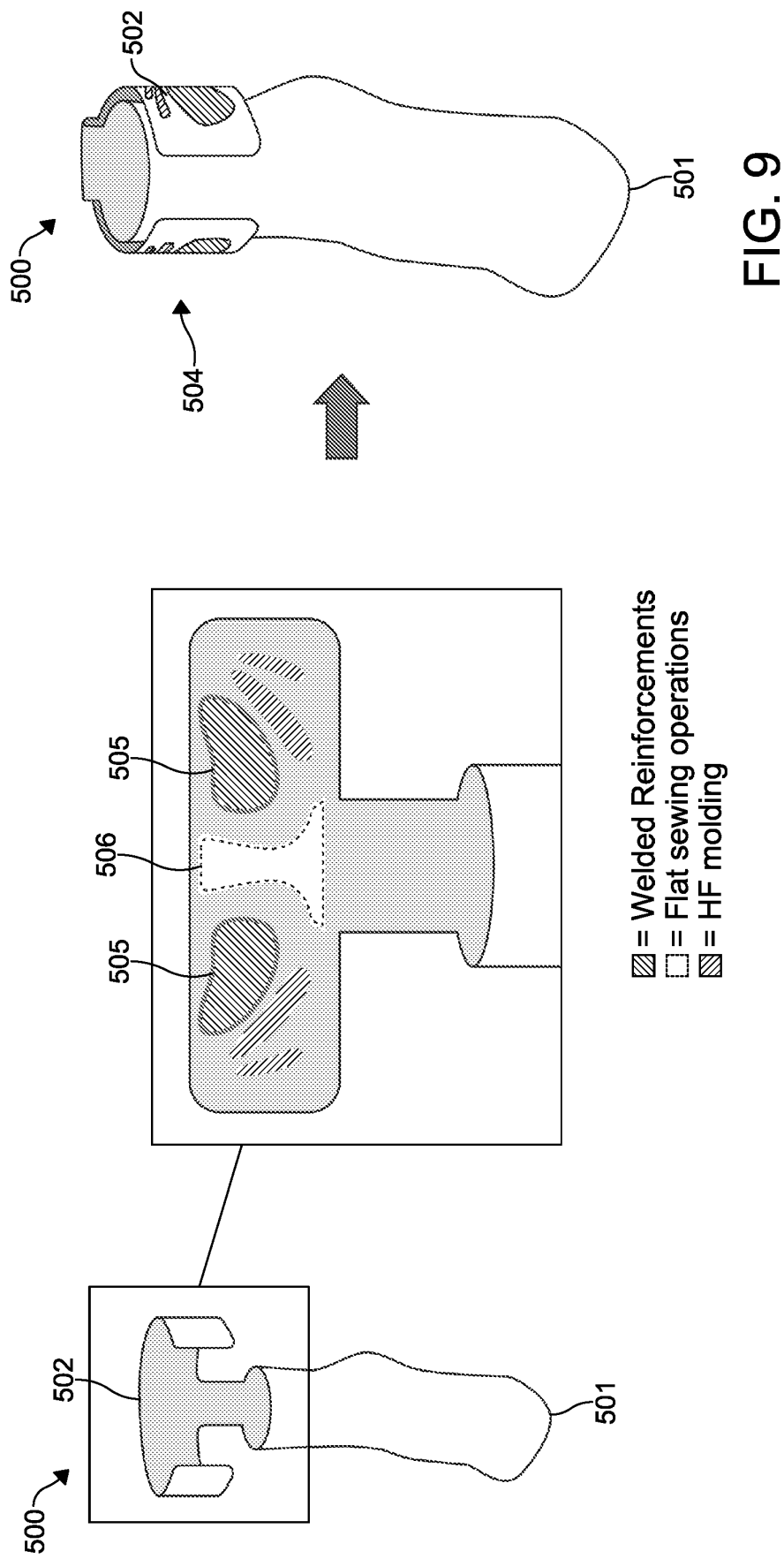
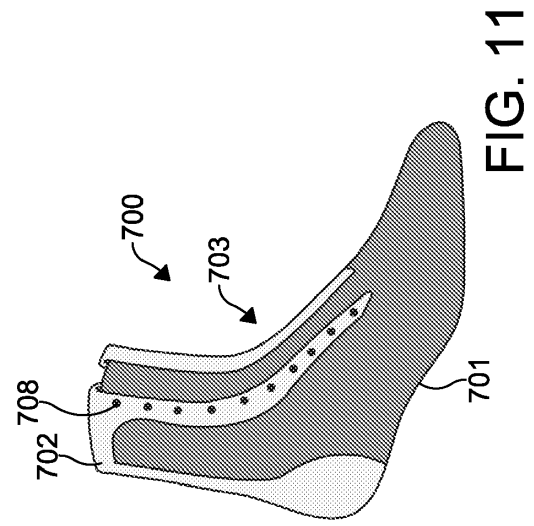
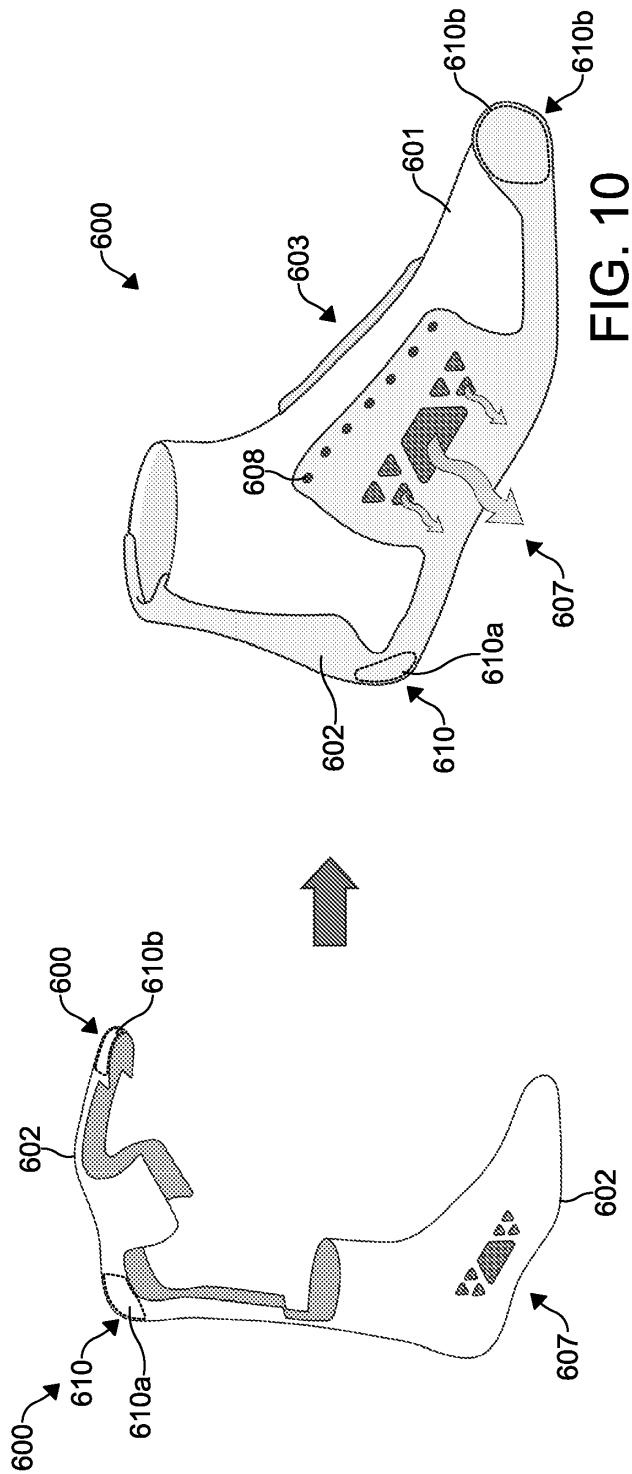
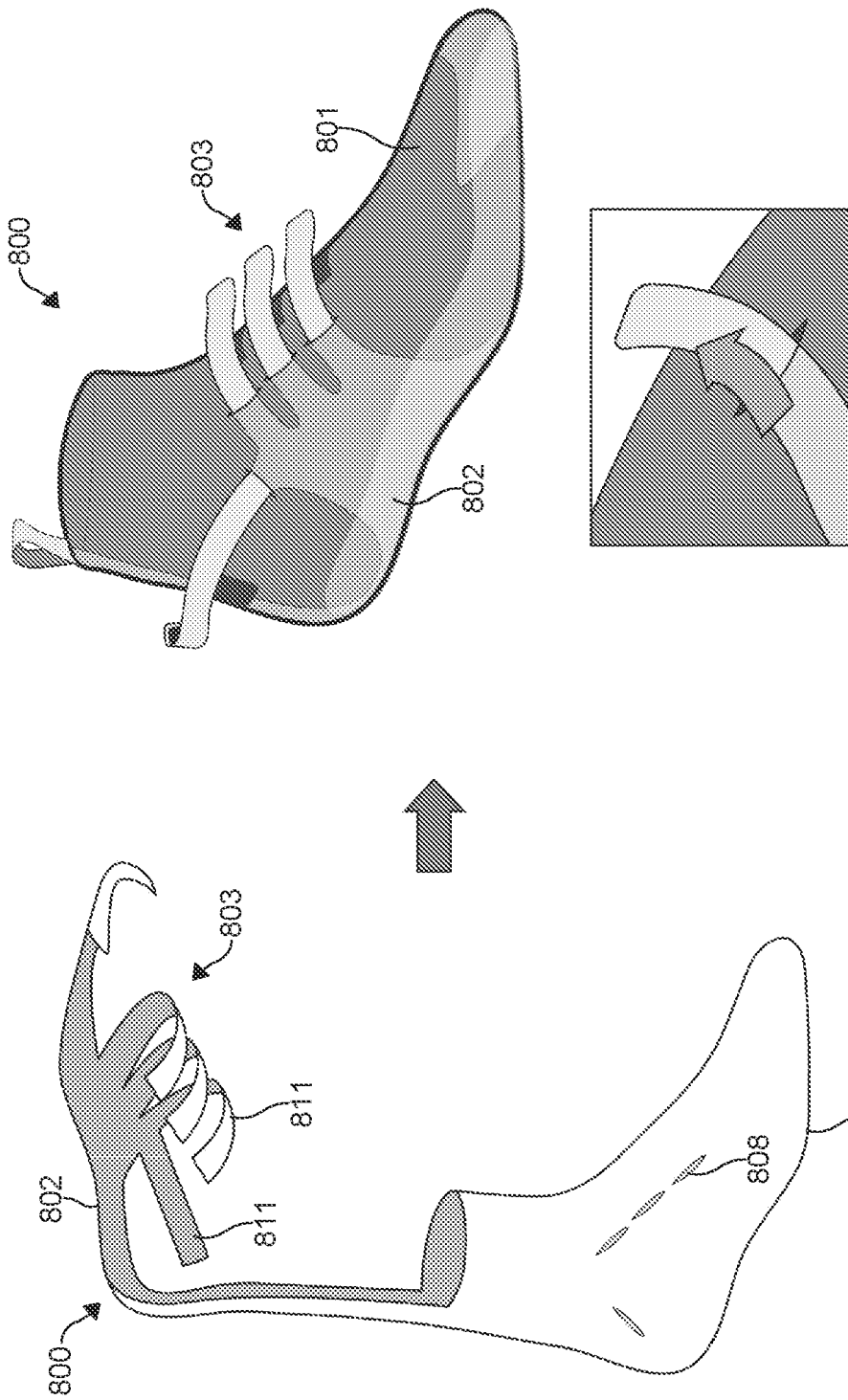


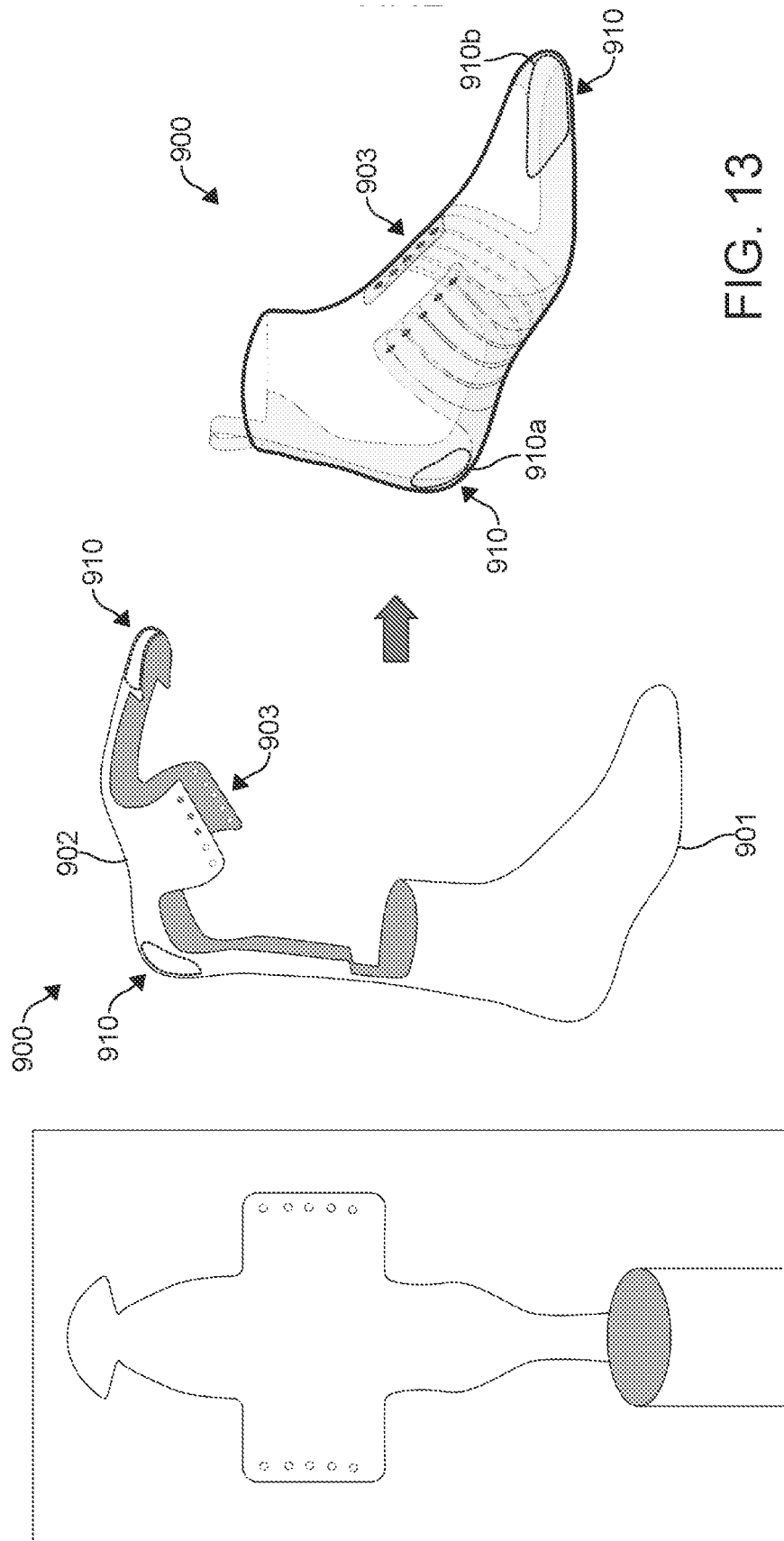
FIG. 6











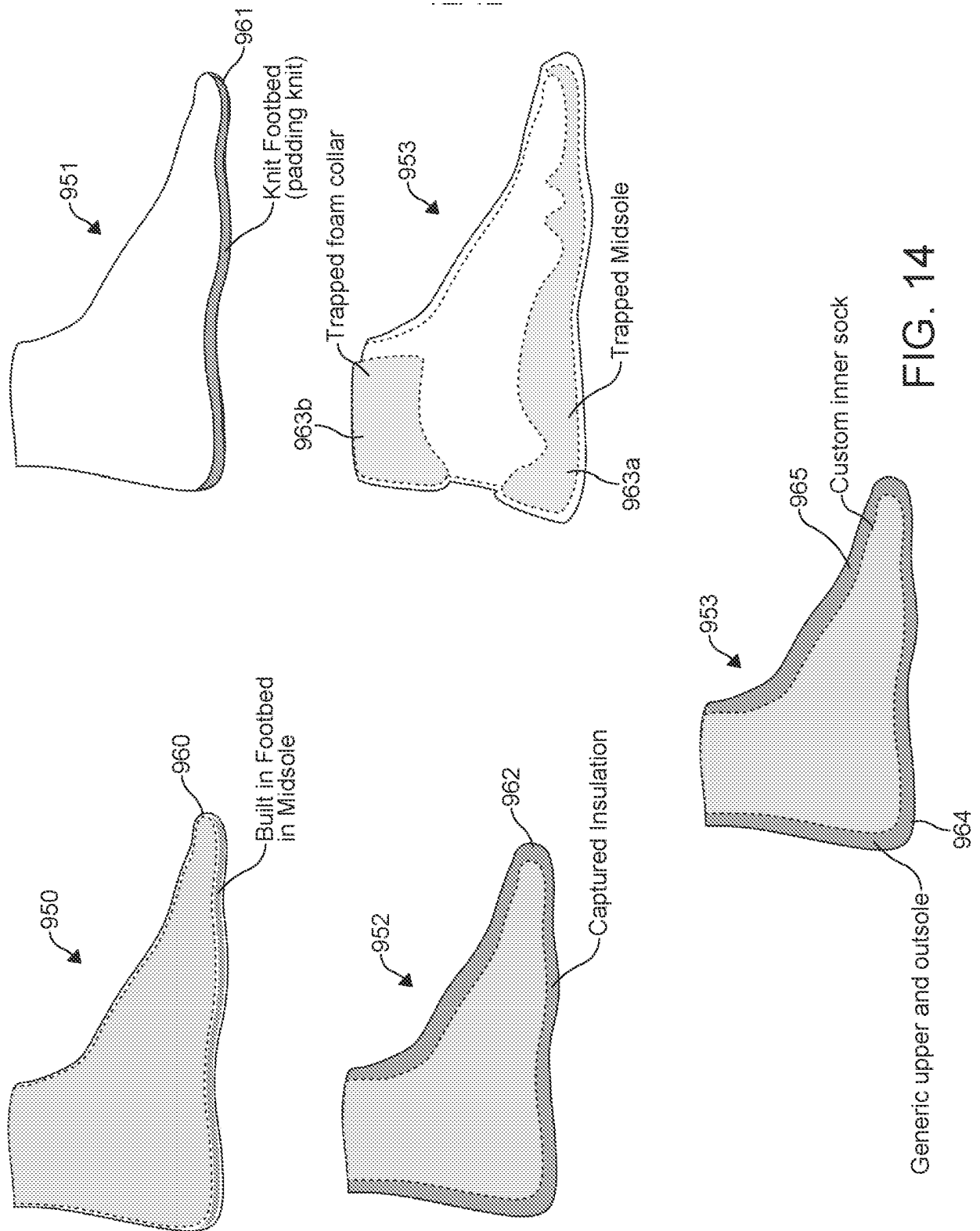


FIG. 14

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2019208862 A [0002]
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