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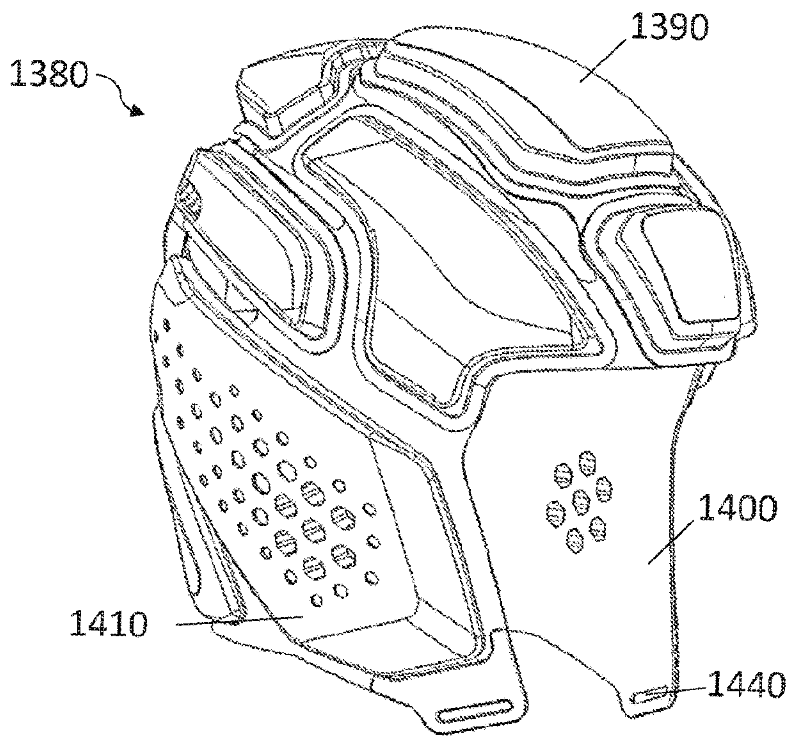

FIG. 38B

(57) Abrégé/Abstract:
The protective helmet may comprise a flexible protective helmet that includes a plurality of impact zones that could be particularized to a specific occupation, sport, player-position and/or the individual behavior of a specific player. The protective helmet comprising a plurality of impact mitigation pads coupled to a flexible liner may easily conform to a head of wearer. The different embodiments comprise elements to provide a padded protective helmet that is flexible or semi-flexible, light-weight and adapted to reduce the risk of head trauma due to the multi-layered padded configuration.

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(54) Title: PROTECTIVE HELMET

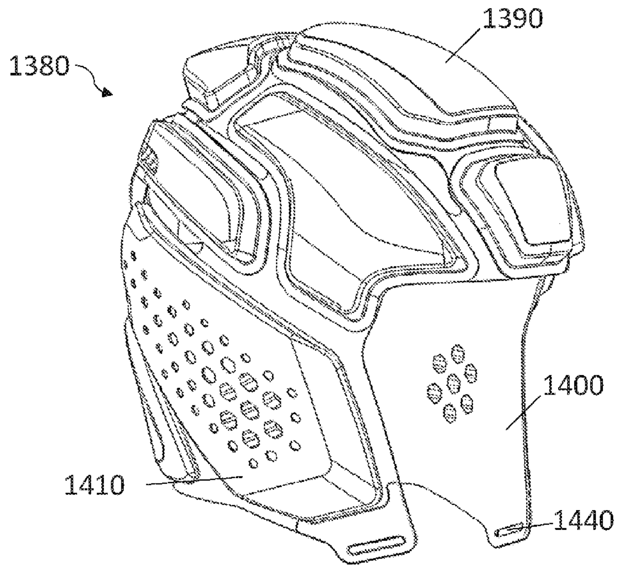

FIG. 38B

(57) Abstract: The protective helmet may comprise a flexible protective helmet that includes a plurality of impact zones that could be particularized to a specific occupation, sport, player-position and/or the individual behavior of a specific player. The protective helmet comprising a plurality of impact mitigation pads coupled to a flexible liner may easily conform to a head of wearer. The different embodiments comprise elements to provide a padded protective helmet that is flexible or semi-flexible, light-weight and adapted to reduce the risk of head trauma due to the multi-layered padded configuration.

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PROTECTIVE HELMET

TECHNICAL FIELD

[0001] The present invention relates to devices and methods for optimizing a protective helmet or other item of protective clothing with various impact and/or protection zones, some or all of which incorporate flexible, pliable and/or "softer" protective features that, in various embodiments, could be particularized to a specific sport, player-position and/or the individual behavior of a specific player. More specifically, the present invention relates to devices and methods that can be utilized to protect an athlete or other individual from a variety of incidental impacts (i.e., hitting another player and/or having their head strike the ground or goal post) as well as single and/or repetitive head impacts from relatively high speed, "lighter" objects during sports such as footballs, lacrosse balls, softballs, soccer balls, basketballs, baseballs, field hockey pucks, rugby balls, jai alai balls and/or water polo balls.

BACKGROUND OF THE INVENTION

[0002] Many modern organized sports employ substantial "hard and/or flexible shell" helmets that are designed to provide players with significant head protection from intentional and/or unintentional impacts, including substantial impacts having a significant potential to cause traumatic brain injuries (TBI). However, many shell helmet designs are fairly bulky and heavy, and they often limit a player's visibility and "field awareness" when worn. Moreover, research suggests that the protection provided by shell helmets may result in a higher incidence of hits involving the player's head, in that the shell helmet may cause the player to develop a feeling of "invulnerability," possibly leading the player to "lead with their helmet" during collisions. Furthermore, the use of hard shell helmets may be limited in some sports (e.g., soccer, rugby and women's lacrosse) due to the requirements and/or traditions within the game.

[0003] Soccer (also called "football" outside of the United States of America) is one of the world's most popular sports. Like many athletic activities, soccer involves some risk of injury, including head injury. While intentional contact between soccer players is highly discouraged, head injuries in soccer can include head collisions with another player's head, elbow, knee, or foot, as well as injuries when the head collides into a goal post, the ground or some other object.

[0004] A less well-known cause of head injury in soccer and other sports is the use of the head by a player to redirect a soccer ball in a desired direction at a desired speed, in what is typically called a "header." Many studies have shown that "heading" a soccer ball (or similar repetitive impacts) can cause minor cumulative brain damage. Many soccer players who repeatedly headed the ball during their careers have been found to have chronic changes on their electroencephalograms (EEGs), in many ways similar to the changes found in amateur boxers. These players were found to have chronic mild to severe deficits in attention, concentration, memory, and judgement. More importantly, children, who have had significantly less exposure to heading a soccer ball that their professional counterparts (but who do play soccer on a frequent basis) have been found to have greater changes in their EEGs.

[0005] While hard shell-type helmets are conventionally used in most sports which involve a risk of head injury from one or more major impact events, such as American football, baseball, ice hockey, lacrosse, cycling, skiing, snowboarding, kayaking, equestrian sports, and rock climbing, such hard shell helmets can often interfere with the "play" and/or enjoyment of a sport, such as seriously interfering with a soccer player's ability to "head" a ball - thus interfering with the very nature of the sport of soccer. Thus, conventional helmets are not used in soccer, even though there is a significant risk of head injury.

BRIEF SUMMARY OF THE INVENTION

[0006] The present invention includes the realization of a need for a lightweight, flexible, form-fitting protective helmet for various occupations and participants of sports and sporting activities where a more substantial and/or heavier rigid or shell-type helmet may be undesirable for a variety of reasons. More specifically, the soft-shell helmet or soft helmet should provide protection for both "ball-to-head" related impacts and "non-ball" related impacts (e.g., head-to-head, elbow-to-head, head-to-ground, etc.). The protective helmet or soft-shell helmet may comprise a partial head coverage or full head coverage protection.

[0007] In at least one exemplary embodiment, a "soft" shell helmet can include a protective headband. The protective headband can protect at least a portion of the head. The protective headband may comprise a tubular or generally cylindrical shape and configuration, which desirably fits around an upper portion of the wearer's head (i.e., across the forehead and above a portion of the ears). The headband may comprise at least one or more padded regions and at least one boot layer. The at least one boot layer may comprise one single material layer or two or more material layers. In one preferred embodiment, the at least one boot layer may comprise at least one first material, at least one second material, and at least one foam material and/or layer, the at least one foam material and/or layer being affixed to the at least one first and at least one second material. The at least one first or at least one second material may be a two- or four-way stretch fabric, where the top and bottom covering may be the same material or the at least one top and bottom covering may be different materials. The at least one or more padded regions comprising one more individual impact pads, which can be separated by one or more stretchable regions. In various embodiments, the stretchable regions can comprise one or more layers of elastic material or "two- or four-way stretch fabric," which can allow the helmet to be expanded and/or contracted to accommodate heads of differing shapes, sizes and/or configurations, as well as to accommodate different wearing positions and/or styles by the player. Various embodiments can further include lower portions for extending along the sides, face and/or jaws of the wearer, as well as an optional peak or domed portion for protecting the top of the wearer's head. In various embodiments, the padded regions may protect the forehead, temples, and the occipital bone in the back of the wearer's head.

[0008] In one exemplary embodiment, a soft-shell helmet may comprise a full-coverage or full-face soft-shell helmet. The full-coverage helmet may cover the entire head, with a rear that covers the base of the skull, and a protective section that may cover the front of the chin and temples. Such full coverage helmets desirably have an open cutout to allow access to the face.

[0009] The full-coverage soft-shell helmet can comprise at least one of a boot layer or liner, at least one impact pad, at least one optional ear cover (which may comprise a removable and/or replaceable separate ear cover), a chinstrap, and/or any combination thereof. The at least one boot layer may comprise one single material or two or more materials. The at least one boot layer may further comprise an impact mitigation layer. In one preferred embodiment, the at least one boot layer may comprise at least one first material, a second material, and a foam layer material, the foam layer being affixed to the first and second material and disposed between the first and second material. The at least one ear cover and/or the chinstrap may be removably coupled to the soft-shell full-coverage helmet. The at least one or more individual impact mitigation pads may be directly affixed to the boot layer or liner. The impact mitigation pads may be desirably positioned on different regions of the head, including the frontal section, top or ridge section, lower back, mid-back, left side and front side, temples, jaw region and/or any combination thereof. The at least one or more individual impact pads may comprise at least one impact structure that can be affixed to the boot layer in desired regional locations to enhance impact protection. The at least one or more individual impact pads may further comprise a foam layer.

[00010] In various embodiments, the soft-shell helmet may optionally not incorporate an ear cover and/or may comprise a perforated portion of the helmet and/or may comprise a material capable of reasonable levels of sound transmission therethrough.

[00011] In another exemplary embodiment, the at least one or more individual impact pads may further comprise at least one impact structure, at least one first layer and at least one second layer. The at least one first layer or the at least one second layer may include a foam layer, polycarbonate

layer, a hotmelt layer, a 2-way stretch material, a 4-way stretch material, Lycra, Ducksan Power Net, Neoprene, and/or any combination thereof. The polycarbonate layer can be thin, flexible, yet substantially rigid to assist with absorption of the forces and reduce wear/tear. The foam layer can include polymeric foams, quantum foam, polyethylene foam, polyurethane foam (PU foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, compression foam, latex rubber foam, convoluted foam ("egg create foam"), EVA foam, VN 600 foam, Evlon foam, Ariaprene or Ariaprene-like material, impact hardening foam, and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure. The foam layer can be further tailored to obtain specific characteristics, such as anti-static, breathable, conductive, hydrophilic, high-tensile, high-tear, controlled elongation, and/or any combination thereof.

[00012] In another exemplary embodiment, the at least one or more individual impact pads may further comprise at least one impact structure assembly, at least one first layer and at least one second layer. Alternatively, the at least one or more individual impact pads may further comprise at least one impact structure assembly, at least one foam layer, at least one first layer and at least one second layer. The impact structure assembly may comprise a two-piece assembly that comprises an impact mitigation structure and a first layer. The first layer may comprise a recess forming a pocket and a flange, the pocket may be shaped and configured to receive the impact mitigation structure, the impact mitigation structure disposed within the pocket. The at least one second layer may be affixed to the at least one first layer, impact mitigation structure, at least one second layer, and/or any combination thereof. Alternatively, the impact structure assembly may comprise a one-piece assembly that integrates the impact mitigation structure within the first layer. The one-piece impact mitigation structure assembly is comprised of a first layer and an impact mitigation structure that may be thermoformed, injection molded, 3D printed, casted and/or die cut as a one-piece construct.

[00013] The at least one first layer and/or the at least one second layer may comprise a single layer or multiple layers. Each of the at least one first layer and/or the each of the at least one second layer may comprise a 2-way stretch material, a 4-way stretch material, a foam layer, a polycarbonate layer, a hotmelt layer, a boot layer, Lycra, Ducksan and/or any combination thereof. The polycarbonate layer can be thin, flexible, yet substantially rigid to assist with absorption of the forces and reduce wear/tear. The foam layer can include polymeric foams, quantum foam, polyethylene foam, polyurethane foam (PU foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, latex rubber foam, convoluted foam ("egg create foam"), EVA foam, VN600 foam, Evlon foam, Ariaprene or Ariaprene-like material, impact hardening foam,

compression and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure.

[00014] In one exemplary embodiment, the at least one or more individual impact pads may be encapsulated to form pockets, where the pockets can be affixed to the boot layer. The at least one or more individual impact pads may comprise at least one impact structure and/or at least one impact structure assembly, at least one first layer, at least one second layer, and at least one top covering or at least one bottom covering. Alternatively, the at least one or more pocketed individual impact pads may comprise an impact mitigation structure and/or at least one impact mitigation structure assembly, and a least one top covering. The at least one first layer or the at least one second layer may include a 2-way stretch material, a 4-way stretch material, a foam layer, polycarbonate layer, a hotmelt layer, boot layer and/or any combination thereof. The at least one top or at least one bottom covering may be a two- or four-way stretch fabric, where the top and bottom covering may be the same material or the at least one top and bottom covering may be different materials. The impact mitigation structure may be "free-floating" and/or fixed within the at least one top covering and/or at least one bottom covering, or permanently secured within the at least one top and/or bottom covering. The polycarbonate layer can be thin, flexible, yet substantially rigid to assist with absorption of the forces and reduce wear/tear. The foam layer can include polymeric foams, quantum foam, polyethylene foam, polyurethane foam (PU foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, latex rubber foam, convoluted foam ("egg create foam"), EVA foam, VN600 foam, Evlon foam, Ariaprene or Ariaprene-like material, impact hardening foam, compression foam, and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure. The foam layer can be further tailored to obtain specific characteristics, such as anti-static, breathable, conductive, hydrophilic, high-tensile, high-tear, controlled elongation, and/or any combination thereof.

[00015] In various embodiments, the one or more impact pad section(s) can comprise at least one impact structure, the at least one impact structure can comprise at least a portion of filaments, a portion of auxetic structures, a portion of zigzag structures, a portion of herringbone structures, and/or laterally supported filaments and/or wall structures. Such impact mitigation structures may include polygonal structures and/or thin, longitudinally extending members that may be shaped and configured to deform non-linearly in response to an impact force, auxetic structures, re-entrant structures, TPU cones, impact foam, and/or any combination thereof. In various instances, a non-linear deformation behavior of one or more of these structures is expected to provide improved protection

against high-impact forces and/or oblique forces, as well as afford a significant level of durability, elasticity and/or flexibility to the impact pad section(s). In various embodiment, the impact pad section(s) can be deformable and/or stretchable, which can include deformability in a variety of directions, including along the cephalad/caudal, medial/lateral and/or anterior/posterior axes of the helmet and/or the wearer, as well as complex combinations thereof.

[00016] In various embodiments, the one or more impact pad sections could comprise auxetic structures and/or could comprise re-entrant shaped structures, such as bowtie shapes, and/or could comprise a series of repeating geometric shapes or undulating structures, such as T-shaped or chevron shapes, or various combinations thereof.

[00017] In various embodiments, a soft helmet design could be designed and/or tailored to accommodate various types and/or locations of forces, including factors or a combination of two or more factors in a sport-specific and/or position-specific manner, which could include impact protection features designed to protect against one or more specific locations and/or types of locations and/or degrees of impact or other forces, including (but not limited to) source of impact, angle of impact, player activity type, play type, player position, location of impact, angle of impact, severity of impact, and/or frequency of impacts.

[00018] In one embodiment, an impact mitigation structure comprises a plurality of spaced apart elongated walls, each of the plurality of elongated walls having a wall height and a undulated pattern, each of the plurality of elongated walls having a cross-sectional shape, the cross-sectional shape including a first lower portion and a second upper portion, the first lower portion comprising a base having a cross-sectional base width and a base height, the second upper portion comprising an upwardly extending longitudinal member, the upwardly extending longitudinal member extending generally perpendicular from the base and having a cross-sectional longitudinal member width and a longitudinal member height, the base width is greater than the longitudinal width and the base height is less than the longitudinal member height; and at least one support member, the at least one support member extending perpendicular from at least a portion of a length of the plurality of spaced apart elongated walls.

[00019] In one embodiment, an impact mitigation pad comprises a base material layer, the base material layer having a first surface and a second surface, a recess disposed onto a first surface extending towards the second surface; and an impact mitigation structure, the impact mitigation structure comprising a plurality of spaced apart elongated walls, the plurality of spaced apart walls disposed within the recess, the recess having a recess height, each of the plurality of elongated walls

having an elongated wall height, an elongated wall width and a undulated pattern, each of the plurality of elongated walls having a cross-sectional shape.

[00020] In one embodiment, the protective helmet comprises a liner, the liner having an external surface and an internal surface; and a plurality of impact pads, at least a portion of the plurality of impact pads comprising base material layer, an impact mitigation structure, a first material layer and a second material layer, the base material layer having a first surface and a second surface, a recess disposed onto a first surface extending towards the second surface, the impact mitigation structure comprising a plurality of spaced apart elongated walls, the plurality of spaced apart walls disposed within the recess, the recess having a recess height, each of the plurality of elongated walls having an elongated wall height, an elongated wall width and a undulated pattern, each of the plurality of elongated walls having a cross-sectional shape, the plurality of impact pads being coupled to the liner external surface.

[00021] While the various optimized soft-shell helmet components and/or designs provided herein are depicted with respect to soccer and/or related sports, it should be understood that the various devices, methods and/or components may be suitable for use in protecting players in various other athletic sports, as well as law enforcement, military and/or informal training session uses. For example, the embodiments of the present invention may be suitable for use by individuals engaged in athletic activities such as football, two hand touch football, flag football, softball, dodge ball, baseball, bowling, boxing, cricket, cycling, motorcycling, golf, hockey, lacrosse, soccer, rowing, rugby, running, skating, skateboarding, skiing, snowboarding, surfing, swimming, table tennis, tennis, or volleyball, water polo, wrestling, wakeboarding and/or during training sessions related thereto.

[00022] Described herein are many specific embodiments, but these should not be construed as limitations on the scope of any inventions or of what may be claimed, but rather as descriptions of factors specific to various implementations of the present inventions. Certain factors described herein in the context of separate implementations can also be implemented in a single implementation. Conversely, various factors described in the context of a single implementation can also be implemented in multiple implementations separately or in any suitable sub combination. Furthermore, the factors as described above may be recited as acting in certain combinations and even initially claimed as such, one or more factors from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub combination or variation of a sub combination.

DETAILED DESCRIPTION OF DRAWINGS

[00023] FIG. 1 depicts an isometric view of one embodiment of a soft-shell helmet;

[00024] FIG. 2A depicts a side view of an alternate embodiment of a soft-shell helmet;

[00025] FIG. 2B depicts a front view of one embodiment of a boot layer or liner;

[00026] FIG. 3A depicts a side view of the soft-shell helmet in FIG. 2A;

[00027] FIG. 3B depicts a front view of one embodiment of one or more impact mitigation structures;

[00028] FIGS. 4A-4B depicts a top and side view of an alternate embodiment of one or more impact mitigation structures;

[00029] FIG. 5 depicts a side and isometric view of an impact mitigation structure that may be encapsulated in a soft shell helmet;

[00030] FIG. 6 depicts a top view of an alternate embodiment of one or more impact mitigation structures;

[00031] FIGS. 7A-7B depict exploded views of different embodiments of a boot layer or liner;

[00032] FIGS. 7C-7D depict cross-sectional views of one embodiment of a boot layer or liner;

[00033] FIGS. 8A-8C illustrate top views of different embodiments of the one or more impact mitigation structure configurations;

[00034] FIGS. 9A-9E illustrate one embodiment of a method to manufacture a boot layer or liner;

[00035] FIGS. 10A-10C depict cross-sectional views of one or more impact mitigation pads or one or more impact mitigation structures coupled to a boot layer or liner;

[00036] FIGS. 11A-11G illustrate one embodiment of a method to manufacture one or more impact mitigation pads;

[00037] FIGS. 12A-12C illustrate one embodiment of a method to couple the one or more impact mitigation pads to a boot layer or liner;

[00038] FIGS. 13A-13B depict a side and front view of the soft-shell helmet of FIG. 2A;

[00039] FIG. 13C depicts a front view of one alternative embodiment of a covered soft-shell helmet;

[00040] FIG. 14 depicts one embodiment of an assembly of a soft-shell helmet;

[00041] FIGS. 15A-15C depicts an alternate embodiment of a method to couple or affix the one or more impact mitigation pads to a boot layer or liner;

[00042] FIGS. 16A-16B depicts different embodiments of one or more impact mitigation pads;

[00043] FIGS. 17A-17C illustrates one embodiment of a boot layer or liner construction;

[00044] FIG. 18 depicts a front view of one embodiment of a headband;

[00045] FIGS. 19A-19B depicts a front view of one embodiment of a soft shell helmet with ear protection;

[00046] FIG. 20 depicts an isometric view of an alternate embodiment of an impact structure;

[00047] FIG. 21 depicts a top view of one embodiment of an undulated wall impact structures;

[00048] FIGS. 22A-22C depicts various views of an alternate embodiment of a soft-shell helmet;

[00049]

FIGS. 23A-23B depicts one embodiment of a front impact pad assembly and/or a rear impact pad assembly to form a soft-shell helmet;

[00050] FIGS. 24 depicts one embodiment of a front impact pad assembly to form a soft-shell helmet;

[00051] FIGS. 25A-25B depicts a top and bottom view of one embodiment of one or more impact mitigation pads;

[00052] FIGS. 26A-26B depicts a front and isometric view of an alternate embodiment of one or more impact mitigation pads;

[00053] FIGS. 27A-27B depicts an exploded view of an alternate embodiment of one or more impact mitigation pads;

[00054] FIGS. 28A-28B depicts a side view of the one or more impact mitigation pads of FIGS. 27A-27B coupled to a base layer or liner;

[00055] FIGS. 29A-29F depict one embodiment of a method to manufacture a front impact pad assembly to form a soft-shell helmet;

[00056] FIGS. 30A-30C depict one embodiment of a method to manufacture a back impact pad assembly to form a soft-shell helmet;

[00057] FIGS. 31A-31C depict one embodiment of a method to couple the front impact pad assembly with the back impact pad assembly to form a soft-shell helmet;

[00058] FIGS. 32A-32B depict a front and side view of an alternate embodiment of a headband;

[00059] FIGS. 33A-33D depict different views of one embodiment of a headband construction;

[00060] FIGS. 34A-34C depicts various views of one embodiment of a headband size and configuration on a head of wearer;

[00061] FIGS. 35A-35C depicts one embodiment of a method to manufacture the one or more impact mitigation structures for a headband;

[00062] FIGS. 36A-36C depicts different views of an alternate embodiment of a headband with headband skin;

[00063] FIGS. 37A-37C depicts different views of an alternate embodiment of a headband;

[00064] FIG. 37D depicts an exploded view of a portion of the headband of FIGS. 37A-37C; and

[00065] FIGS. 38A-38G depicts various views of an alternate embodiment of a soft-shell helmet.

DETAILED DESCRIPTION OF THE INVENTION

[00066] SOFT SHELL HELMETS

[00067] The term “soft helmet” or “soft shell” should not be limited to helmet designs that solely incorporate only soft or flexible components, but could also include helmets or other protective clothing designs that may incorporate harder and/or relatively rigid, shell or plate components or similar features, including the incorporation of flexible or sliding plates that can accommodate stretching and/or flexing of the overlying/underlying helmet structure(s).

[00068] In various embodiments, a soft helmet can comprise a headband, head wrap, cap and/or full coverage helmet having one or more impact mitigating structures disposed thereon, such as shown in Figure 1, Figure 2, Figure 13A, and/or Figure 18. The soft helmet may comprise at least one of a breathable and/or sweat wicking layer, an impact mitigating structure layer, a foam layer, a boot layer and/or any combination(s) thereof. Figure 1 and 19A-19B depicts an isometric view of one embodiment of a soft helmet design. The soft helmet 10 comprises a boot layer or liner 30 and one or more impact mitigation pads 20. The soft helmet 10 may further comprise ear protection 35 or a chin strap (not shown). The impact mitigation pads 20 may be desirably affixed to an external surface of the boot layer or liner 30 and positioned on different regions of the head, including the frontal section, top or ridge section, lower back, mid-back, left side, right side and front side, temples, jaw region and/or any combination thereof. The impact mitigation pads 20 may comprise impact mitigation structures. The impact mitigating structures may comprise deforming filament and/or laterally supported filaments, and/or lateral wall-based structures, including the employment of repeating geometric patterns, undulating structures, and/or auxetic/non-auxetic impact mitigating structures. Figures 2A-2B and 3A-3B depict another exemplary embodiment of a soft helmet 40. The soft helmet system 40 comprising a liner or boot layer 50 and an impact mitigation layer 60. The impact mitigation layer comprises one or more impact mitigation pads or impact mitigation structures that can be affixed to an external surface of the liner or boot layer 50. The impact mitigating structures comprising a portion of filaments, laterally supported filaments, undulating structures or repeating geometric patterns, and/or auxetic wall structures.

[00069] Figures 3A-3B depicts one embodiment of an impact mitigation layer 60. The impact mitigation layer 60 can comprise one or more impact mitigation structures 90. The impact mitigation structures 90 can include “auxetic” structures, a plurality of interconnected members forming an array of reentrant shapes positioned on the flexible head layer. Each of the reentrant shapes may be connected to the adjacent reentrant shape by at least one shared wall. In one specific embodiment, impact mitigation structures 90 may comprise a plurality of interconnected reentrant structures forming an array, the array comprises a first reentrant shape and a second reentrant shape, the second reentrant shape is connected perpendicular to the first reentrant shape. Each of the first or second reentrant shape having a length, the length provides for an ideal buckling structure, the buckling is a sudden lateral defection away from a longitudinal axis. The term “auxetic” generally refers to a material or structure that has a negative Poisson ratio, when stretched, auxetic materials or structures become thicker (as opposed to thinner) in a direction perpendicular to the applied force. The employment of such auxetic structures can result in a protective device capable of high energy absorption and fracture resistance. In particular, when a force is applied to the auxetic material or structure, the impact may cause it to expand (or contract) in one direction, resulting in associated expansion (or contraction) in a perpendicular direction. It should be recognized by those skilled in the art that the auxetic structures shown in FIG. 2A-2B and 3A-3B may include a wide variety of differently shaped segments or other structural members, as well as combinations of repeating and/or different shaped voids. The one or more impact mitigation structures 90 can be injection molded, where the injection molded process allows the one or more impact mitigation structures 90 to be manufactured flat, and flexible. The one or more impact mitigation structures 90 may be flexed to affix to the head boot or liner 50 to conform to the complex curvature of the head. Alternatively, the one or more impact mitigation structures 90 may be covered by a fabric (not shown).

[00070] Accordingly, the boot layer or liner 50 may be constructed from a single, continuous template or using two or more templates. As shown in Figure 2B, the boot layer or liner 50 may comprise two or more templates 80, 90. The two or more templates 80, 90 may be coupled together to form the boot layer or liner 50 that can be form fitting and substantially conforms to a wearer’s head. The boot layer or liner 50 may comprise an ear aperture 70, where the ear aperture 70 is sized and configured to fit a wearer’s ear and/or ear protection. Furthermore, the boot layer or liner 50 may comprise one or more layers. More specifically, the boot layer or liner 50 may comprise at least a first layer, a second layer. The first or second layer may comprise a foam layer (e.g., EVA), a 4-way stretch material, or a 2-way stretch material. The foam layer can include polymeric foams, quantum foam,

polyethylene foam, polyurethane foam (PU foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, compression foam, latex rubber foam, convoluted foam ("egg create foam"), EVA foam, VN 600 foam, Evlon foam, Ariaprene or Ariaprene-like material, impact hardening foam, and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure. The foam layer can be further tailored to obtain specific characteristics, such as anti-static, breathable, conductive, hydrophilic, high-tensile, high-tear, controlled elongation, and/or any combination thereof.

[00071] Figures 4 through 6 depict another exemplary embodiment of impact mitigating structures comprising undulating structures 100, including chevron-shapes, "zig-zag" and/or herringbone patterned structures that form "V" shapes as shown in FIG. 21. In this embodiment, Figures 4A-4B depict one embodiment of an undulating impact structure 100. The undulating impact structures 100 comprises a plurality of undulating walls 110 and a plurality of lateral support walls or support members 120, the plurality of undulating walls 110 forming an array, each of the plurality of undulating walls 110 having a sinusoidal shape and a height. The plurality of lateral support walls or support members 120 can reinforce, connect and/or support the plurality of undulating walls 110 (e.g., chevron, zig-zag or herringbone structures). Each of the undulating structure 100 may further comprise a vertical height 130. In various embodiments, the lateral walls 120 may extend the entire vertical height 130 of the undulating structure 100, or undulating chevron, zig-zag or herringbone structure, while in other embodiments the lateral walls 120 may not extend the full vertical height of the chevron structures and/or may partially extend substantially perpendicular along the upper, lower and/or center portion(s) of the undulating walls 110. "Substantially" may comprise angles of 70-110 degrees. Alternatively, the undulating walls 110 may have different configurations, including herringbone, chevron structures or zig-zag patterns that may comprise of lateral walls 120 with frustum or cone-shape and/or configuration. FIG. 20 depicts one embodiment of a frustum shaped chevron patterned lateral wall, where the lateral wall has a top surface and a bottom surface, the top surface has tapered walls that extend from the top surface to the bottom surface. The bottom surface may further comprise an enlarged base or flange that extends outward from the bottom surface. The top surface may be radiused, chamfered and/or beveled. For example, the chevron shapes or structures may be manufactured from materials with different durometers. Such durometers may comprise a range from 70 Shore A to 70 Shore D.

[00072] Figures 5 and 6 depict one embodiment of an undulating impact mitigation structure 100 that may be covered or uncovered. Each of the plurality of undulating impact mitigation structure

100 may be sized and configured to a custom shape. The custom shape may desirably allow mirror images of the custom shape (e.g., left and right structures) for ease of manufacturing. Each of the plurality of undulated impact mitigation structure 100 may be affixed directly onto the boot layer or liner or they may include a covering to form an undulated impact mitigation pad 150. The undulated impact mitigation pad 150 may comprise a first layer, a second layer and an undulated impact mitigation structure 100. Figure 6 shows one exemplary embodiment of a custom shaped undulated impact mitigation structure 160. The custom shaped undulated impact mitigation structure 160 may comprise a plurality of undulating walls 180, at least one lateral support wall or support member 170, and a border 190. The plurality of lateral support walls or support members 170 can reinforce, connect and/or support the plurality of undulating walls 180 (e.g., chevron, zig-zag or herringbone structures). Each of the plurality of undulating walls 180 may further comprise a wall height 140. In various embodiments, the lateral walls 170 may extend the entire vertical height 200 of the undulating structure 160, or undulating chevron, zig-zag or herringbone structure, while in other embodiments the lateral walls 170 may not extend the full vertical height of the chevron structures and/or may partially extend substantially perpendicular along the upper, lower and/or center portion(s) of the undulating walls 180. "Substantially" may comprise angles of 70-110 degrees. Alternatively, the undulating walls 180 may have different configurations, including herringbone, chevron structures or zig-zag patterns that may comprise of lateral walls 170 with frustum or cone-shape and/or configuration. The border 190 may surround at least a portion or the entire plurality of undulating walls 180. The undulating wall height 140 may comprise an elongated height that facilitates a buckling deformation, the buckling being a sudden lateral deflection away from each of the plurality of undulating wall 180 longitudinal axis.

[00073] In various embodiment, the impact mitigation structures can range in size or wall height 140 from 1 to 20 mm thick, and may incorporate different thicknesses of structure(s) throughout one single impact mitigation pad and/or pad assembly, and among the several impact mitigation pads and/or pad assemblies in the soft shell helmet, to desirably accommodate different frequencies, types and/or magnitudes of impact anticipated for the wearer. Such design can be sport and/or player specific, including various designs for sports such as soccer, etc.

[00074] In various additional embodiments, the impact mitigating structures may comprise filaments (longitudinally extending members that deform non-linearly in response to an impact source), polygonal structures (in an array or segmented), single-layered impact layers or multi-layered impact layers, and/or any combination thereof. Furthermore, the impact mitigating structures may be provided in a continuous array or a segmented array. The thin, longitudinally extending members may be shaped

and configured to deform non-linearly in response to an impact force. The non-linear deformation behavior is expected to provide improved protection against high-impact forces, and/or oblique forces. The non-linear deformation behavior can be described by at least a portion of the filament's individual and/or en-masse stress-strain profile. The non-linear stress-strain profile can illustrate that there is an initial rapid increase in resistance to an impact force, followed by a change in slope that may be flat, decreasing or increasing slope, followed by a third region with a different slope.

[00075] If desired, the impact mitigating structures can comprise laterally supported filaments. The impact mitigating structures can comprise at least a portion of a plurality of filaments that are interconnected by laterally positioned walls or sheets in a polygonal configuration. At least a portion of the filaments arranged in a hexagonal pattern interconnected by laterally positioned walls. Alternatively, other polygonal structures known in the art may be contemplated, such as triangular, square, pentagonal, hexagonal, septagonal, octagonal, etc. A plurality of sheets or lateral walls can be secured between adjacent pairs of filaments with each filament having a pair of lateral walls attached thereto. In the disclosed embodiment, the lateral walls can be oriented approximately 120 degrees apart about the filament axis, with each lateral wall extending substantially along the longitudinal length of the filament. Alternatively, the hexagonal pattern may allow at least one lateral wall to be asymmetric, which the angle of the wall may be between 90 to 135 degrees. The shape, wall thickness or diameter, height, and configuration of the lateral walls and/or filaments may vary to "tune" or "tailor" the structures to a desired performance. For example, one embodiment of a hexagonal structure may have a tapered configuration. The hexagonal structure can have a top surface and a bottom surface, with the bottom surface perimeter (and/or bottom surface thickness/diameter of the individual elements) may be larger than the corresponding top surface perimeter (and/or individual element thickness/diameter). In another example, the hexagonal structure can have an upper ridge. The upper ridge can also facilitate connection to another structure, such as an inner surface of a helmet, an item of protective clothing, and/or a mechanical connection (e.g., a grommet or plug having an enlarged tip that is desirably slightly larger than the opening in the upper ridge of the hexagonal element).

[00076] Desirably, at least a portion of the elements in the impact mitigating structures will desirably buckle and/or deform in response to an incident force, where buckling may be characterized by a localized, sudden failure of the filament structure subjected to high compressive stress, where the actual compressive stress at the point of failure is less than the ultimate compressive stress that the material is capable of withstanding. Furthermore, the at least a portion of the filaments may be

configured to deform elastically, allowing the at least a portion of the filaments to substantially return to their initial configuration once the external force is removed.

[00077] Furthermore, the polygonal or hexagonal structures may be manufactured as individual structures. The manufacturing individual polygonal or hexagonal structures may include extrusion, investment casting or injection molding process. Each individual polygonal or hexagonal structure may be affixed directly to the inner or outer surface of the helmet outer layer, inner or outer surface of the helmet inner layer, the inner or outer surface of the helmet impact absorbing layer, and/or any combination thereof. Also, they may have the same shape and configuration with repeating symmetrical arrangement or asymmetrical arrangement and/or different shape and configurations with repeating symmetrical arrangement or asymmetrical arrangement.

[00078] Conversely, the polygonal or hexagonal structures may be manufactured directly into a patterned array affixed to at least one base material. The base material may be manufactured with a polymeric or foam material. The polymeric or foam material may be elastic to allow it to be easily bent, twisted or flexed to conform to complex surfaces. Alternatively, the polymeric and/or foam material may be substantially rigid. The manufacturing of each patterned array of polygonal or hexagonal structures may include extrusion, investment casting or injection molding process. Each patterned array of polygonal or hexagonal structure and/or the base material may be affixed directly to the liner.

[00079]

[00080] If desired, a regional location and/or distribution of the segmented arrays on the boot layer may be positioned to accommodate a desired “position-specific” purpose. In various embodiments, the segmented arrays may include regionally specific arrays, such as the front, jaw, midline (surrounding the majority of the circumference to include right side, mid-back and left side), top, lower back layer 1 and lower back layer 2.

[00081] The impact mitigating structures may be bonded or coupled directly to a boot layer or liner. The impact mitigating structures and the boot layer may further comprise at least one top covering and one bottom covering. The at least one top covering and at least one bottom covering may comprise a resilient fabric that may include a two-way or four-way stretch material, any elastic material, a soft-flexible material, and/or any combination thereof. The at least one top covering and at least one bottom covering may be the same material, or they may be different materials. The impact mitigating structures and the boot layer may be coupled to a foam layer or other layer. Such coupling may be accomplished by using adhesives, molding, heat and/or material welding, sintering or any other method known in the art. The foam layer may comprise a single layer or multiple layers, which any of the layers

may be comprised of various types of foam, such as TPU foam, Poron XRD foam, impact resistant foam, compression foam, and/or any combination thereof. All of the segmented impact mitigating structures may be coupled to the base layer or at least a portion of the segmented impact mitigating structures may be coupled to the base layer. Alternatively, the impact mitigating structures may be “free-floating” within the base layer. The base layer can be coupled around the complete perimeter of the impact mitigating structure completely enclosing the impact mitigation structure, but still allowing the impact mitigation structure to “freely-float” and/or be fixed within the base layer. In addition, the base layer can be coupled around at least a portion of the perimeter of the impact mitigating structure leaving an opening, such that the impact mitigation structure “freely-floats” within base layer. The opening may be sized and configured to allow the impact mitigation structure to be removably coupled within the base layer, and easy replacement of the impact mitigation structure. The opening may be closed using various mechanical methods known in the art, including stitching, snaps, Velcro, magnets, and/or any combination thereof.

[00082] In various embodiments, each of the individual impact mitigating structures or patterned arrays of mitigating structures may be have at least one covering to form individual pads, pad assemblies or pad arrays. The at least one covering may be a loosely or tightly woven fabric. The fabric may be polymeric, such as polypropylene, polyethylene, polyester, nylon, PVC, PTFE, and/or any combination thereof. The fabric may be 2-way or 4-way stretch material. Furthermore, the at least one covering may be breathable and wick away moisture easily from the skin while carrying out various sporting and athletic activities. For example, the covering may completely or continually cover an entire array of impact mitigating structures (not shown). Conversely, the covering may cover at least a portion of an entire array of impact mitigating structures. Furthermore, the covering may cover segmented arrays of impact mitigating structures or individual impact mitigating structures.

[00083] In various embodiments, each of the individual impact mitigating structures or patterned array of mitigating structures may have at least one foam layer. The at least one foam layer can include polymeric foams, quantum foam, polyethylene foam, polyurethane foam (foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, compression foam, latex rubber foam, convoluted foam (“egg create foam”), EVA foam, VN600, Evlon foam, impact hardening foam, and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure. The at least one foam layer can be further tailored to obtain specific characteristics, such as anti-static, breathable, conductive, hydrophilic, high-tensile, high-tear, controlled elongation, and/or any combination thereof.

[00084] One particularly advantageous feature of the designs described herein is the ability to mold and/or assemble the impact layer and various other helmet components in a flat plane, which can make the tool design and construction much easier. For the best possible fit on all different head shapes, an ideal material to wrap the head with is a four way stretch material or a material that can stretch in all directions, and the impact mitigating structures can be attached to this type of a material and, due to the unique design, can flex and take shape over a complex contoured shape without wrinkles. Finally, the walled impact structure allows for an impact protective layer that easily allows for moisture vapor to pass thru, allowing the users head to naturally cool when wearing, unlike other impact layers that limit this ability.

[00085] For example, Figures 7A-7B depicts different exemplary embodiments of a helmet “boot layer,” “boot” construction or “liner”. Figures 7C-7D depicts one embodiment of a boot layer or liner 230, the boot layer or liner 230 may comprise at least one single material layer or a plurality of material layers. Each of the plurality of layers may be manufactured to accommodate and protect the desired region of the player’s head. The desired regions may include the front, upper sides (right and left) lower sides (right and left), ridge (top of head), mid back, lower back, jaw, temples, and/or any combination thereof. The boot layer may comprise one material layer. Alternatively, the boot layer or liner 230 may comprise at least one first material 240 and at least one second material 260. In one preferred embodiment, the boot layer or liner 230 may comprise at least one of a first material 240, at least one second material 260, and at least one foam layer 250. The at least one foam layer 260 may comprise EVA foam, Ariaprene or an impact mitigation structure. The at least one foam layer 250 being affixed to the at least one first 240 and at least one second material 260, and/or disposed between the at least one first material 240 and the at least one second material 260. The at least one first 240 or at least one second material 260 may be a two- or four-way stretch fabric, and/or a sweat wicking or anti-microbial fabric, where the top or first material and/or bottom or second material covering may be the same material or the at least one top and bottom covering may be different materials. For example, the boot layer first material 240 or second material 260 comprises at least one of a skin contact fabric material (which could comprise a wicking material, an anti-microbial material such as Neoprene, Ducksan Power Net, Diamond pattern) , an Ethylene-Vinyl Acetate (EVA) foam layer or an Ariaprene foam layer, a 4-way stretch material, and/or any combination thereof, each and/or all of which could be bonded together using heat pressing techniques, vibration welding techniques or similar construction techniques, known to those of skill in the art.

[00086] Accordingly, the boot layer or liner 230 may form a seam 270, the seam 270 may be formed through a heat press, ultrasonic welding or vibration welding techniques to surround the perimeter of the boot liner 230. The foam layer can include polymeric foams, quantum foam, polyethylene foam, polyurethane foam (PU foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, compression foam, latex rubber foam, convoluted foam (“egg create foam”), EVA foam, VN 600 foam, Evlon foam, Ariaprene or Ariaprene-like material, impact hardening foam, and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure. The foam layer can be further tailored to obtain specific characteristics, such as anti-static, breathable, conductive, hydrophilic, high-tensile, high-tear, controlled elongation, and/or any combination thereof.

[00087] As best seen in Figures 8A through 8C, various configurations of boot components can be constructed in simple and/or complex shapes, including a “butterfly” shape 8A, which allows helmet components to be manufactured in a “flat” configuration, and then ultimately be flexed and/or “deformed” into a desired helmet shape that can easily take the complex contoured shape of the head and/or that can be combined with other shaped/sized components. In addition, the various components described herein could be amendable to additive or “3-D” manufacturing and/or printing techniques.

[00088] Figure 9A through 9E depict one exemplary manufacturing technique for forming a boot layer or liner 290. The boot layer or liner 290 may comprise a first material 300, a second material 310 and a foam layer 280. In this embodiment, an initial step is to laser cut a desired shape of the foam layer 280. More specifically, the foam layer 280 may comprise of EVA foam or Ariaprene. The foam layer is then laminated with a first material 300 and a second material 310. The first 300 or second 310 material may have a size and shape that is larger than the foam layer 280. The first 300 or second 310 material may comprise a 4-way stretch material (e.g., Ducksan DS4015-B45 Power Net) and/or the second material 310 may comprise a 4-way stretch material (e.g., Diamond Pattern). The resulting bonded construct can then be die or laser cut to a desired shape, and subsequently utilized to construct the boot. Alternatively, Figure 17 shows another embodiment for forming a boot layer. Figures 9C illustrate how the first 300 and second 310 materials are cut into the desired shape of the foam layer 280. The boot layer or liner 290 may be positioned over an edge compress tool 320, ensuring the liner edges are aligned with the edge compress tool 320 edges. The edge compress tool 320 having a recess 330 that conforms to the desired shape of the foam layer 280. A die cut liner 340 is positioned over the

boot layer or liner 290 and inserted into the recess 330 firmly to "cut" the desired shape. Accordingly, Figure 9E illustrates the finished boot layer or liner 350 with the compressed and cut edges.

[00089] Figures 10A-10C depicts two exploded cross-sectional views of an exemplary embodiments of multi-layer construction of a soft helmet. Figure 10A depicts a soft-shell helmet 360 that comprises at least one impact mitigation structure 370 may be affixed to the boot layer or liner 390. The at least one impact mitigation structure 370 may comprise a flange 380 that can be welded, glued or stitched 430 to the boot layer or liner 390. The boot layer or liner 390 may comprise a first material 400, a second material 420 and a foam layer 410, where the foam layer 410 is disposed between the first material 420 and a second material 520. Alternatively, the soft-shell helmet 440 may comprise, wherein an impact absorbing structural component 370 can be attached to the head boot and/or encapsulated within a boot "pouch." Figure 10C depicts a soft-shell helmet 440 that comprises at least one impact mitigation pad 450, the at least one impact mitigation pad 450 comprises a first material 460, a second material 480, and/or an impact mitigation structure 370. The at least one impact mitigation pad 450 may further comprise a third material 470. The second material 480 may extend beyond the width of the impact mitigation structure 370 to form a flange, and the first material 460 may encapsulate the impact mitigation structure 370 to form a pouch. A glue strip 490 may be placed under a portion of the second material 480 flange, such that the glue strip 490 may surround the perimeter of the impact mitigation structure 370. A plurality of impact mitigation pads 450 may be affixed to the boot layer 390. The boot layer or liner 390 may comprise a first material 400, a second material 420 and a foam layer 410, where the foam layer 410 is disposed between the first material 420 and a second material 520. The first material 460, the second material 470, and/or the third material 480 may comprise of the same fabrics or different fabrics. The fabrics may comprise a 2-way stretch material, a 4-way stretch material, and/or a foam layer (e.g., a stretch knit, a stretch air mesh, and/or an open cell foam). The foam layer can include polymeric foams, quantum foam, polyethylene foam, polyurethane foam (PU foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, compression foam, latex rubber foam, convoluted foam ("egg create foam"), EVA foam, VN 600 foam, Evlon foam, Ariaprene or Ariaprene-like material, impact hardening foam, and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure. The foam layer can be further tailored to obtain specific characteristics, such as anti-static, breathable, conductive, hydrophilic, high-tensile, high-tear, controlled elongation, and/or any combination thereof.

[00090] Figures 11A through 11G depict one exemplary technique for forming pockets creating an impact mitigation pad, where the materials can encapsulate the impact absorbing structural

components. In this embodiment, a thermoplastic polyurethane (TPU) film 510 is initially placed into a TPU forming tool 500, which then closes and forms a TPU film or a first material 540within the each of the cavities/pockets 530 of the tool 520. Then, a plurality of impact absorbing structures 550 and associated open cell polyurethane foam layers 560 (the foam layer can be 1 mm to 5 mm thick) can be inserted into the pockets that form the first material 540 (Figure 11D), and a hotmelt layer 570 with release paper 580 can be applied to the formed TPU 520 (Figure 11E). Alternatively, the pockets or the impact mitigation pads can be bonded to the liner using ultrasonic welding or high-frequency welding (e.g., using a controlled vibration of the tooling to partially liquify the TPU material itself and weld the flanges or base of the pocket to the liner). The pockets can then be die cut 590 (Figure 11F) and removed from the TPU form tool 520. Figure 11G depicts an isometric view of the plurality of individual impact mitigation pads 600 after they were die cut 590 into separate pads. Figure 16 depicts an alternative method for forming pockets that encapsulate the impact absorbing structure.

[00091] Figures 12A through 12C and Figure 15 illustrate one exemplary technique for bonding the impact mitigation pads 600, i.e., the pockets and impact absorbing structures, to the liner or at least one boot layer. In this embodiment, the impact mitigation pads 600 or pockets are first inserted into the tool cavity 620, and then the liner component 620 is inserted into or over the tool 610. Heat and pressure are applied by the tool 610 in a known manner, and then the tool 610 is opened and the completed part removed for use and/or further assembly. Alternatively, the liner and/or the boot layer 620 can be bonded together using ultrasonic welding or high-frequency welding (e.g., using a controlled vibration of the tooling to partially liquify the materials and weld the liner to the boot layer together). Figure 12C depicts a front view of one exemplary embodiment of a completed soft shell helmet 630 comprising one or more impact mitigation pads 600 and a liner 620.

[00092] Figures 13A-13C depict one embodiment of a soft shell helmet design as similarly shown in Figures 2A and 3A. Figures 13A-13B show a side and a front view of the soft-shell helmet of Figures 2A-3A. The soft shell helmet comprises a liner 50 and at least one impact mitigation structure 60 affixed to the liner 50. The soft shell helmet may further comprise an ear aperture 70, the ear aperture 70 may be sized and configured to fit a wearer's ear shape. Figure 13C illustrates a covered soft-shell helmet 45, the covered soft-shell helmet 45 comprises a cover 55, a liner 50, and at least one impact mitigation structure 60 affixed to the liner 50. The cover 55 would encapsulate the entire liner 50 and at least one impact mitigation structure 60 assembly to provide protection from sweat and/or anti-microbial protection.

[00093] FIG. 14 and 15A-15C illustrates one exemplary embodiment for forming a soft shell helmet 640. The soft shell helmet 640 may comprise a plurality of liner assemblies, where each of the plurality of liner assemblies 650 comprise a liner 660 and at least one impact mitigation pad 650. Each of the plurality of liner assemblies 650 or segments are connected to an adjacent liner segments or liner assemblies 650. The liner assemblies 650 or segments or a plurality of boot layers can be connected to each other using various methods known in the art. Such connections may include ultrasonic welding, RF welding, stitching, gluing, stretch seam taping, Velcro, riveting, and/or any combination thereof. More specifically, each of the liner assemblies 650 may have the liner 660 that extended edge a certain width beyond the at least one impact mitigation pad 650, which the liner edge 680 extends allows the edges 680 to be coupled to each other to form a soft-shell helmet 640. The liner segments or a plurality of boot layers may provide for a border or periphery that surrounds each liner segment to provide additional features. Such additional features may include a snap button pose for a chinstrap mount (not shown), through-holes 670, and/or a seam edge to affix the adjacent edge to each other.

[00094] In various embodiments, the impact mitigation structures can incorporate varying offsets (i.e., array thickness as measured in a perpendicular direction outward from the surface of the wearer's head), including offsets of 4 to 6 millimeters, 7 to 9 millimeters and/or 11 to 13 millimeters. The soft helmets can be provided in a variety of sizes (3 sizes, in at least one example), with each size desirably accommodating a range of head sizes, with overlap between each member of each range.

[00095] In various embodiments, the overall thickness of the soft helmet could be 8 millimeters or less, which is a significant improvement over competitive designs that can be 15 to 20 millimeters or more in thickness.

[00096] Figures 16A-16B depict an alternative embodiment to manufacture at least one impact mitigation pad 690. Figure 16A depicts an impact mitigation pad 690 that comprises a first material 700, a second material 740, and/or an impact mitigation structure 710. The at least one impact mitigation pad 690 may further comprise a third material 720. The second material 740 may extend beyond the width of the impact mitigation structure 710 to form a flange, and the first material 700 may encapsulate the impact mitigation structure 700 to form a pouch. The first material 700 contacts the second material 740 in order to create a seam 730, the seam 730 may be created with ultrasonic welding, RF welding, stitching, gluing, stretch seam taping, Velcro, riveting, and/or any combination thereof. The first material 460, the second material 470, and/or the third material 480 may comprise of the same fabrics or different fabrics. The fabrics may comprise a 2-way stretch material, a 4-way stretch

material, and/or a foam layer (e.g., a stretch knit, a stretch air mesh, stretch poly, and/or an open cell foam). Figure 16B illustrates various embodiments of impact mitigation pads.
Figures 17A-17C depict different views of another embodiment of a liner 750. The liner 750 may comprise a first material 760, a second material 780, and a foam layer 770, the foam layer 770 disposed between the first material 760 and the second material 780. The first material 760, the second material 780, and/or the foam layer 770 may comprise of the same fabrics/materials or different fabrics/materials. The fabric/materials may comprise a 2-way stretch, a 4-way stretch, a foam material (e.g., EVA or Ariaprene). The liner 750 may have sealed seam 790 that surrounds the perimeter of the liner 750. The sealed seam may be approximately 1 mm to 5 mm.The foam layer can include polymeric foams, quantum foam, polyethylene foam, polyurethane foam (PU foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, compression foam, latex rubber foam, convoluted foam ("egg create foam"), EVA foam, VN 600 foam, Evlon foam, Ariaprene or Ariaprene-like material, impact hardening foam, and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure. The foam layer can be further tailored to obtain specific characteristics, such as anti-static, breathable, conductive, hydrophilic, high-tensile, high-tear, controlled elongation, and/or any combination thereof.

[00097] Figure 20-21 depict another embodiment of an undulating impact mitigation structure 810. The undulating impact structure 810 having a plurality of undulating walls 820 forming an array, each of the undulating walls 820 having a cross-sectional shape 830, the cross-sectional shape 830 having a first portion 840 and a second portion 850, the second portion 840 comprises a longitudinal member that extends perpendicular from the first portion 840. The second portion 850 having a length 860 and a width 870 to form an aspect ratio. If the length is greater than the width, a high aspect ratio structure, the second portion 850 can be more prone to buckling, the buckling being a sudden lateral deflection away from the longitudinal axis of the undulating walls 820. The aspect ratio may be between 3:1 to 1,000:1, where the length is greater than the width. The cross-sectional shape may comprise a solid or hollow shape. The longitudinal member may comprise a conical or frustum shaped structure, but it also may comprise a square, cylinder, triangle, shaped structure. The undulated walls 820 may comprise herringbone shape 880, chevron shape 890, a zig zag shape 900, and/or any combination thereof as shown in Figure 21Figures 22A-22E depict an alternative embodiment of a full-coverage soft shell helmet. The full coverage soft shell helmet may comprise at least one of a boot layer or liner, one or more individual impact pads or individual impact pad assemblies, a chinstrap, ear protection elements and/or any combination thereof. The soft shell helmet 910 comprising a liner 920,

one or more impact mitigation pads 930. The one or more impact mitigation pads 930 are affixed to the liner 920. The liner 920 may comprise apertures 940 that allow ventilation. The at least one "boot layer," or "liner" 920 may comprise at least one material layer or a plurality of material layers. The at least one boot layer 920 may comprise a single material layer. Alternatively, the at least one boot layer 920 may comprise a first material and a second material. The at least one boot layer 920 may be custom manufactured to fit the desired head of the player and/or be manufactured to standard sizes (small, medium, large, x-large, etc.) The at least one boot layer 920 may be manufactured to accommodate and protect the desired region of the player's head. The desired regions may include the front, upper sides (right and left) lower sides (right and left), ridge (top of head), mid back, lower back, jaw, temples, and/or any combination thereof. In a preferred embodiment, the at least one boot layer 920 may comprise a first material, a second material, and a foam layer and/or any combination thereof.

[00098] The one or more individual impact pads or individual impact pad assemblies may permanently and/or removably affixed or coupled to the at least one boot layer or liner and regionally placed around the player's head for enhanced protection. The one or more individual impact pads and/or impact pad assemblies may be desirably positioned on different regions of the head, including the frontal section, top or ridge section, lower back, mid-back, left side and front side, temples, jaw region and/or any combination thereof. For example, Figures 23A-23B and 24 depict one embodiment of a front impact pad assemblies 950, 980 and/or a rear impact pad assemblies 970, which each of the front 950 and rear 970 assemblies comprise one or more impact mitigation pads 960.

[00099] Figures 25A-25B and 26A-26B depict another exemplary alternative embodiment of an individual impact mitigation pad 990. The at least one or more individual impact mitigation pads 980 may comprise at least one impact structure 1040 at least one first layer or material 1000. The first layer or material 1000 comprises a flange 1010, the flange 1010 surrounds a perimeter of one end of the first layer or material 1000 and at least one recess 1020 forming a pocket, the pocket having a pocket height 1050, and the pocket may be shaped and configured to receive the impact mitigation structure 1040. The first layer or material 1000 may further comprise ventilation holes 1030the pocket having a pocket height 1050 the impact mitigation structure 1040 disposed within the pocket. The impact mitigation structure may comprise a portion of filaments, laterally supported filaments, auxetic structures, and/or undulating structures. In one embodiment, the impact mitigation structure 1040 can comprise undulating structures. The undulating structures comprise a plurality of spaced apart elongate walls, each of the plurality of elongate walls having a height and an undulated pattern, each of the plurality of elongate walls having a cross-sectional shape including a first lower portion and a second upper portion,

the first lower portion comprising a base having a cross-sectional width and a height, the second upper portion comprising an upwardly extending longitudinal member, the upwardly extending longitudinal member extending generally perpendicular from the base and having a cross-sectional width and a height, the base width is greater than the upwardly extending longitudinal member width and the base height is less than the upwardly extending longitudinal member height; and at least one support member, the at least one support member extending at least a portion of a length of the plurality of spaced apart elongate walls Furthermore, the plurality of spaced apart elongate walls is disposed within the pocket, where the plurality of spaced apart walls having an end that is flush with the perimeter of the pocket. Alternatively, the plurality of spaced part walls having an end that extends beyond the perimeter of the pocket or below the perimeter of the pocket. The height and undulated pattern may be uniform or non-uniform. Furthermore, each of the individual impact mitigation pads 990 may comprise a one-piece assembly that integrates the impact mitigation structure within the at least one first layer. The one-piece impact mitigation structure may be injection molded, 3D printed, casted, thermoformed and/or die cut with the first layer as a one-piece construct.

[000100] Figures 27A-27B depicts the impact mitigation pad assembly 1060. The impact mitigation pad assembly 1060 comprises an impact mitigation pad 990, at least one first layer 1070 and at least one second layer 1080. Alternatively, the impact structure assembly may further comprise a top and/or a bottom covering. The at least one first layer 1070 or the at least one second layer 1080 may be coupled and/or affixed to the impact mitigation pad 990, the impact mitigation structure (not shown) and/or impact structure assembly. The at least one first layer or the at least one second layer may include a 2-way stretch material, a four-way stretch material, at least one foam layer, at least one polycarbonate layer or a force distribution layer, a hotmelt layer, boot layer and/or any combination thereof. The at least one first and/or at least one second covering may be a two- or four-way stretch fabric (e.g. Lycra), where the top and bottom covering may be the same material or the at least one top and bottom covering may be different materials. The at least one top covering and/or at least one bottom covering may be coupled to the impact mitigation structure and/or the impact mitigation structure assembly as shown by Figures 28A-28B. The coupling may include stitching, hook and loop fasteners, snaps, adhesive, melting, any form of welding known in the art. The polycarbonate layer can be thin, flexible, yet substantially rigid to assist with absorption of the forces and reduce wear/tear. The foam layer can include polymeric foams, quantum foam, polyethylene foam, polyurethane foam (PU foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, latex rubber foam, convoluted foam (“egg create foam”), EVA foam, VN600 foam, Evlon

foam, Ariaprene or Ariaprene-like material, impact hardening foam, compression foam, and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure. The foam layer can be further tailored to obtain specific characteristics, such as anti-static, breathable, conductive, hydrophilic, high-tensile, high-tear, controlled elongation, and/or any combination thereof. Each of the impact pad assemblies 1060 may be affixed to a liner 1090. The affixation may comprise ultrasonic welding, gluing, hot melt, etc. The one or more individual impact pads and/or impact pad assemblies 1060 may be desirably positioned on different regions of the head, including the frontal section, top or ridge section, lower back, mid-back, left side and front side, temples, jaw region and/or any combination thereof.

[000101] FIG. 29A-29F and/or 30A-30C depict one embodiment of the manufacture of a full-coverage soft shell helmet. In one embodiment, creating a plurality of individual impact pads and/or individual impact pad assemblies, coupling the plurality of individual impact pads to a least one boot layer, , cutting the boot layer to substantially match the perimeter of the plurality of individual impact pads leaving a 0 to 6 mm edging, coupling a portion of the booth layer edging to the proximate base layer edging to form a circumferential shaped construction. Such process may be repeated for the front pad assembly and the rear pad assembly, then coupled to each other to form the circumferential shaped construction as shown in FIG. 31A and 31B. In one embodiment, the soft shell helmet 1180 comprises a front pad assembly 1100 and a back panel pad assembly 1150 and a base layer 1120. Each of the front panel assembly 1100 and/or the back panel pad assembly 1150 comprises a plurality of impact mitigation pads 990 or impact mitigation pad assemblies 1060. The method to manufacture a soft shell helmet comprises the steps of die cutting the plurality of foam panels 1110 that substantially conforms or conforms to the shape and configuration of the plurality of impact mitigation pads 990 and/or the plurality of impact mitigation pad assemblies 1060, bonding the foam panels 1110 to a base layer 1120 (e.g., a 2-way or 4-way stretch material), cutting the base layer 1129 with the plurality of foam panels 1110 to create a custom base layer 1120 that substantially conforms to the plurality of impact mitigation pads 990 and/or plurality the impact mitigation pad assemblies 1060, replacing at least a portion of the foam panels 1110 with a portion of the plurality of impact mitigation pads 990 and/or the impact mitigation pad assemblies 1060 and affixing them to the base layer, flexing the tabs 1140 of the base layer to conform to the head of a wearer, affixing the remaining the impact mitigation pads 990 and/or the impact mitigation pad assemblies 1060 to the base layer.

[000102] Accordingly, the front pad assembly 1100 with the back pad assembly 1150 must be affixed or coupled together to create the soft shell helmet 1180 as shown in Figures 31A-31C. The key

impact mitigation pad 1160 has a first end and a second end. The first end is affixed to the front pad assembly 1100 and the second end is affixed to the back pad assembly 1150 creating a seam or stitch 1170. The back pad assembly 1150 is flexed to conform to the head of the wearer. The back pad assembly having tabs 1140 that may couple a chin strap (not shown).

[000103] Figures 38A-38G depict different plan views of an alternate embodiment of a soft-shell helmet 1380. The soft-shell helmet 1380 may comprise a plurality of impact pads 1390 and a liner 1400. The liner may comprise one or more material layers. The one or more material layers may comprise a 2-way stretch material, a 4-way stretch material, a foam layer, and/or any combination thereof. The liner may further comprise an impact mitigation structure (not shown) and one or more ventilation holes 1430, 1420.

[000104] The plurality of impact mitigation pads 1390 may comprise an impact pad assembly. The impact pad assembly comprises an impact mitigation pad 990, a first material layer 1070, a second material layer 1080 as shown in Figures 27A-27B. The impact mitigation pad 990 comprises a base material layer (or first material layer), the first material layer or base material layer having a first surface and a second surface, a recess disposed onto a first surface extending towards the second surface, the recess having a recess height; and an impact mitigation structure, the impact mitigation structure comprising a plurality of spaced apart elongated walls, the plurality of spaced apart walls disposed within the recess, each of the plurality of elongated walls having a height, a width and a undulated pattern, each of the plurality of elongated walls having a cross-sectional shape.

[000105] Alternatively, the plurality of impact pads 1390 may comprise a first material layer or base material layer having a first surface and a second surface, a recess disposed onto a first surface extending towards the second surface, the recess having a recess height; and an impact mitigation structure, the impact mitigation structure comprising a plurality of spaced apart elongated walls, the plurality of spaced apart walls disposed within the recess, the recess having a recess height, each of the plurality of elongated walls having a height, a width and a undulated pattern, each of the plurality of elongated walls having a cross-sectional shape.

[000106] Each of the plurality of elongated walls or a plurality of elongated walls may comprise a uniform height, width and undulated pattern. Alternatively, each of the plurality of elongated walls or a plurality of elongated walls may comprise a non-uniform height, width and undulated pattern. The elongated wall height may comprise a range between 6 mm to 1.2 cm. The undulated pattern may be may comprise herringbone shape 880, chevron shape 890, a zig zag shape 900, and/or any combination thereof as shown in Figure 21. Furthermore, in another embodiment, the plurality of impact pads 1390

may comprise only a first material layer or base material layer. Furthermore, each of the plurality of elongated wall height is less than, equal to, and/or greater than the recess height. Also, a plurality of impact pads 1390 may further comprise ventilation holes.

[000107] In addition, the elongated wall height may be a high-aspect ratio structure. If the length is greater than the width, a high aspect ratio structure, the impact mitigation structure 1370 can be more prone to buckling, the buckling being a sudden lateral deflection away from the longitudinal axis of the elongated walls. The aspect ratio may be between 3:1 to 1,000:1, where the length is greater than the width. The cross-sectional shape may comprise a solid or hollow shape. The longitudinal member may comprise a conical or frustum shaped structure, but it also may comprise a square, cylinder, triangle, shaped structure. The elongated walls may also undergo elastic deformation, allowing the elongated walls to return to its initial configuration after an impact. The first or base material layer 1070 and/or the second material layer 1080 may comprise a 2-way stretch material, a 4-way stretch material, a polymer or polycarbonate material, and/or a foam layer. The foam layer can include polymeric foams, quantum foam, polyethylene foam, polyurethane foam (PU foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, latex rubber foam, convoluted foam ("egg create foam"), EVA foam, VN600 foam, Evlon foam, Ariaprene or Ariaprene-like material, impact hardening foam, compression foam, and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure. The foam layer can be further tailored to obtain specific characteristics, such as anti-static, breathable, conductive, hydrophilic, high-tensile, high-tear, controlled elongation, and/or any combination thereof.

[000108] <u>VENTILATION/CLEANING FEATURES</u>

[000109] In various embodiments, the outer surface of the soft helmet can externally expose the various voids within the impact absorbing structures, which could significantly improve ventilation, wicking and/or cooling of the helmet and the player beneath (see Figures 13B and 13C), as well as allow free expression of fluids in water sports such as diving and/or water polo. Alternatively, an outer layer of material could be provided which isolates and/or protects the voids, which could desirably prevent mud, grass or other soils from contaminating and/or filling the voids, if desired (see Figure 13A). If desired, the outer material layer could comprise an over layer of mesh or foam over the top of the helmet. In various embodiments, the soft helmet would incorporate machine washable and/or dryable materials and/or construction.

[000110] In various alternative embodiments, some portion of the impact mitigation structures may have an outer covering, including outer coverings in some regions of the soft helmet and with no outer coverings in other regions of the soft helmet.

[000111] HEAD CAP TOP

[000112] In various embodiments, a soft helmet could include a ridge, dome or peak section that covers the top of the wearer's head. This could include one or more impact absorbing structures and related components to protect the top of the wearer's head. The peak section could cover the entire top of the wearer's head, or some portions thereof, depending upon user desire and comfort. The dome or peak section may be removably coupled or permanently integrated. The dome or peak section may be removably coupled using methods known in the art, such as stitching, Velcro (hook & loop), snaps, magnets, and/or any combination thereof.

[000113] HEADBAND / SWEAT BAND

[000114] In at least one exemplary embodiment, a soft helmet could comprise a head band or sweat band structure 800, 1190, 1200 for encircling at least a portion of the wearer's head, with the band incorporating at least one impact mitigating structure therein and/or thereupon (see Figure 18 and Figure 32A-32B, 33A-33B, and 34B-34C). In such an embodiment, the band could include a uniform and/or smooth outer surface, which might provide a more desirable exterior surface and/or surface profile for use in sports such as soccer, where impacts with the players head/head band and the soccer ball would not significantly degrade ball rebound and play. The headband 800, 1190, 1200 may comprise hidden stitches that surround the top surface and the bottom surface of the headband. In one exemplary embodiment, the headband 1200 may comprise a first portion 1270 and a second portion 1260. Each of the first portion 1270 and the second portions 1260 comprise a first material 1220 and a second material 1230, and an impact mitigation structure 1250, the impact mitigation structure 1250 disposed between the first material 1220 and the second material 1230. The first portion 1270 may be sized and configured to conform to the lower back to mid back region of the wearer's head, and the second portion 1260 may be sized and configured to conform to the forehead of the wearer's head. The first portion 1270 and the second portion may be affixed by an intermediary material 1280. Such intermediary material 1280 may be a 2-way stretch material, a 4-way stretch material, or a foam layer, where an internal stitch or seam 1240 is created to affix the first 1270 and second 1260 portions together. Figures 33C and 33D show a side view and a front view of one embodiment of a headband 1200. These views represent the total area in which graphic printing may be available and can be directly disposed onto the first material 1220.

[000115] The headband 800, 1190, 1200 may have different standard sizes. Such standard sizes may include, small, medium, large, xlarge, etc. The sizes can have a width or circumference of 40 to 70 cm. The first material 1220 and the second material 1230 may comprise TLC AP, with a 65C shore hardness, a 2-way stretch, and/or a 4-way stretch. The impact mitigation structure 1250 can be a portion of filaments, a portion of laterally supported filaments, auxetic structures, undulating structures, and/or any combination thereof. The headband may comprise a rear seam 1300 and/or a side internal stitch or seam 1240.

[000116] In at least one exemplary embodiment, a "soft" shell helmet can include a protective headband. The protective headband may comprise a tubular or generally cylindrical shape and configuration, which desirably fits around the circumference of an upper portion of the wearer's head (i.e., across the forehead and above a portion of the ears and potentially covering the mid-back region). The soft-shell helmet headband may comprise at least one first layer, at least one second layer, and/or at least one impact mitigation structure or impact mitigation structure assembly as shown in Figures 33A-33C and 34. Alternatively, the soft-shell helmet headband may comprise at least one first layer, at least one second layer, at least one impact mitigation structure or impact mitigation structure assembly, a top covering and/or any combination thereof as shown in Figures. 36A-36B.

[000117] The at least one first layer or the at least one second layer may be one or more of the following: a foam layer, polycarbonate layer, two- or four-way stretch fabric (e.g. Lycra), a hotmelt layer, boot layer and/or any combination thereof. The at least one first layer or at least one second layer may be the same material or may be different materials. The polycarbonate layer can be thin, flexible, yet substantially rigid to assist with absorption of the forces and reduce wear/tear. The foam layer can include polymeric foams, quantum foam, polyethylene foam, polyurethane foam (PU foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, latex rubber foam, convoluted foam ("egg create foam"), EVA foam, VN600 foam, Evlon foam, Ariaprene or Ariaprene-like material, impact hardening foam, and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure. The foam layer can be further tailored to obtain specific characteristics, such as anti-static, breathable, conductive, hydrophilic, high-tensile, high-tear, controlled elongation, and/or any combination thereof, and may be 0.5 mm to 3 mm thick, and 45-60cm in diameter. The at least one top covering may be a two- or four-way stretch fabric that may be standard sized and/or a custom sized. The custom sized style fabric (see Figure 36A) that may be added or removed from soft-shell headband to be washed as shown in Figure 36B. Such custom style enclosure can be cut to substantially match the soft-shell helmet headband shape and configuration.

[000118] Figures 35A-35B depict one embodiment of an impact mitigation structure 1250 for assembly into a soft-shell helmet headband. The method comprises cutting the impact structure and/or impact structure assembly to custom shape with tabs 1310 that extends from the impact mitigation structure 1250, flexing the tabs 1310 until they connect with a portion of the impact mitigation structure 1250, the connection may comprise gluing, stitching, welding, etc. The impact mitigation structure 1250 is affixed to a second material 1230 by creating side internal stitches 1240. Coupling an intermediary material or layer 1280 over the side internal stitches 1240 and affix into position; the intermediary material or layer 1280 may comprise VN-600 foam layer; coupling the first material 1220 to the impact mitigation structure 1250 with at least one or more stiches 1290 (the at least one or more stitches 1290 may align with the side internal stiches of 1240) to create a headband 1300. Alternatively, coupling the impact structure and/or impact structure assembly to first or second layer, coupling the first or second layer to the impact structure, impact structure assembly and/or the first or second layer; alternatively, a removably coupling a top covering layer over the soft-shell helmet headband assembly.

[000119] Figures 36A-36B depict an alternative embodiment of a headband 1310. The headband 1310 may comprise a headband skin 1320 that may be removably coupled to a standard headband 1300. The headband skin 1310 having a width 1330, the width being 20-40 cm wide. The headband skin 1310 may be a 2-way stretch or 4-way stretch material with different patterns, colors and/or logos so the wearer may have the flexibility of choosing a headband skin 1310 to fit the wearer's personality.

[000120] Figures 37A-37D depict different views and one exploded view of an alternate embodiment of a headband 1340. The headband 1340 may comprise a first portion 1355 and a second portion 1345, each of the first 1355 and the second 1345 portion comprises at least a first material 1350 a second material 1360, and an impact mitigation structure 1370. The impact mitigation structure 1370 may comprise a portion of filaments, a portion of laterally supported filaments, a portion of undulated structures, and/or any combination thereof. The first portion 1355 and the second portion 1345 are coupled together to form a shape that conforms around the circumference of wearer's head. The coupling may comprise stitching, gluing, welding, Velcro, and/or any other mechanical connection. In one exemplary embodiment, the impact mitigation structure 1370 is an undulated structure. The undulated structure comprises a plurality of spaced apart elongated walls, each of the plurality of elongated walls having a wall height and a undulated pattern, each of the plurality of elongated walls having a cross-sectional shape, the cross-sectional shape including a first lower portion and a second upper portion, the first lower portion comprising a base having a cross-sectional base width and a base height, the second upper portion comprising an upwardly extending longitudinal member, the upwardly

extending longitudinal member extending generally perpendicular from the base and having a cross-sectional longitudinal member width and a longitudinal member height, the base width is greater than the longitudinal width and the base height is less than the longitudinal member height; and at least one support member, the at least one support member perpendicularly extending at least a portion of a length of the plurality of spaced apart elongated walls. The impact mitigation structure 1370 may further comprise a border, the border surrounds the perimeter of the impact mitigation structure 1370, the border having a border height, the border height substantially equivalent or equivalent to the wall height. The wall height may be a range between 6 mm to 1.2 cm. Increasing the base width will provide more surface area for contacting the wearer's head and facilitates the distribution of forces.

[000121] In addition, the wall height and/or the longitudinal member height may be a high-aspect ratio structure. If the length is greater than the width, a high aspect ratio structure, the impact mitigation structure 1370 can be more prone to buckling, the buckling being a sudden lateral deflection away from the longitudinal axis of the elongated walls. The aspect ratio may be between 3:1 to 1,000:1, where the length is greater than the width. The cross-sectional shape may comprise a solid or hollow shape. The longitudinal member may comprise a conical or frustum shaped structure, but it also may comprise a square, cylinder, triangle, shaped structure. The elongated walls may comprise herringbone shape 880, chevron shape 890, a zig zag shape 900, and/or any combination thereof as shown in Figure 21. The elongated walls may also undergo elastic deformation, allowing the elongated walls to return to its initial configuration after an impact.

[000122] Furthermore, the at least a first material 1350 and a second material 1360 may comprise a foam layer or foam material, a 2-way stretch material and/or a 4-way stretch material. The at least a first material 1350 and a second material 1360 may comprise different materials or the same materials. In addition, the at least a first material 1350 and a second material 1360 may further comprise a coating or laminate that is disposed on an interior surface or an exterior surface of the at least a first material 1350 and a second material 1360. Such coating or laminate may comprise a flexible fabric or a urethane. The at least a first material 1350 and a second material 1360 may further comprise one or more ventilation holes 1365, where the one or more ventilation holes 1365 may extend from the first material 1350 through the second material 1360, and/or the one or more ventilation holes 1365 may extend a portion from the first material 1350 towards the second material 1350. The foam layer can include polymeric foams, quantum foam, polyethylene foam, polyurethane foam (PU foam rubber), XPS foam, polystyrene, phenolic, memory foam (traditional, open cell, or gel), impact absorbing foam, latex rubber foam, convoluted foam ("egg create foam"), EVA foam, VN600 foam, Evlon foam, Ariaprene

or Ariaprene-like material, impact hardening foam, compression foam, and/or any combination thereof. The at least one foam layer may have an open-cell structure or closed-cell structure. The foam layer can be further tailored to obtain specific characteristics, such as anti-static, breathable, conductive, hydrophilic, high-tensile, high-tear, controlled elongation, and/or any combination thereof.

[000123] EAR PROTECTION/SHELL ELEMENTS

[000124] In various embodiments, the soft helmet could incorporate auxiliary protection features, such as ear caps or other relative more rigid structures, which could comprise modular components for addition to the helmet if desired. As best seen in Figures 19A and 19B, and ear cap could comprise a molded thermoplastic cup or shell or a foam material, which desirably fits within an ear opening of the soft helmet. The foam material may be compression molded foam to provide a softer and/or more compliant construction. The foam material may be comprised of memory foam, open or closed cell foam, impact foam, ethylene-vinyl acetate (EVA), thermoplastic elastomer (TPE) or a EVA-TPE hybrid, and/or any combination thereof. The cup can include one or more openings to facilitate sound transmission, if desired. Desirably, the ear cap will include a central raised region for accommodating the ear and ear lobes of the wearer, which can extend through an ear opening of the helmet, with a peripheral flange or other feature which can be retained by the helmet (which stretches around the ear cap in a desired manner to accommodate ear caps of varying sizes).

[000125] In another exemplary embodiment, the soft-shell helmet may comprise a chin-strap buckle. The chin-strap may be integrated with the boot layer and/or as a separate, independent feature that may be removably coupled. If the separate, independent chin-strap is removably coupled, the soft-shell helmet may include a through hole where a chin strap may be affixed and a buckle to allow adjustability. Alternatively, if the chin-strap is integrated with the boot layer, the chin-strap would be designed with elasticity to allow the player's chin to stretch the chin-strap to accommodate the different "chin" size and configurations. Such chin-straps can help support and/or retain the soft-shell helmet on the head of the wearer. The chin-strip may be manufactured using an elastic material and may include impact mitigation pads or other impact mitigation structures affixed to the chin-strap, if desired.

[000126] EYE PROTECTION

[000127] In another embodiment, the soft helmet may comprise a visor, eyewear and/or eye shields. The visor may be removably connected/coupled or integrated within the soft helmet. Such removable connections may include magnets, buckles, elastic bands, Velcro, snaps, quick release mechanism, friction, and/or any combination thereof. The visor may be manufactured with a polymer that has specific material characteristics to enhance or protect optical viewing. For example, such

characteristics may include a shatterproof material, an anti-fog coating, anti-glare coating, anti-scratch coating, an anti-reflective coating, photochromic coating, tinting, UV coating, prescription based, and/or any combination thereof. The visor may be substantially flexible and curved to allow insertion under the soft helmet. The soft helmet may have a specific visor opening, where the visor may be positioned. The visor having a flange surrounding the perimeter may be disposed within the visor opening, the soft helmet inner surface may hold the flange of the visor in place. Alternatively, the visor may have mechanical connections that allow the visor to be removably connected to the external surface of the soft helmet.

[000128] SUPPLEMENTAL PROTECTION CAP

[000129] If desired, a soft helmet could also provide an enhanced "underlayer" of protection within an existing protective helmet, such as within a hard, rigid or substantially rigid shell helmet. In essence, the soft helmet could be worn as a "skull cap" within the shell helmet, and provide additional impact protection thereto.

[000130] CONFIGURABLE HELMET

[000131] In at least one alternative embodiment, a soft helmet may comprise a cylindrical/round cap or latticed framework or similar arrangement, that could allow for various designs and/or configurations of impact absorbing structures to be added and/or removed from the helmet structure, depending upon player preference. For example, the latticed framework may comprise a hook and loop fastener surface, that attaches to corresponding surfaces on the impact absorbing structures. This could include the placement of impact mitigations structures in desired locations/arrangements to accommodate sport specific and/or position specific impact needs, including the use of impact protective elements that are modular and/or segmented structures that can be affixed to the exterior and/or interior of the soft helmet to achieve a desired helmet.

[000132] The entire disclosure of each of the publications, patent documents, and other references referred to herein is incorporated herein by reference in its entirety for all purposes to the same extent as if each individual source were individually denoted as being incorporated by reference.

[000133] The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The foregoing embodiments are therefore to be considered in all respects illustrative rather than limiting on the invention described herein. The scope of the invention is thus intended to include all changes that come within the meaning and range of equivalency of the descriptions provided herein.

[000134] Many of the aspects and advantages of the present invention may be more clearly understood and appreciated by reference to the accompanying drawings. The accompanying drawings are incorporated herein and form a part of the specification, illustrating embodiments of the present invention and together with the description, disclose the principles of the invention.

[000135] Although the foregoing invention has been described in some detail by way of illustration and example for purposes of clarity of understanding, it will be readily apparent to those of ordinary skill in the art in light of the teachings of this invention that certain changes and modifications may be made thereto without departing from the spirit or scope of the disclosure herein.

CLAIMS

What is claimed:

1. An impact mitigation structure comprising:

a plurality of spaced apart elongated walls, each of the plurality of elongated walls having a wall height and a undulated pattern, each of the plurality of elongated walls having a cross-sectional shape, the cross-sectional shape including a first lower portion and a second upper portion, the first lower portion comprising a base having a cross-sectional base width and a base height, the second upper portion comprising an upwardly extending longitudinal member, the upwardly extending longitudinal member extending generally perpendicular from the base and having a cross-sectional longitudinal member width and a longitudinal member height, the base width is greater than the longitudinal width and the base height is less than the longitudinal member height; and

at least one support member, the at least one support member extending perpendicular from at least a portion of a length of the plurality of spaced apart elongated walls.

2. The impact mitigation structure of claim 1, wherein the undulated pattern comprises a zig-zag pattern, a herringbone pattern, or a chevron pattern.

3. The impact mitigation structure of claim 1, wherein the impact mitigation structure further comprises a border, the border having a border height, the border surrounding the perimeter of the plurality of spaced part elongated walls, the border height is at least a portion of the elongated wall height.

4. The impact mitigation structure of claim 1, wherein each of the plurality of elongated walls having a uniform or non-uniform wall height.

5. The impact mitigation structure of claim 1, wherein each of the plurality of elongated walls having an aspect ratio between 3:1 to 1,000:1.

6. The impact mitigation structure of claim 5, wherein each of the plurality of elongated walls having an aspect ratio between 3:1 to 1,000:1 buckles after an impact, the buckling being a sudden lateral deflection of a portion of the plurality of elongated walls.

7. An impact mitigation pad comprising:

a base material layer, the base material layer having a first surface and a second surface, a recess disposed onto a first surface extending towards the second surface; and

an impact mitigation structure, the impact mitigation structure comprising a plurality of spaced apart elongated walls, the plurality of spaced apart walls disposed within the recess, the recess having a recess height, each of the plurality of elongated walls having an elongated wall height, an elongated wall width and a undulated pattern, each of the plurality of elongated walls having a cross-sectional shape.

8. The impact mitigation pad of claim 7, wherein the undulated pattern comprises a zig-zag pattern, a herringbone pattern, or a chevron pattern.

9 The impact mitigation pad of claim 7, wherein each of the plurality of elongated walls having a uniform or non-uniform wall height.

10. The impact mitigation pad of claim 7, wherein each of the plurality of elongated walls having an aspect ratio between 3:1 to 1,000:1.

11. The impact mitigation pad of claim 7, wherein the impact mitigation pad further comprises a first material layer and a second material layer.

12. The impact mitigation pad of claim 7, wherein the elongated wall height is equal to, less than or greater than the recess height.

13. A helmet comprising:

a liner, the liner having an external surface and an internal surface; and

a plurality of impact pads, at least a portion of the plurality of impact pads comprising base material layer, an impact mitigation structure, a first material layer and a second material layer,

the base material layer having a first surface and a second surface, a recess disposed onto a first surface extending towards the second surface, the impact mitigation structure comprising a plurality of spaced apart elongated walls, the plurality of spaced apart walls disposed within the recess, the recess having a recess height, each of the plurality of elongated walls having an elongated wall height, an elongated wall width and a undulated pattern, each of the plurality of elongated walls having a cross-sectional shape,

the plurality of impact pads being coupled to the liner external surface.

15. The helmet of claim 13, wherein the undulated pattern comprises a zig-zag pattern, a herringbone pattern, or a chevron pattern.

16 The helmet of claim 13, wherein each of the plurality of elongated walls having a uniform or non-uniform wall height.

17. The helmet of claim 13, wherein each of the plurality of elongated walls having an aspect ratio between 3:1 to 1,000:1.

18. The helmet of claim 13, wherein the impact mitigation pad further comprises a first material layer and a second material layer.

19. The helmet of claim 13, wherein the elongated wall height is equal to, less than or greater than the recess height.

20. The helmet of claim 19, wherein the first material layer or the second material layer comprises a foam layer or a polycarbonate material.

FIG. 1

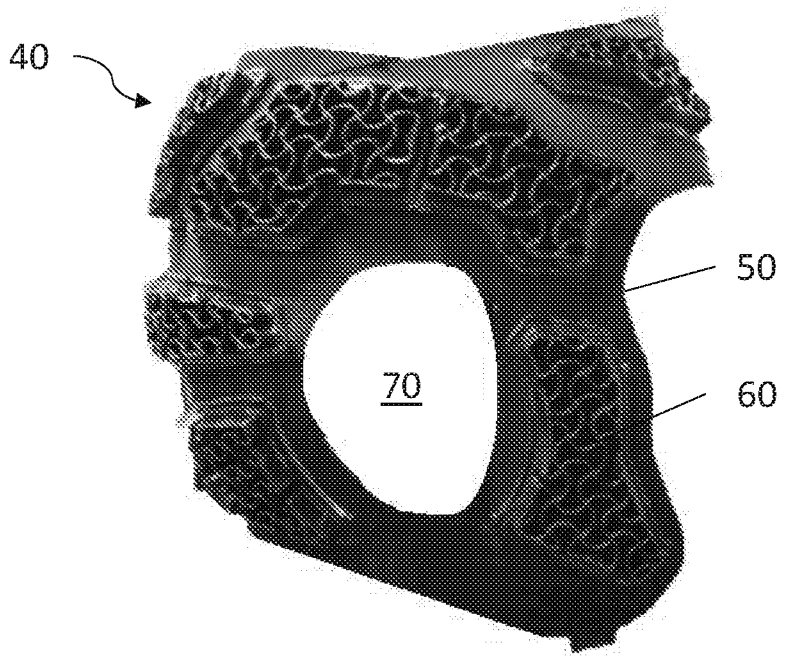


FIG. 2A

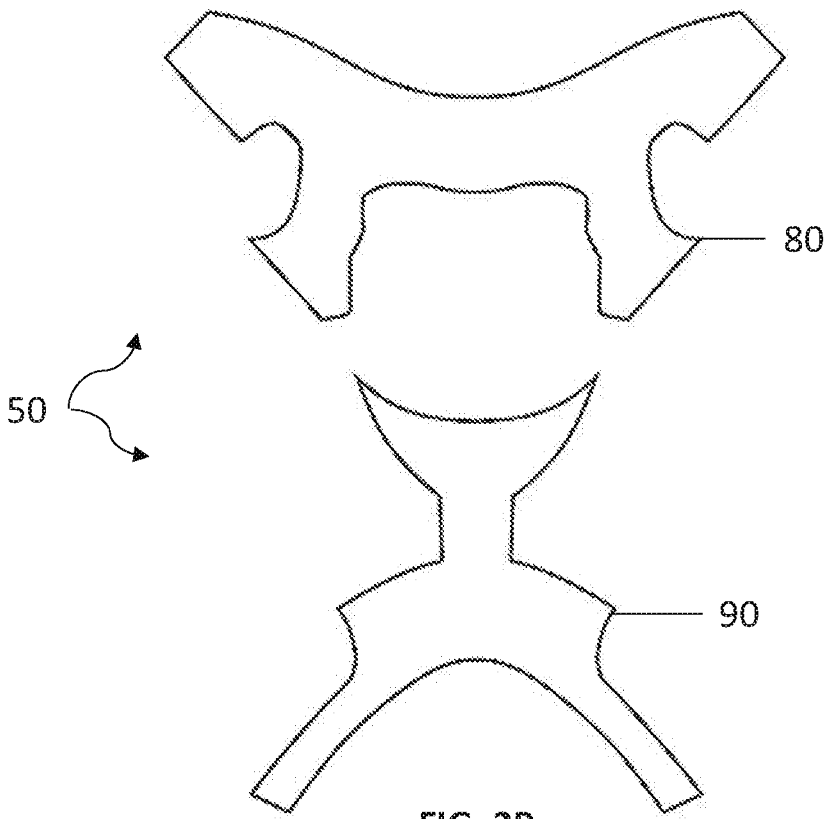


FIG. 2B

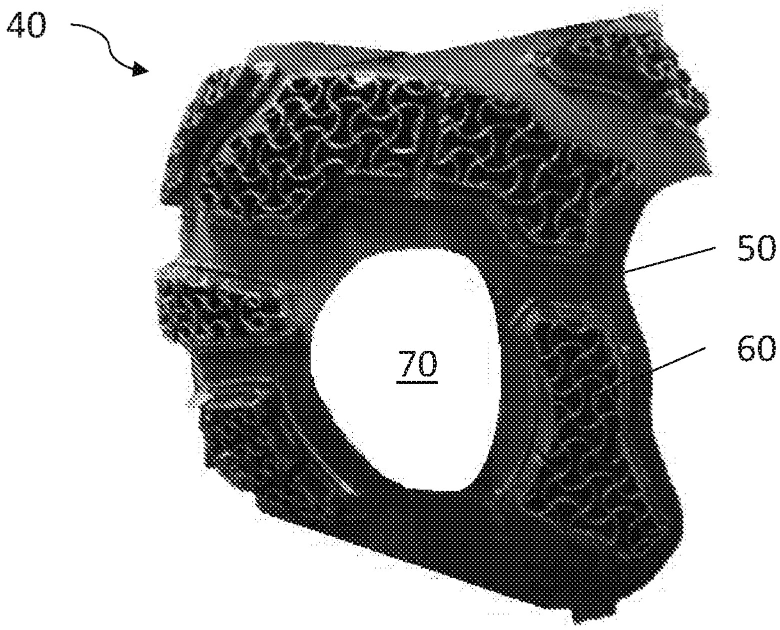


FIG. 3A

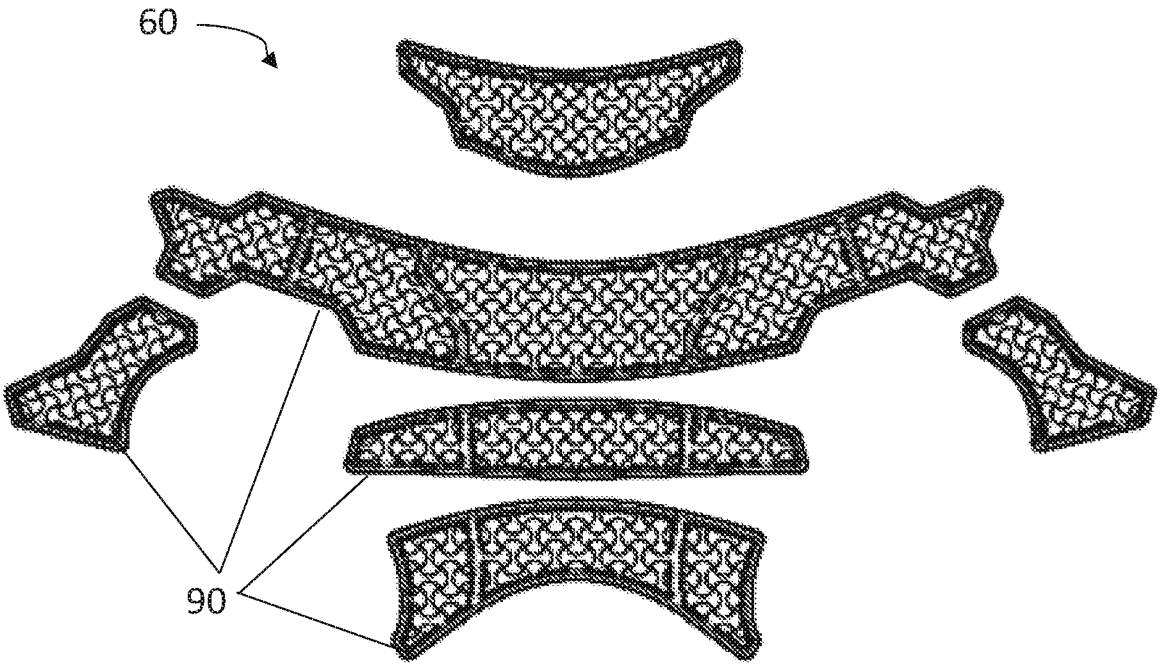


FIG. 3B

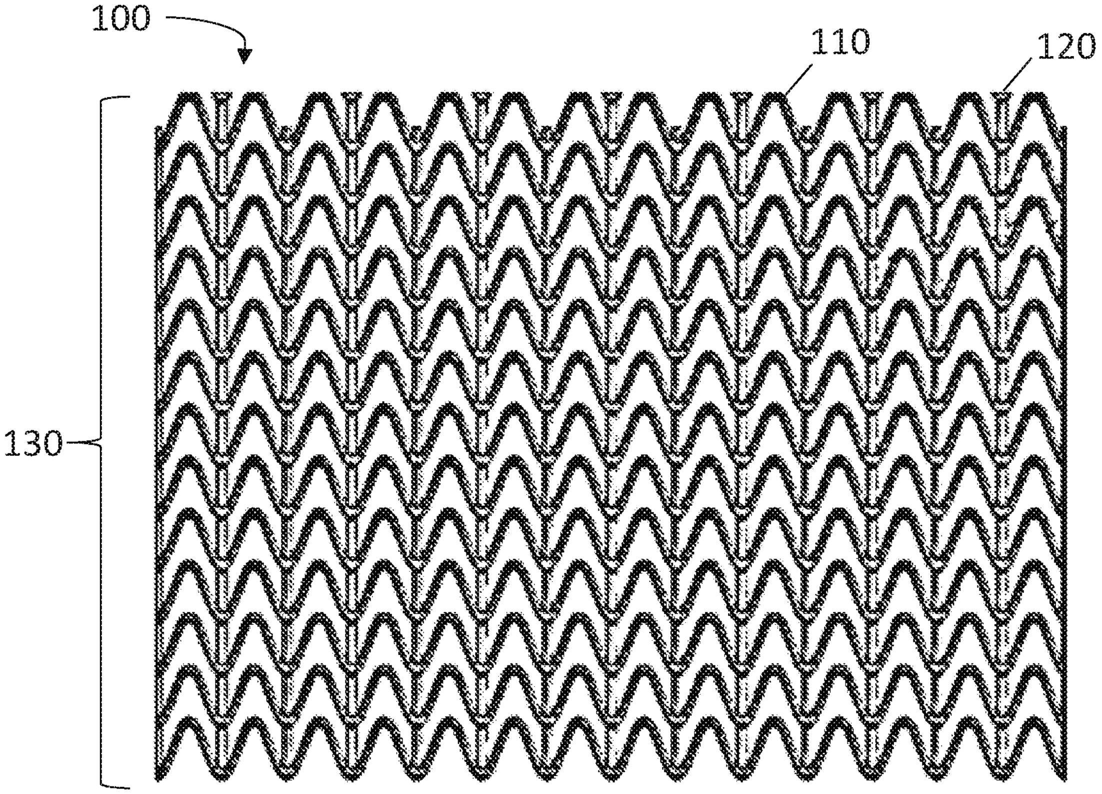


FIG. 4A

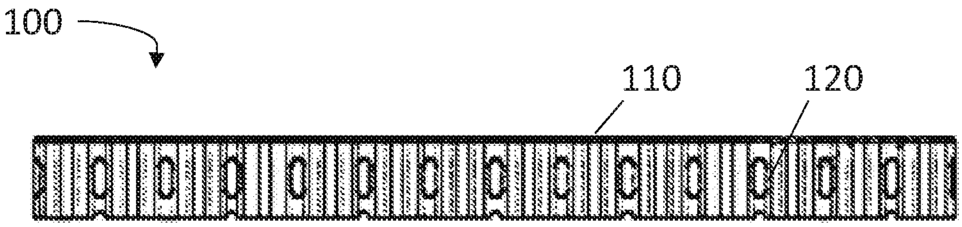
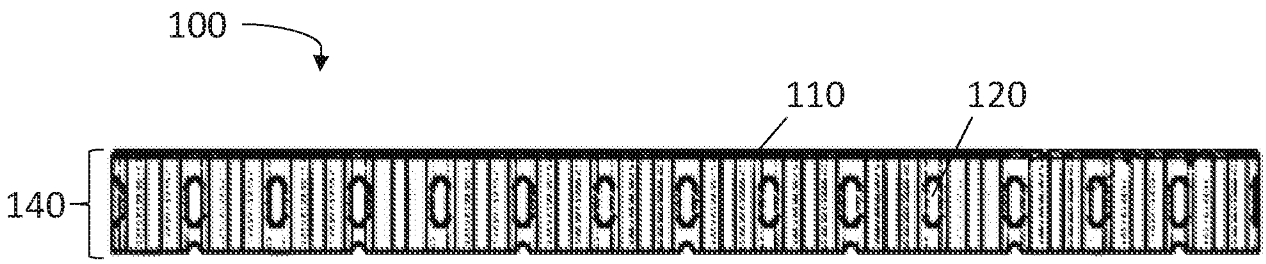


FIG. 4B



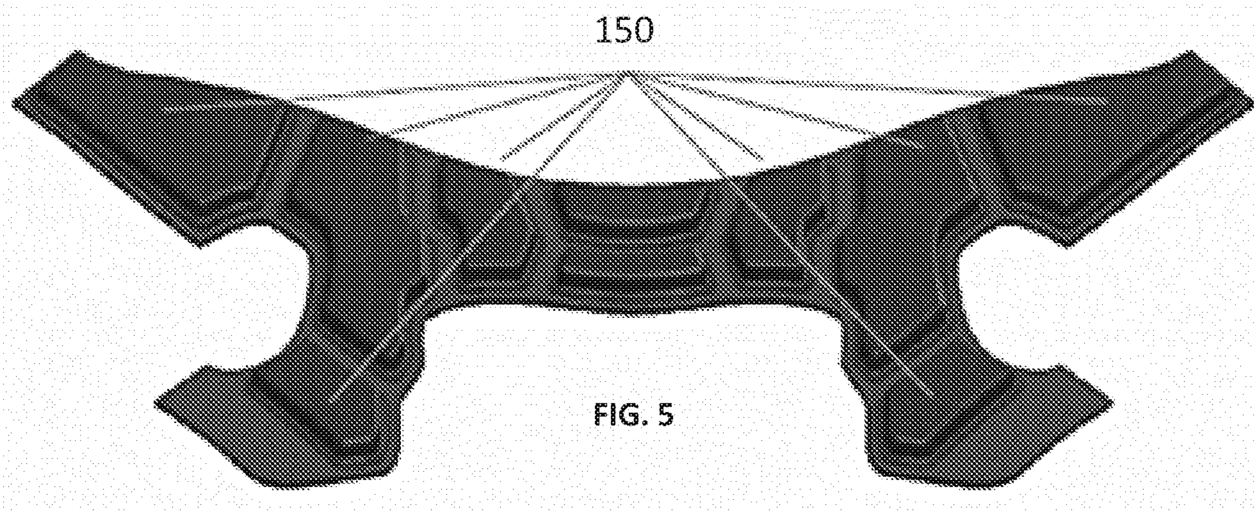


FIG. 5

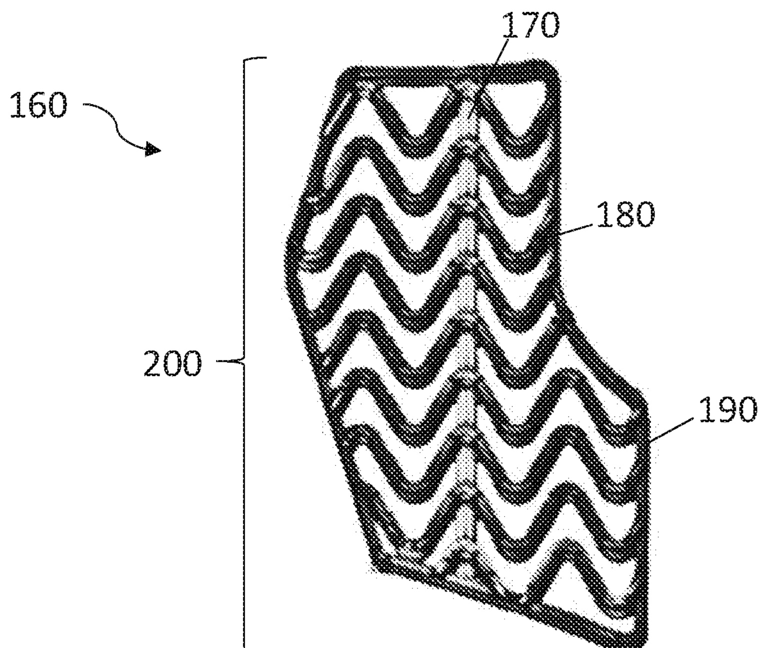


FIG. 6

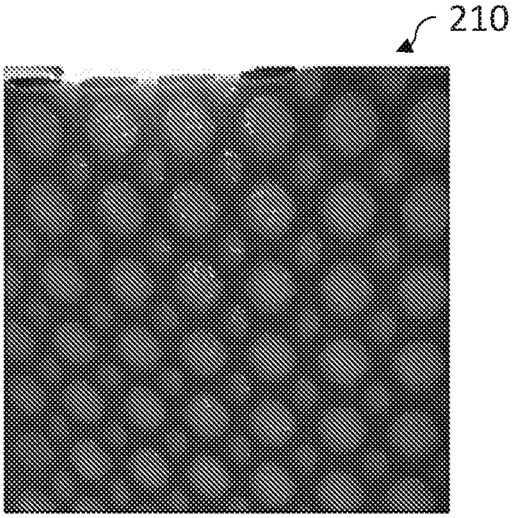


FIG. 7A

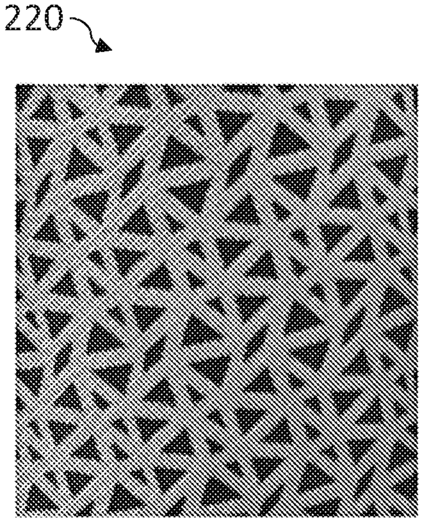


FIG. 7B

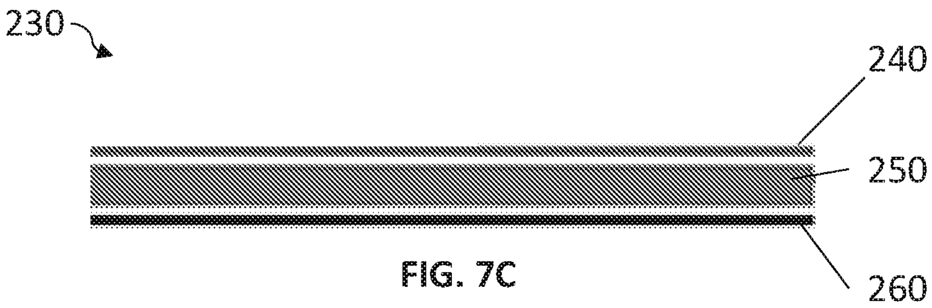


FIG. 7C

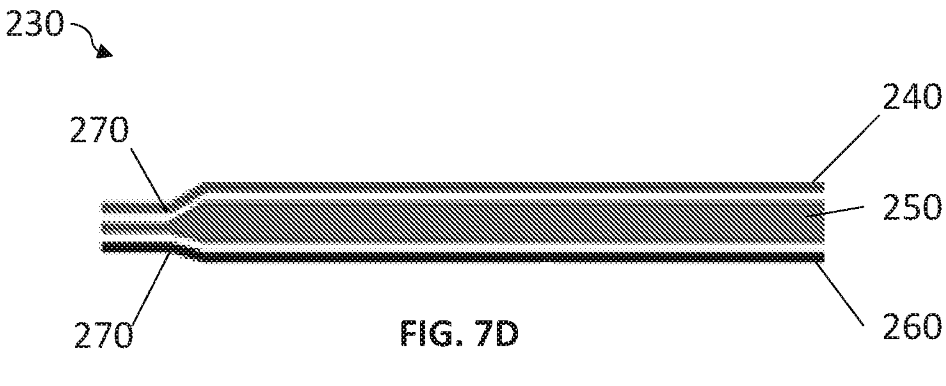


FIG. 7D

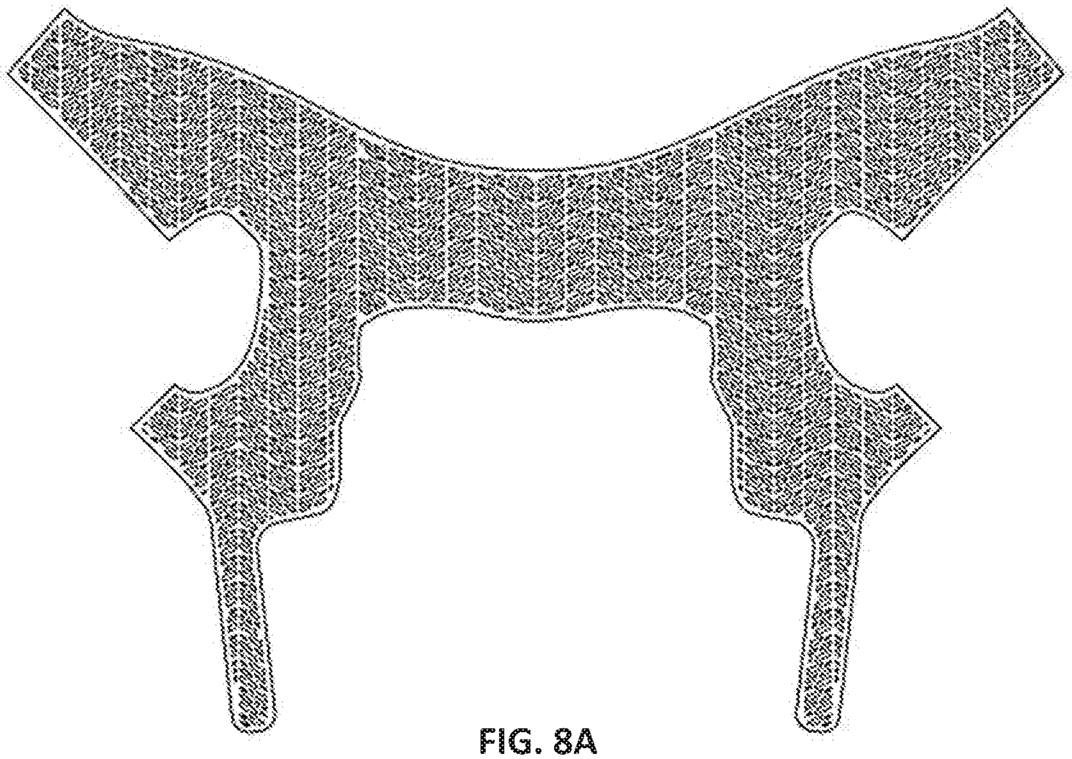


FIG. 8A

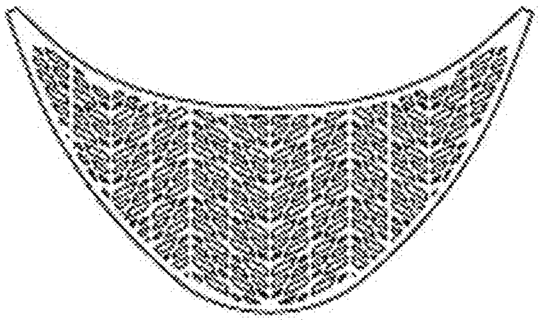


FIG. 8B

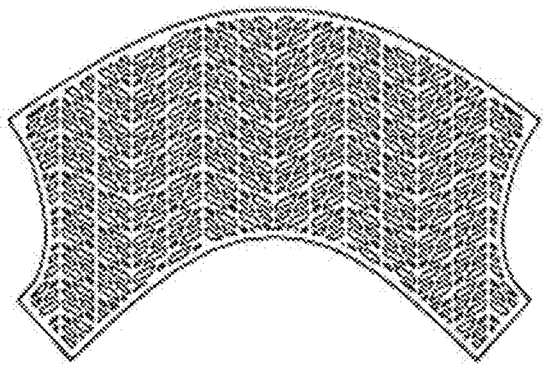


FIG. 8C

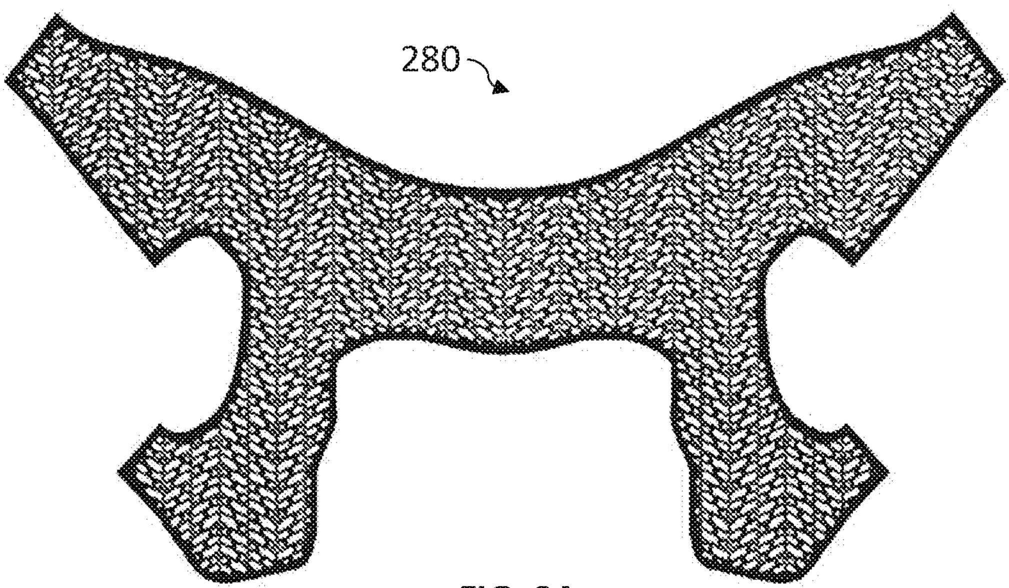


FIG. 9A

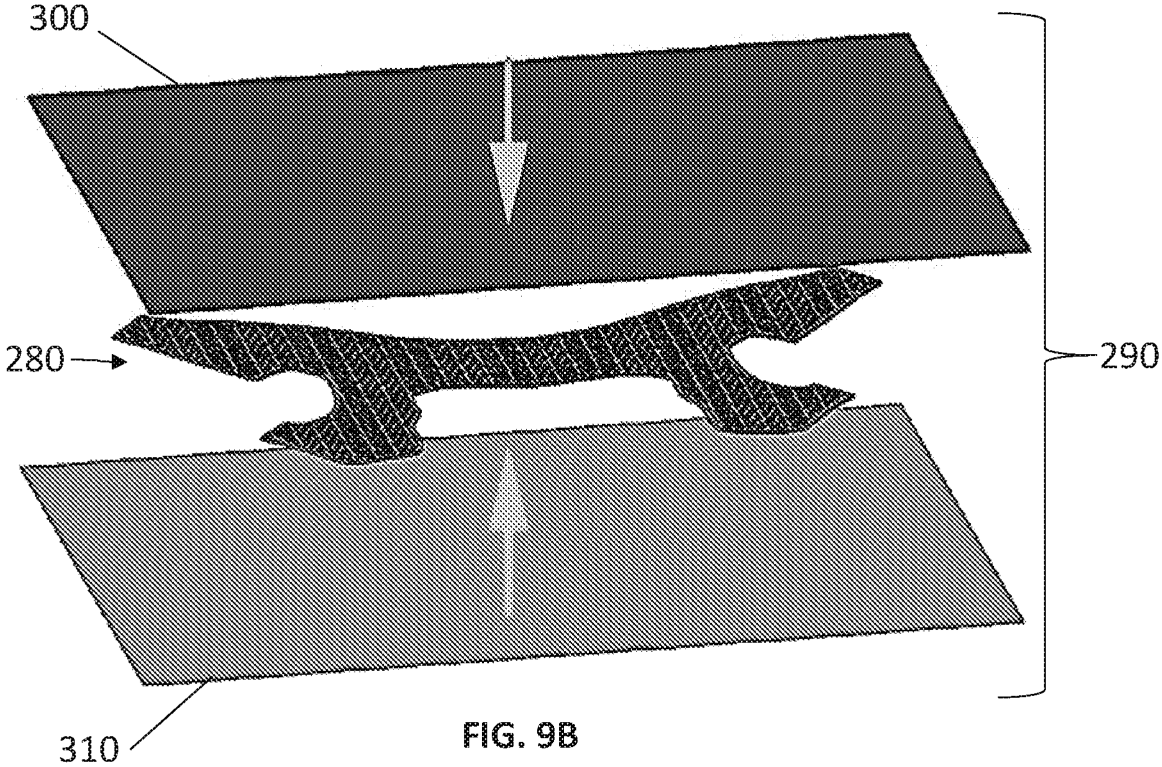


FIG. 9B

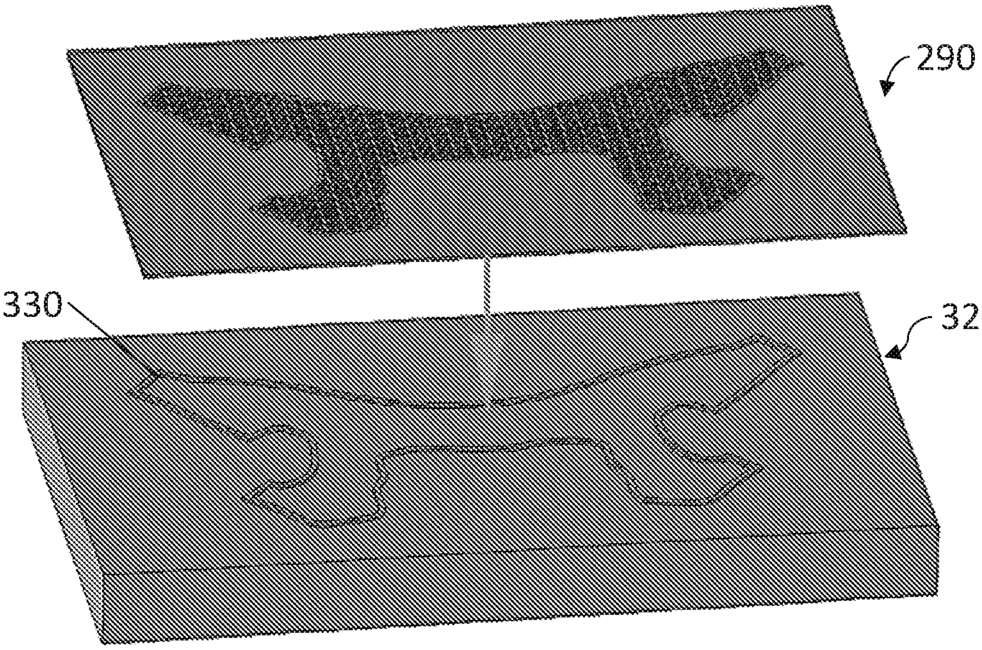


FIG. 9C

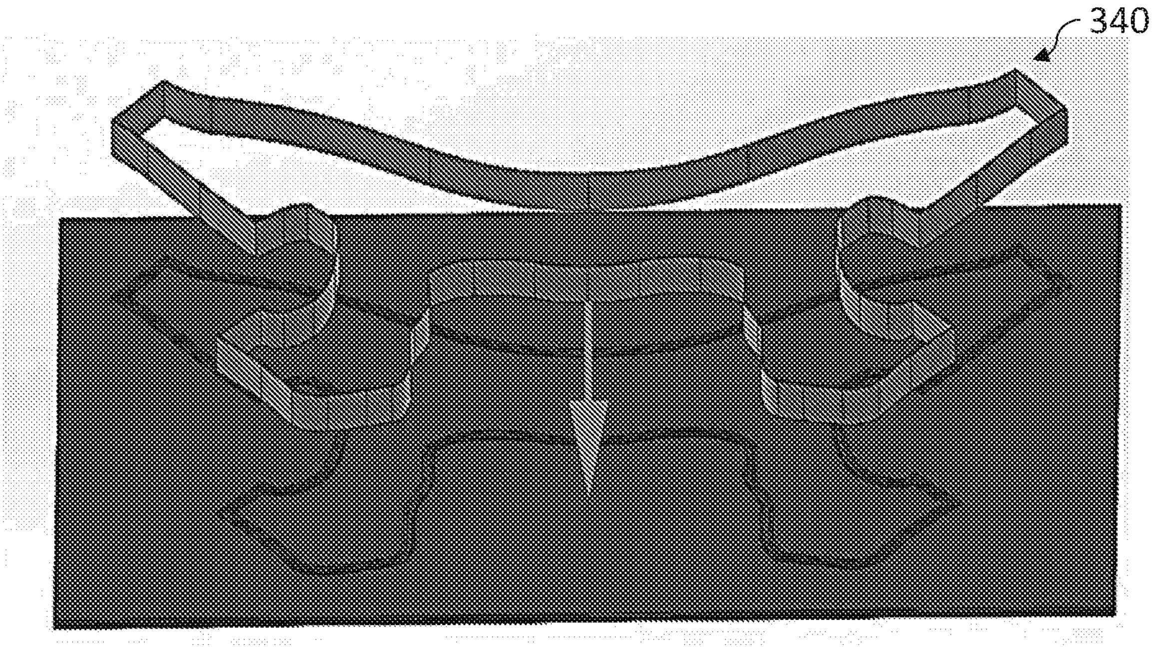


FIG. 9D

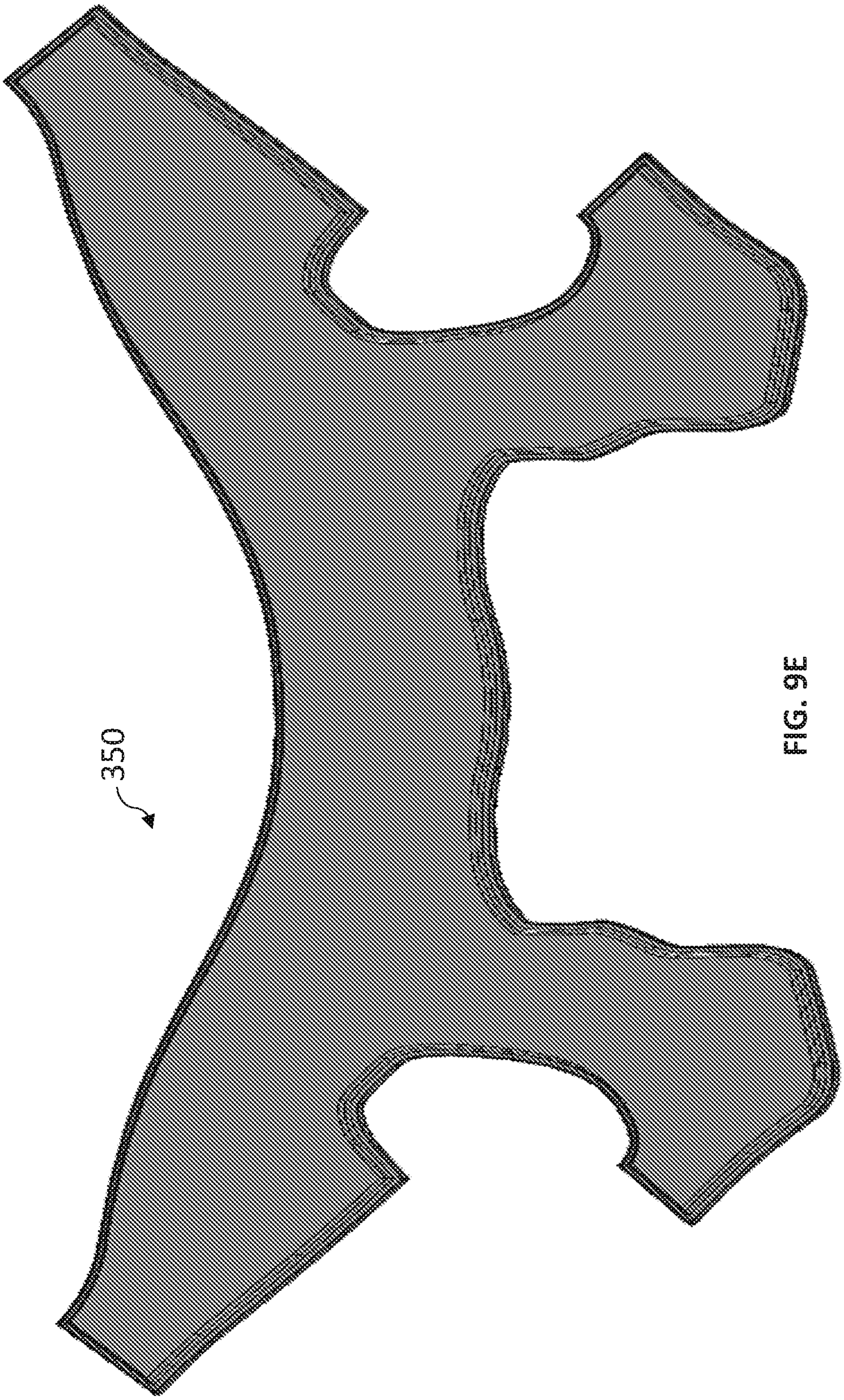


FIG. 9E

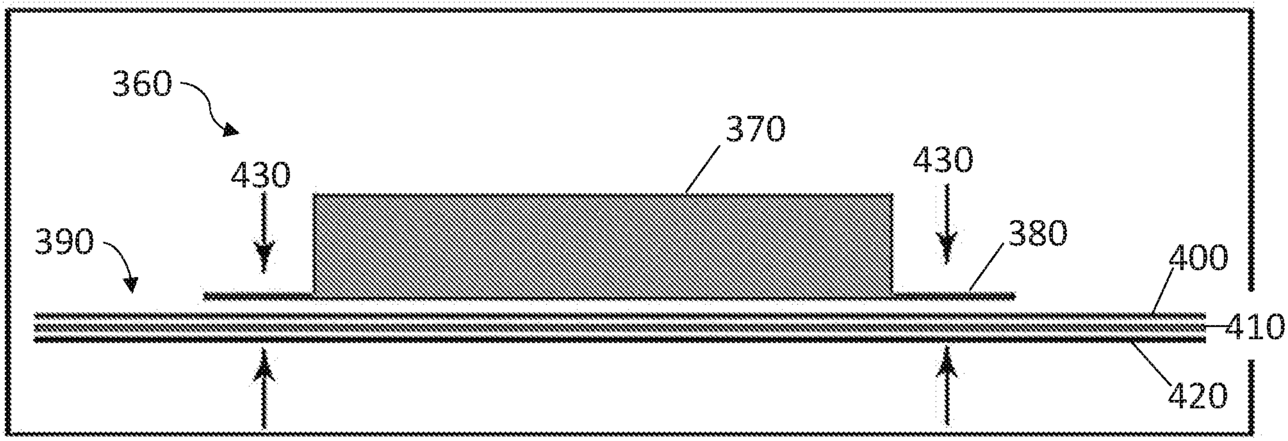


FIG. 10A

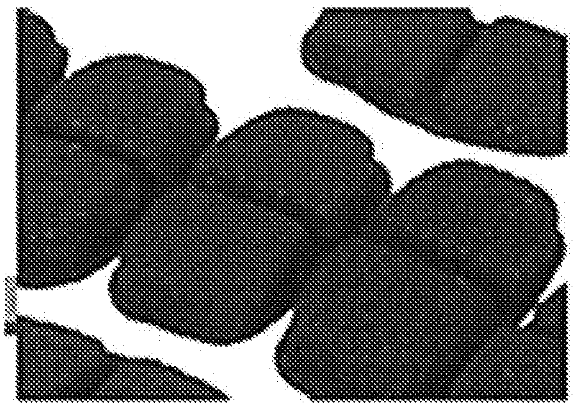


FIG. 10B

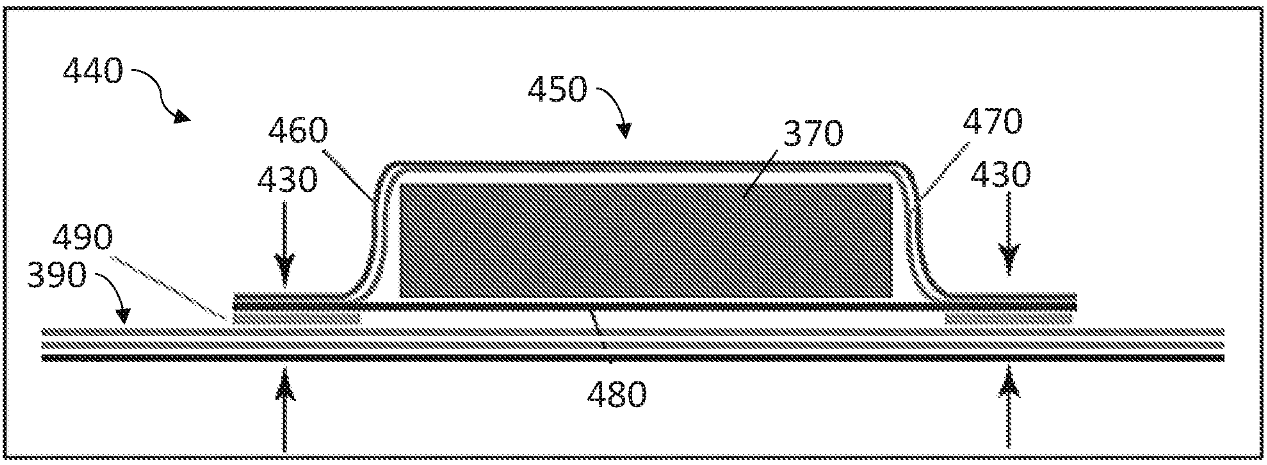


FIG. 10C

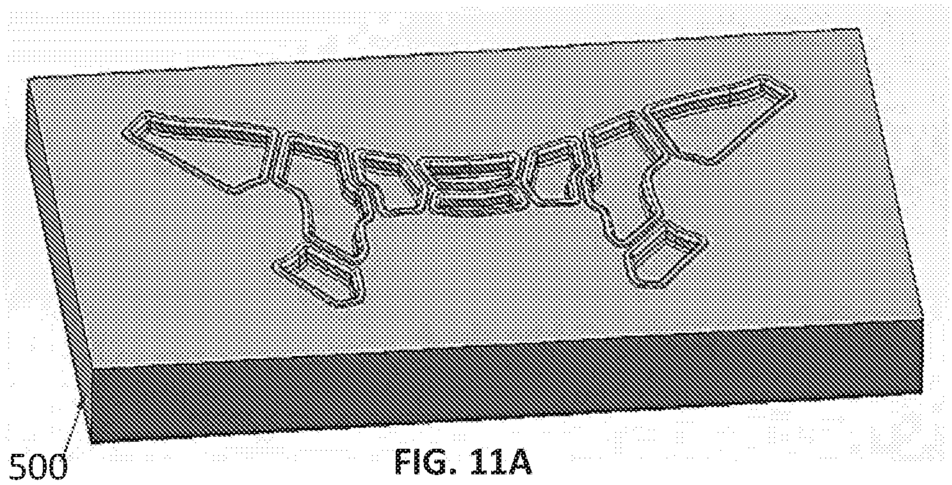


FIG. 11A

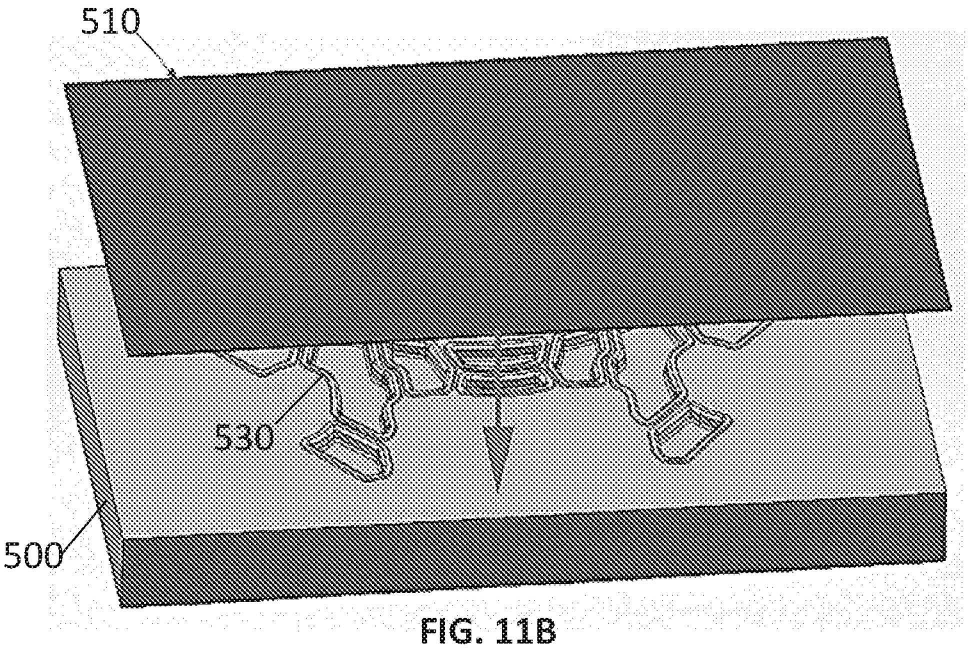


FIG. 11B

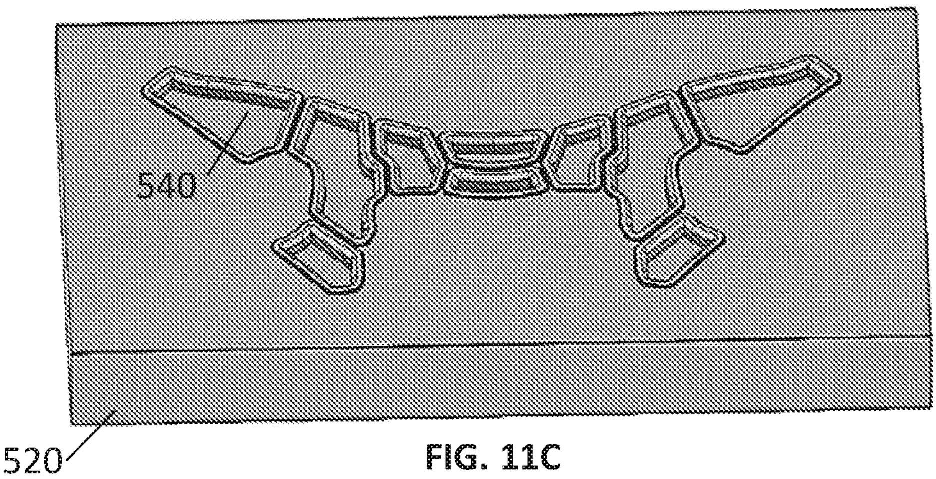


FIG. 11C

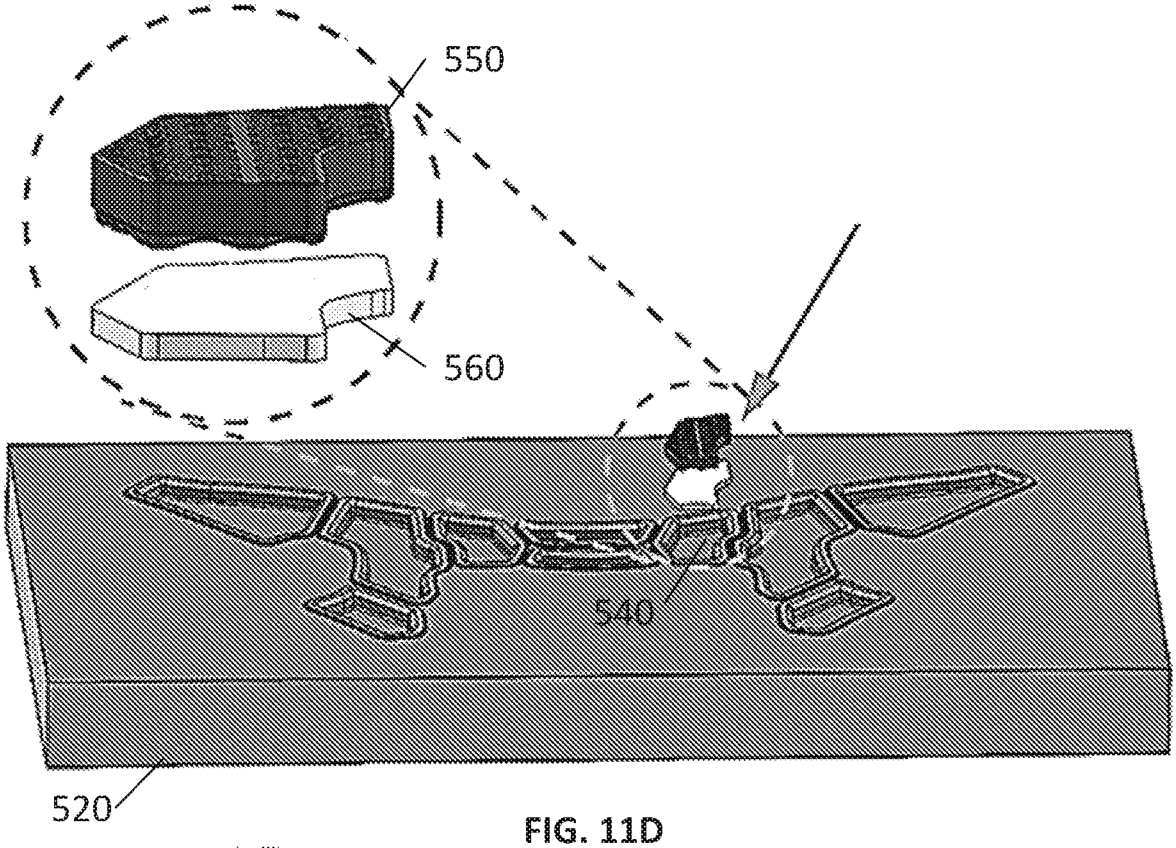


FIG. 11D

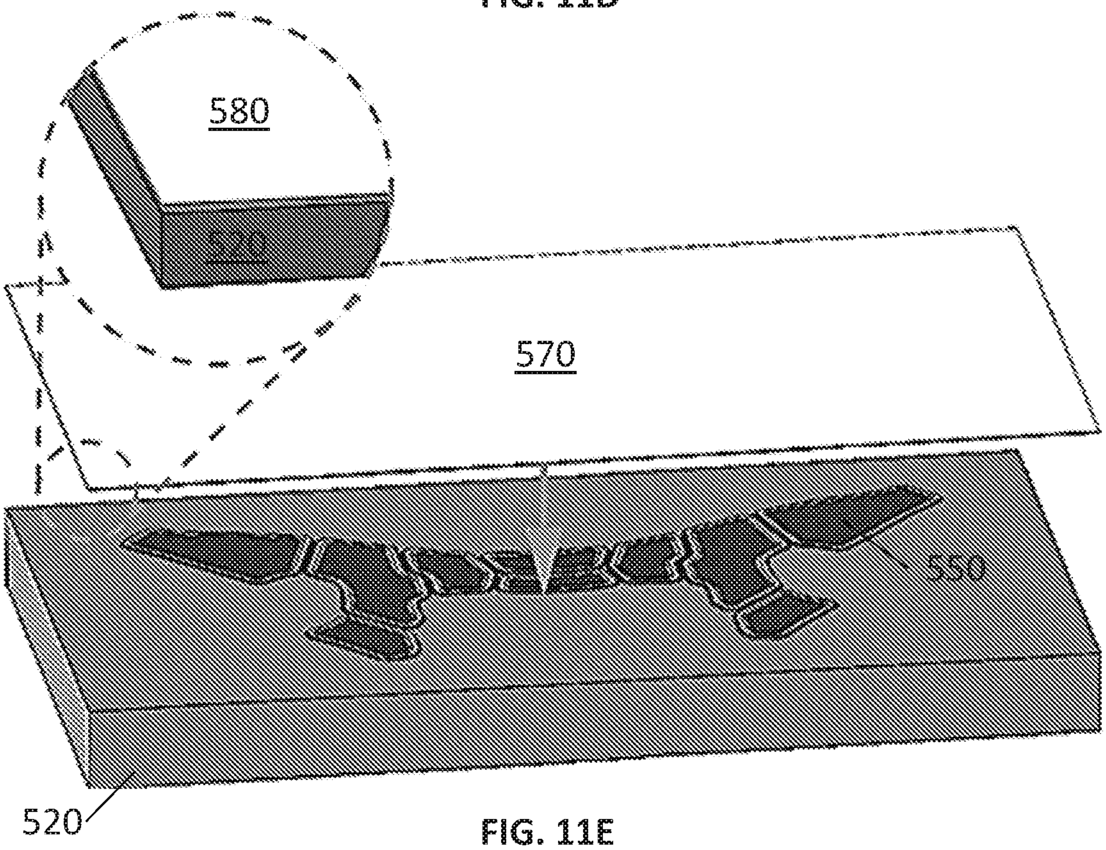


FIG. 11E

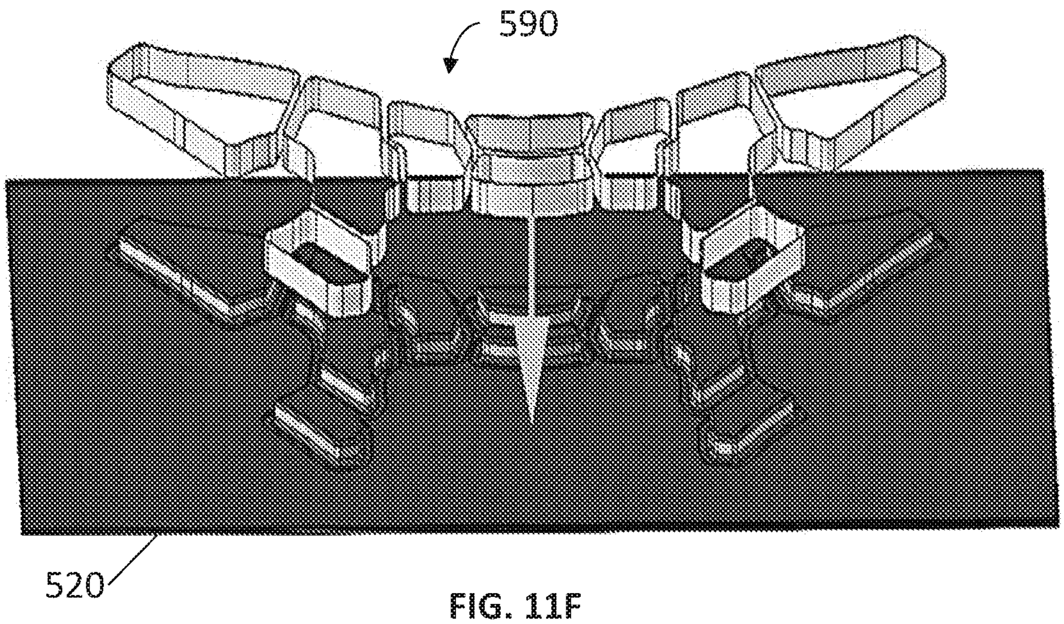


FIG. 11F

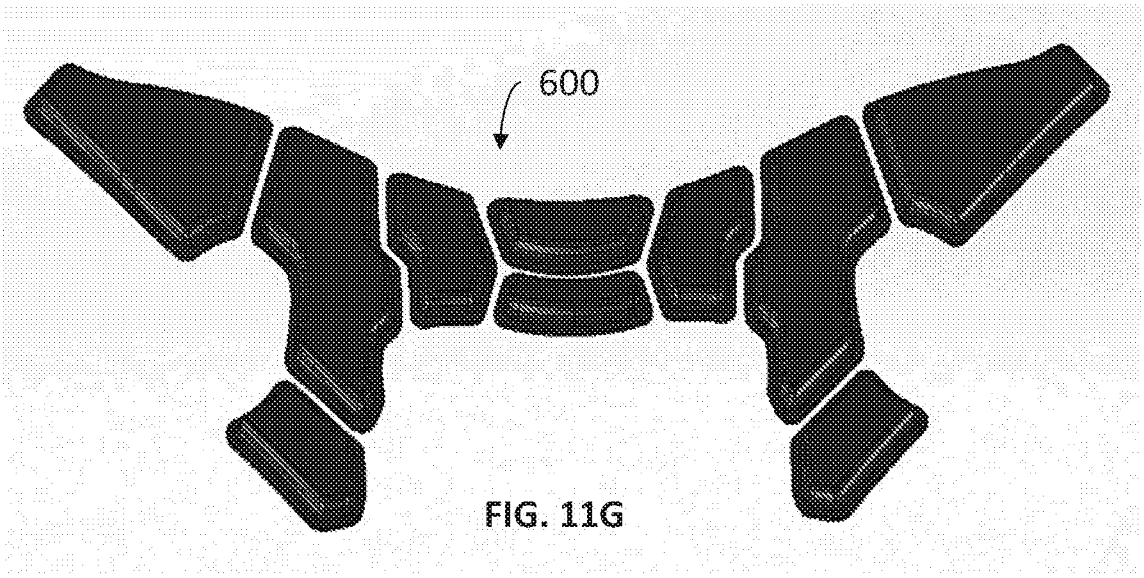


FIG. 11G

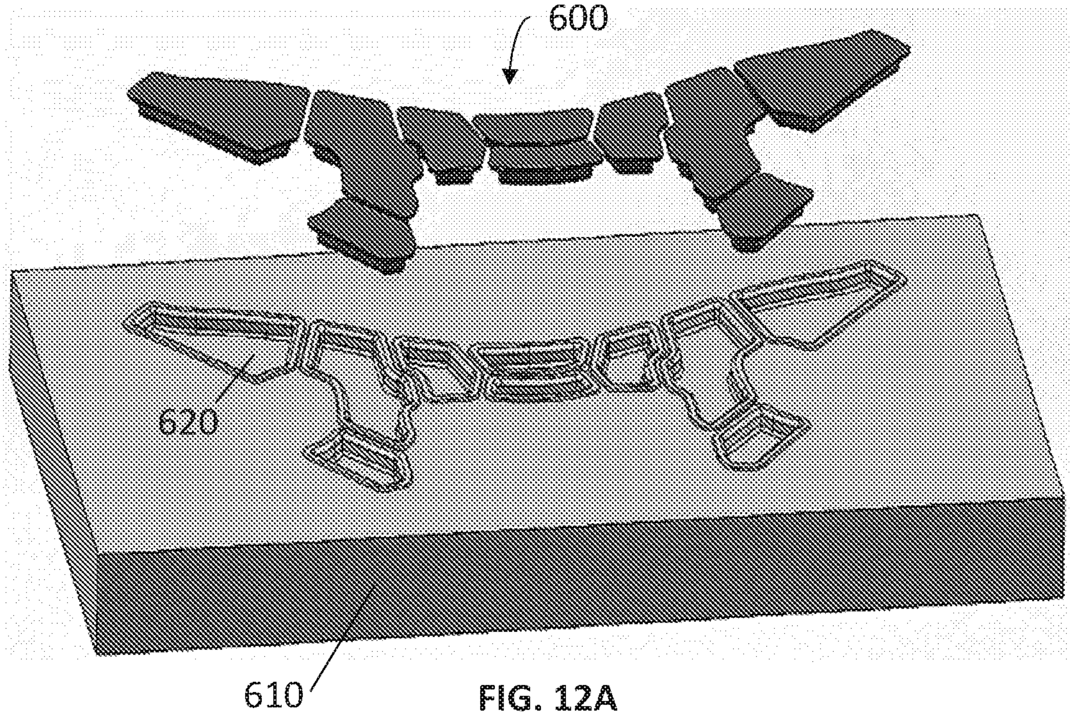


FIG. 12A

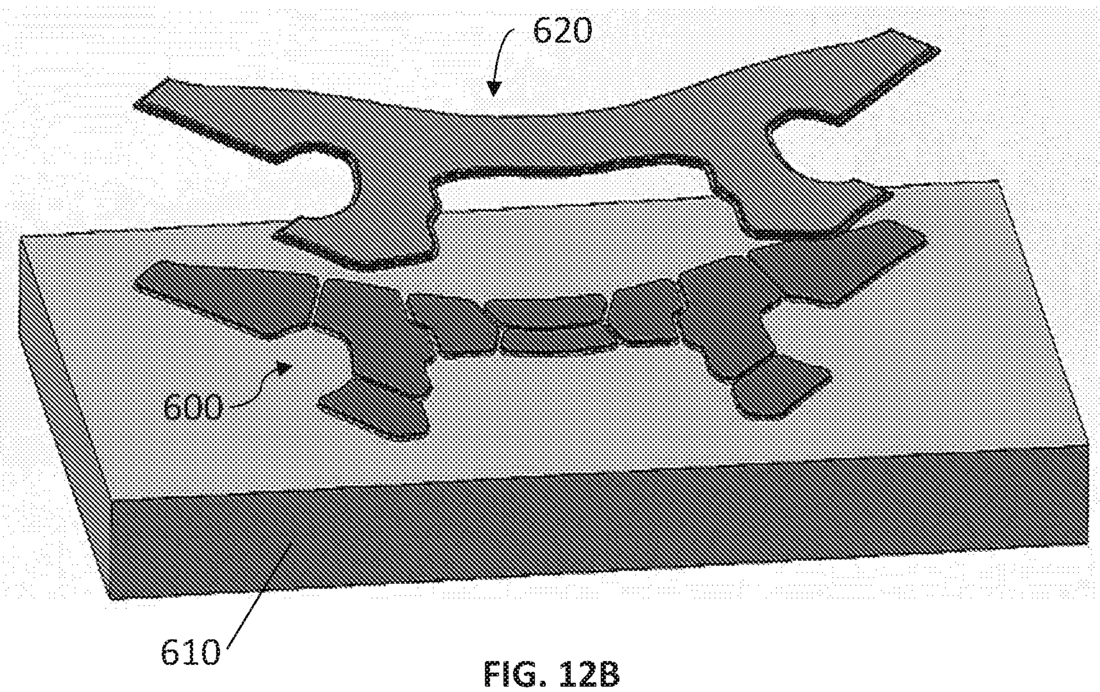


FIG. 12B

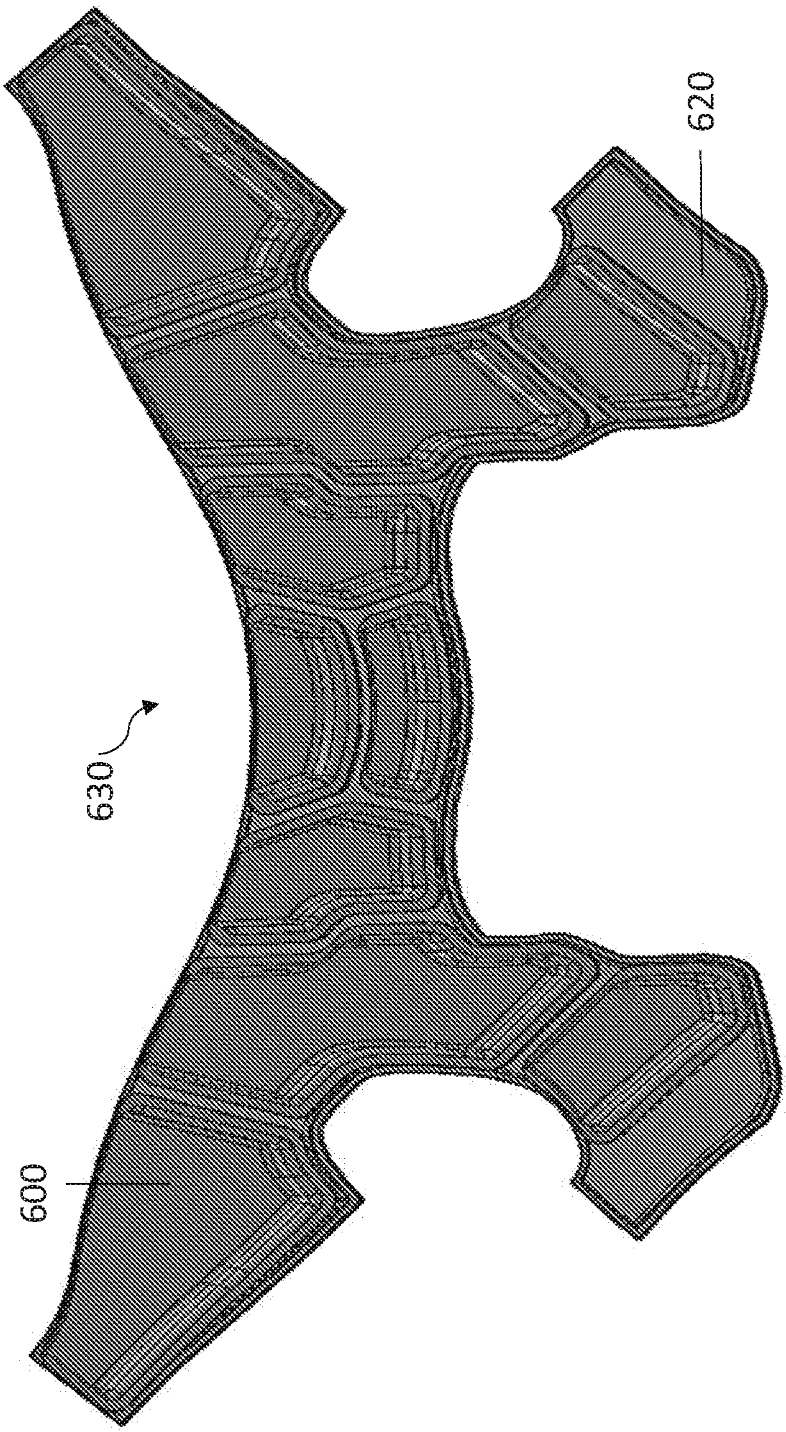


FIG. 12C

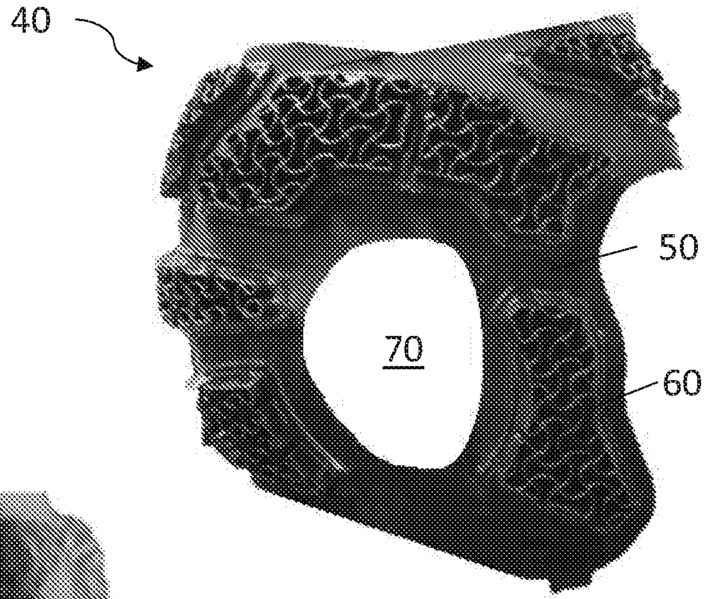


FIG. 13A

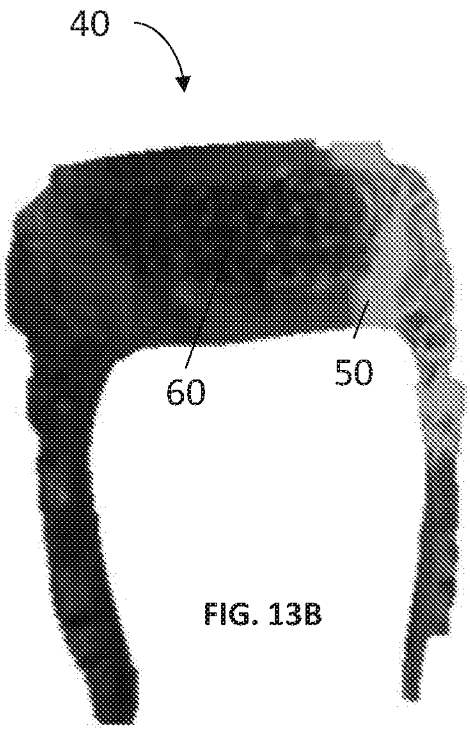


FIG. 13B

FIG. 13C

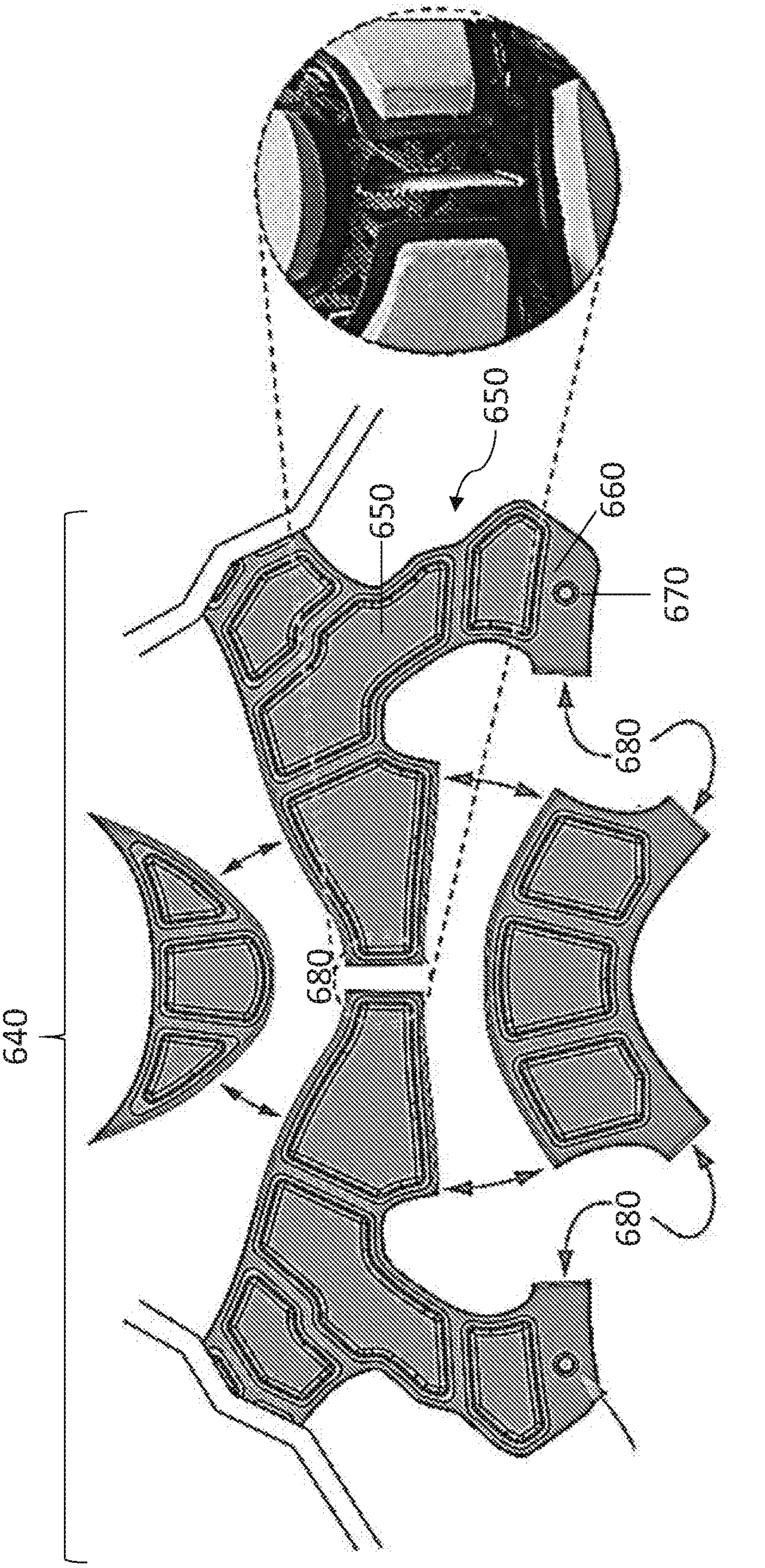


FIG. 14

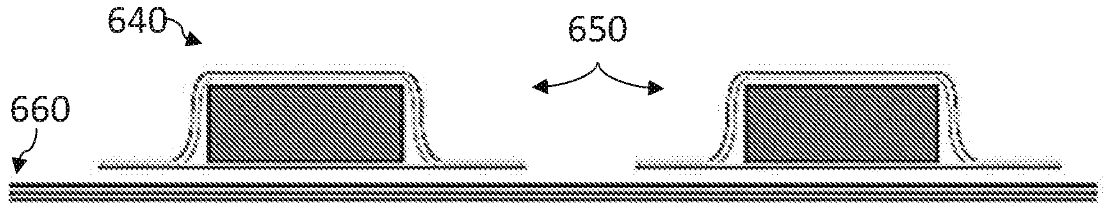


FIG. 15A

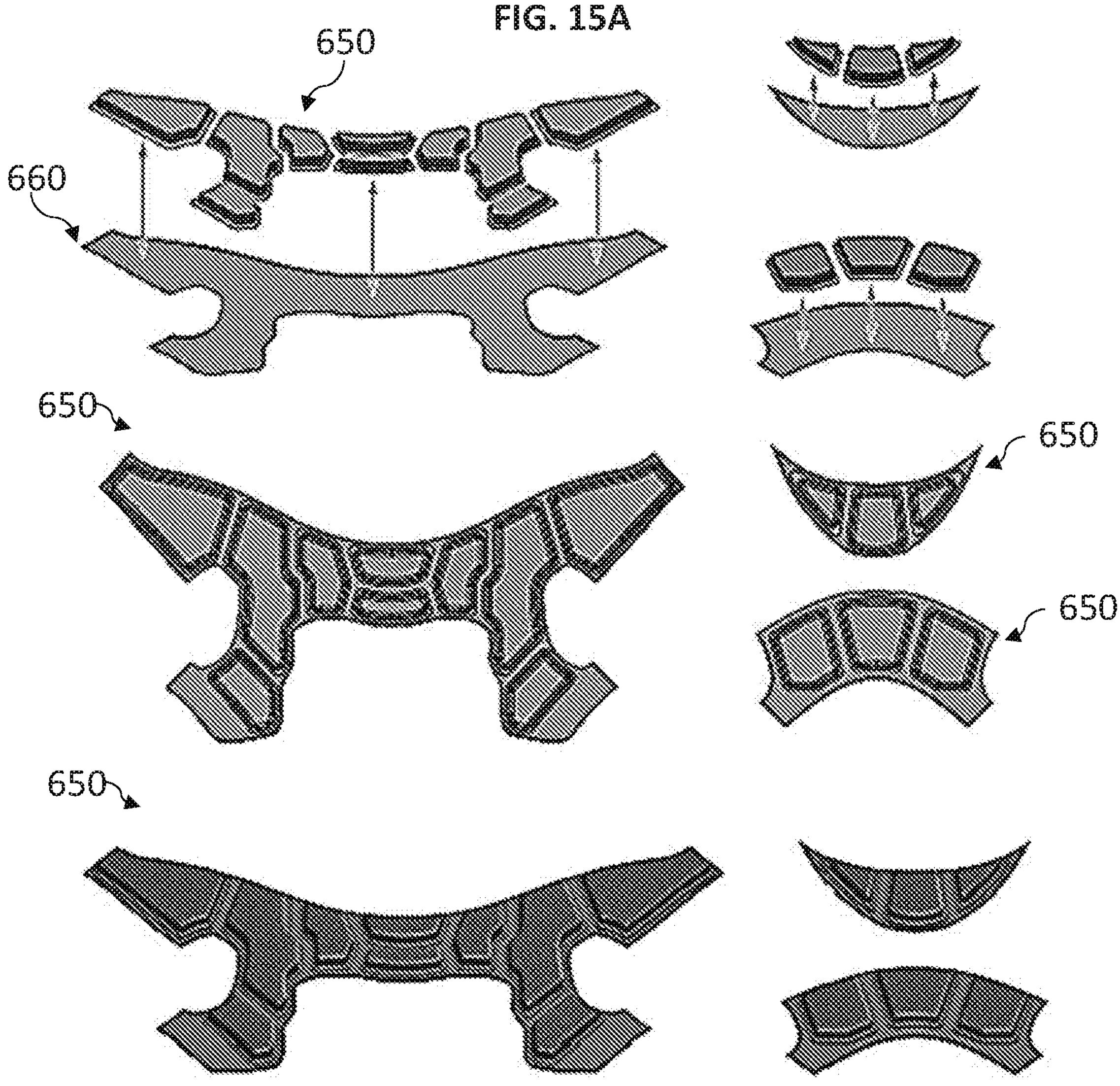


FIG. 15B

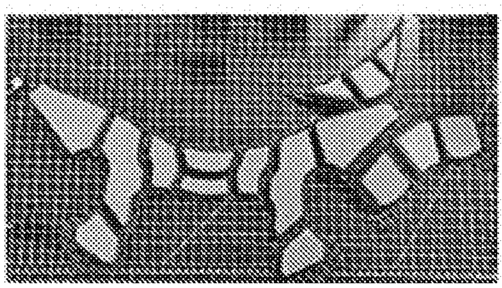


FIG. 15C

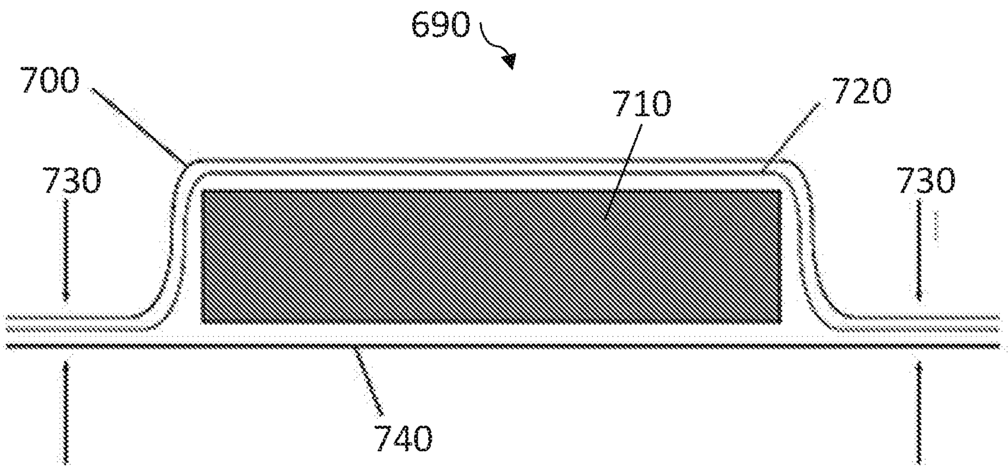


FIG. 16A

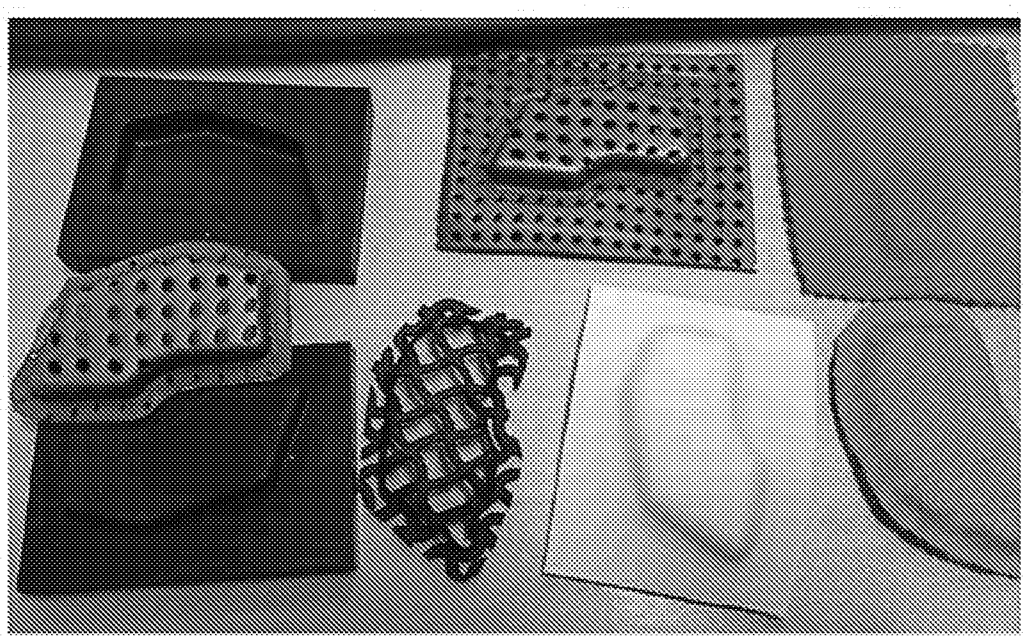


FIG. 16B

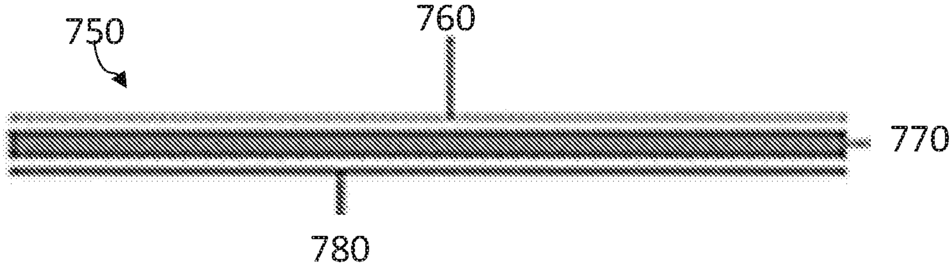


FIG. 17A

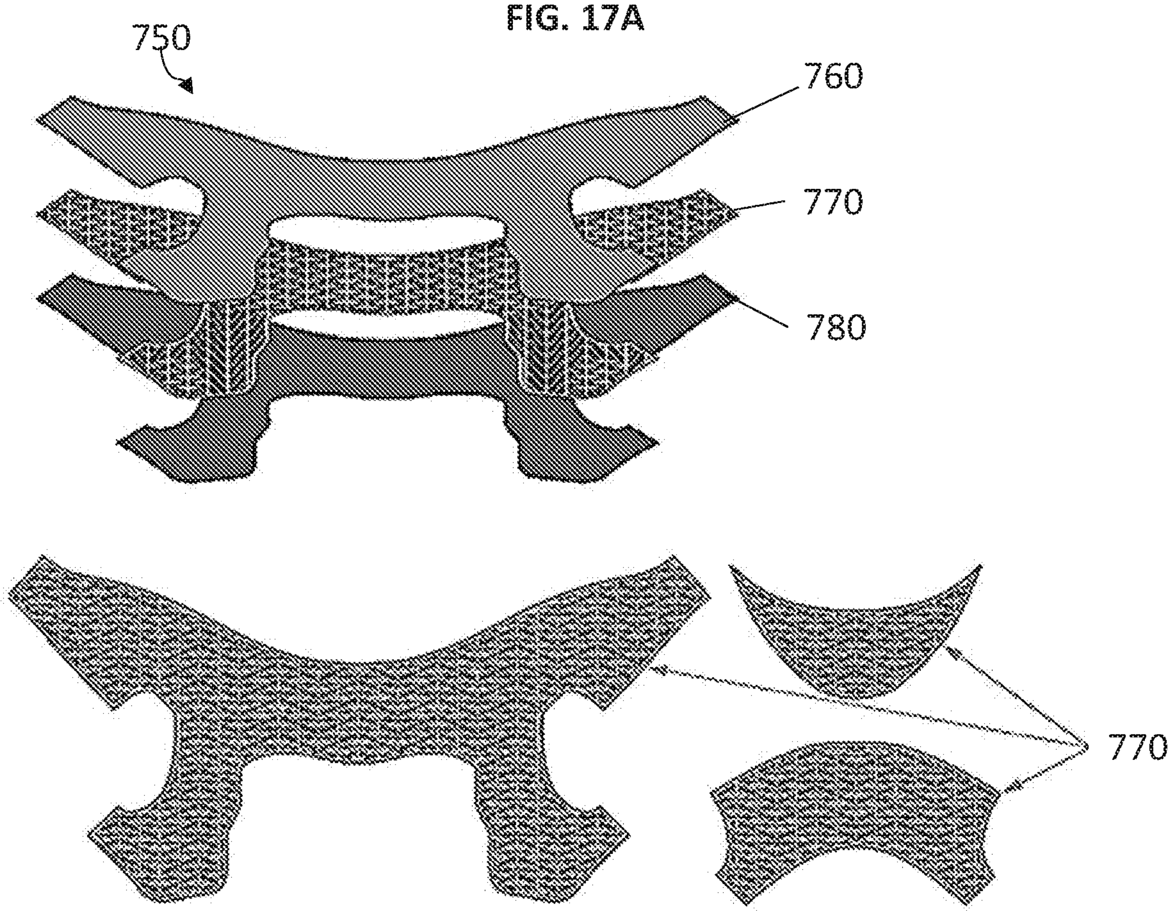


FIG. 17B

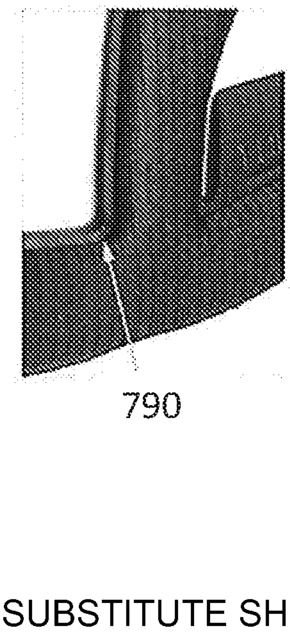


FIG. 17C

FIG. 18

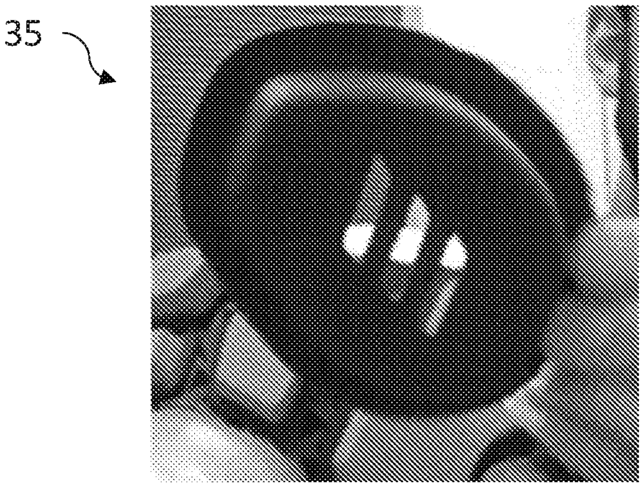


FIG. 19A

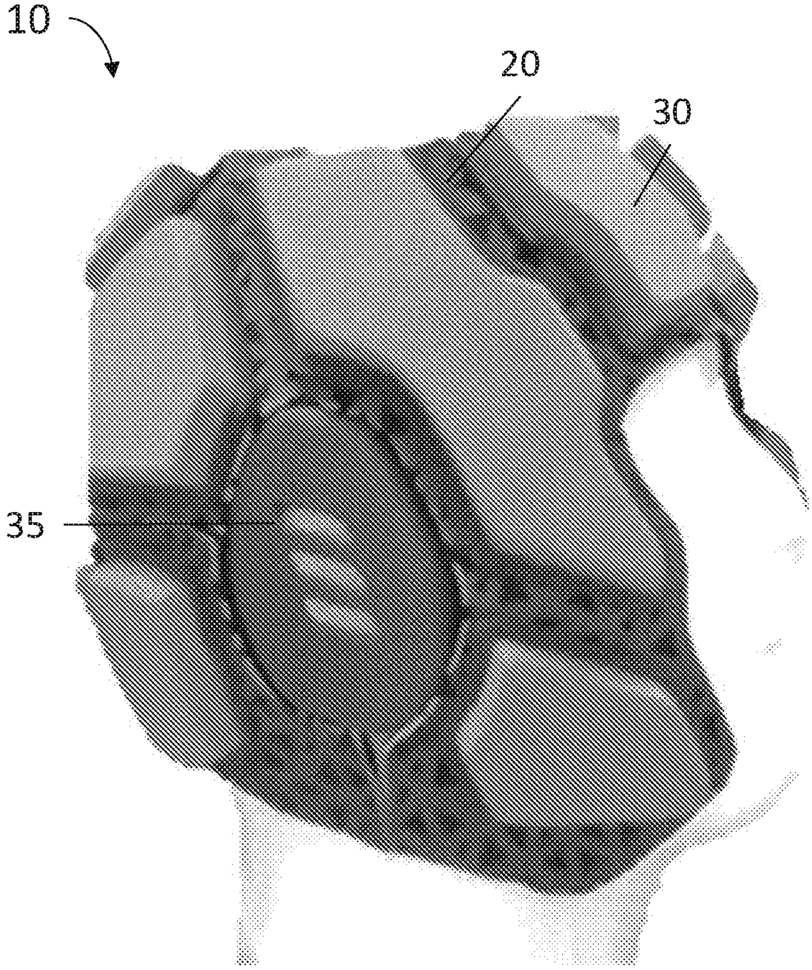


FIG. 19B

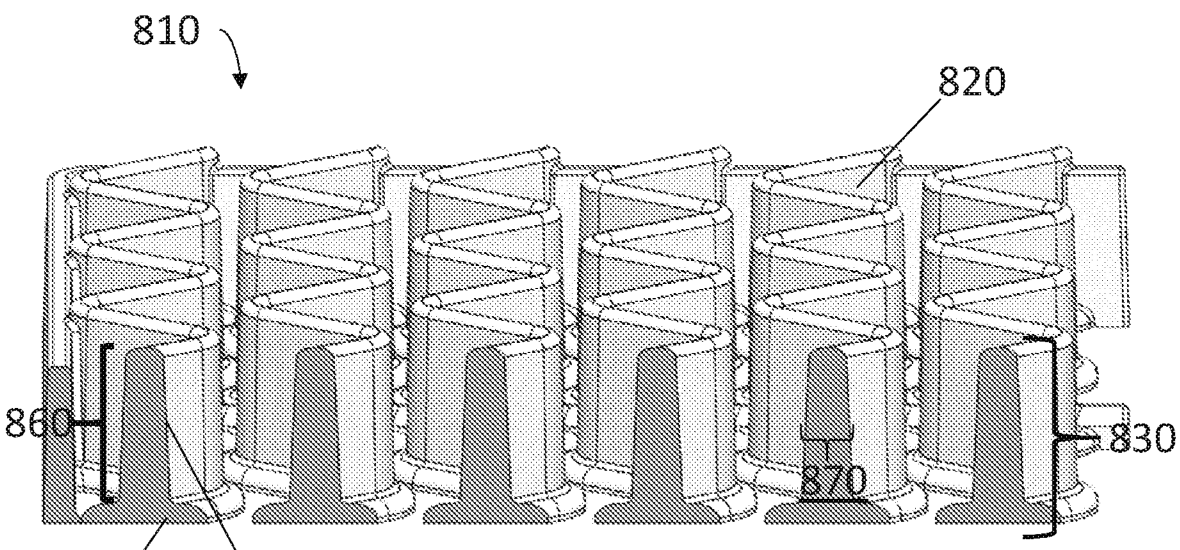


FIG. 20

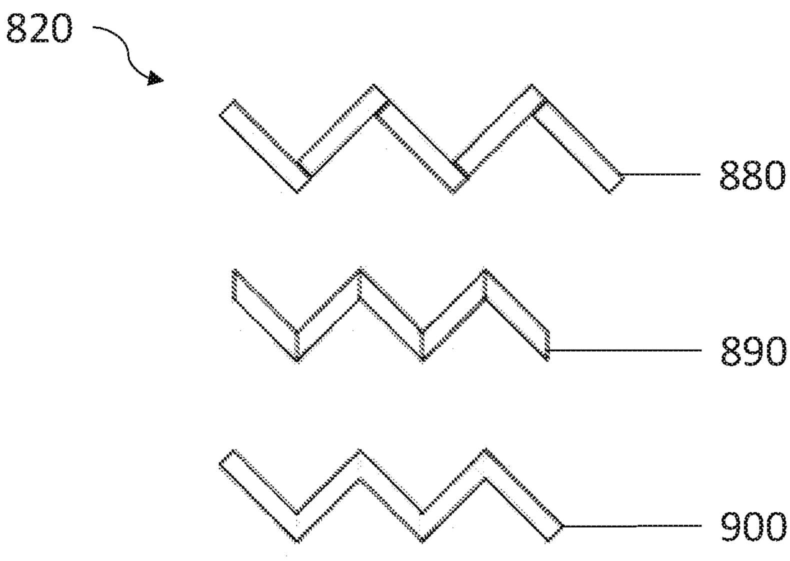


FIG. 21

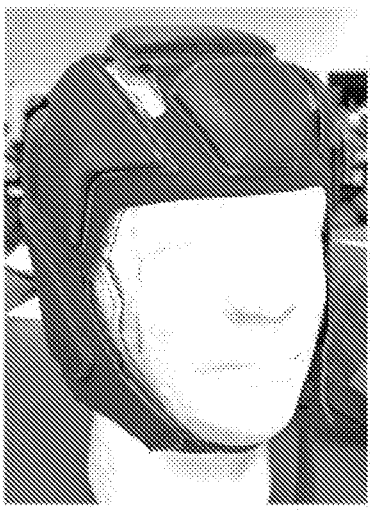


FIG. 22A

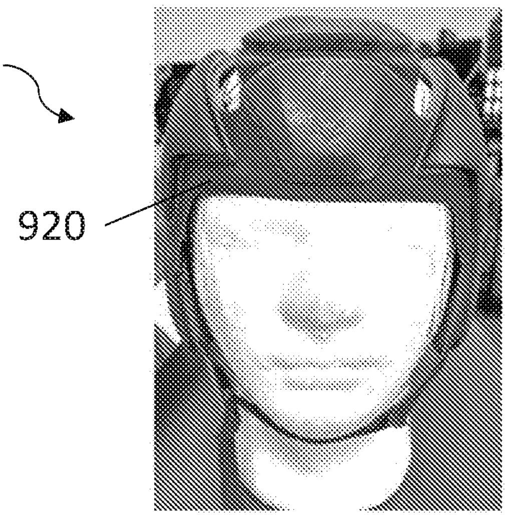


FIG. 22B

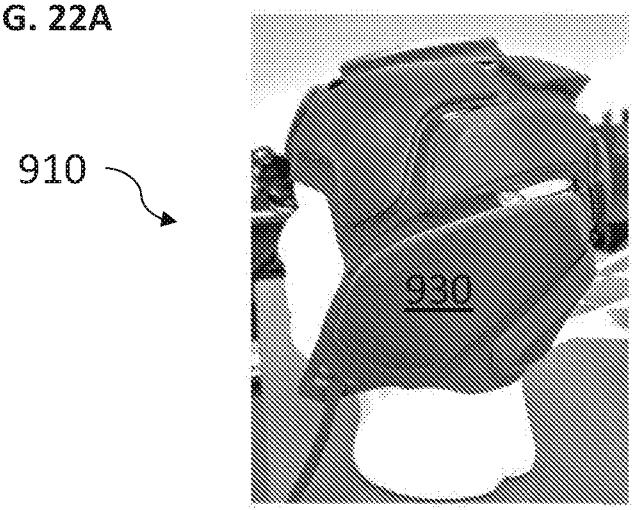


FIG. 22C

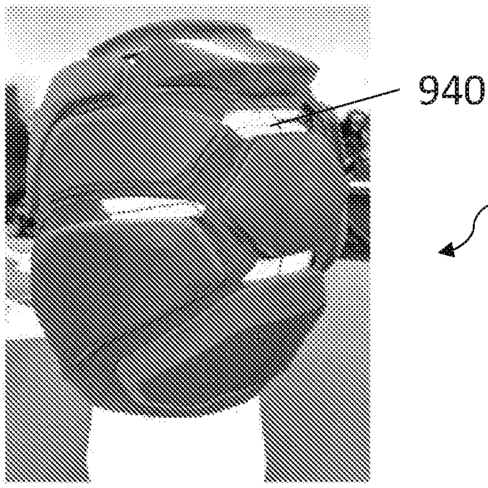


FIG. 22D

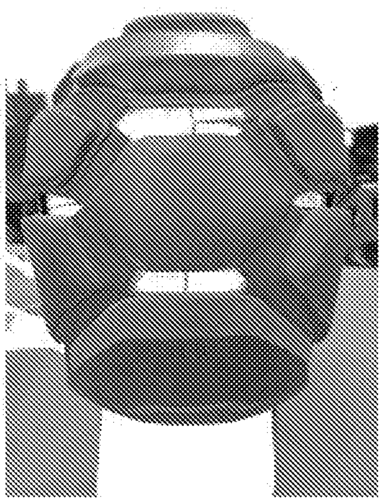


FIG. 22E

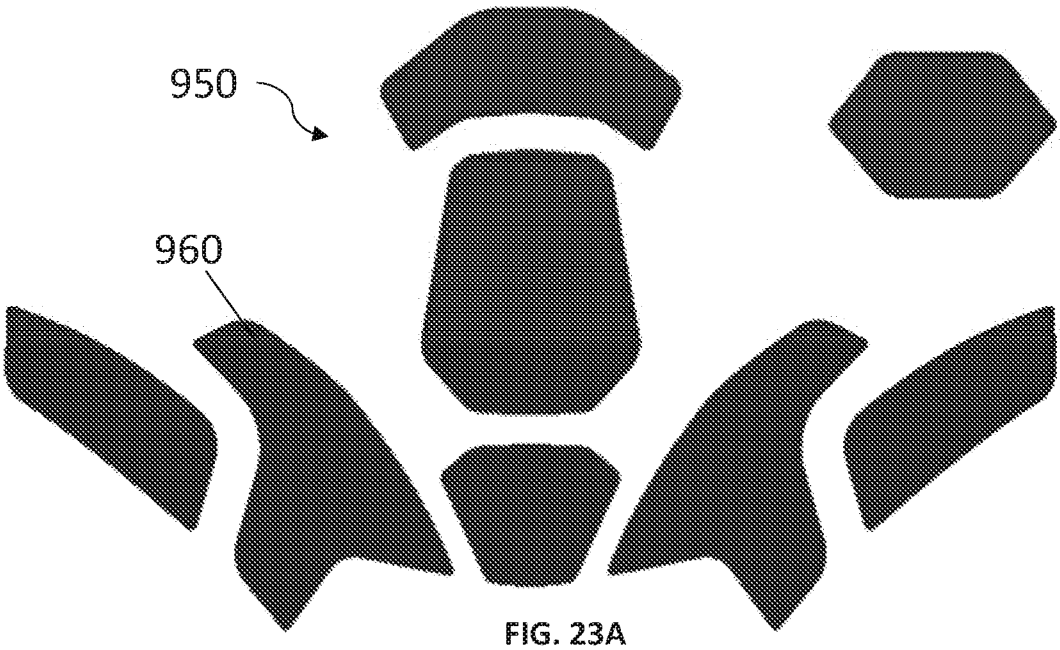


FIG. 23A

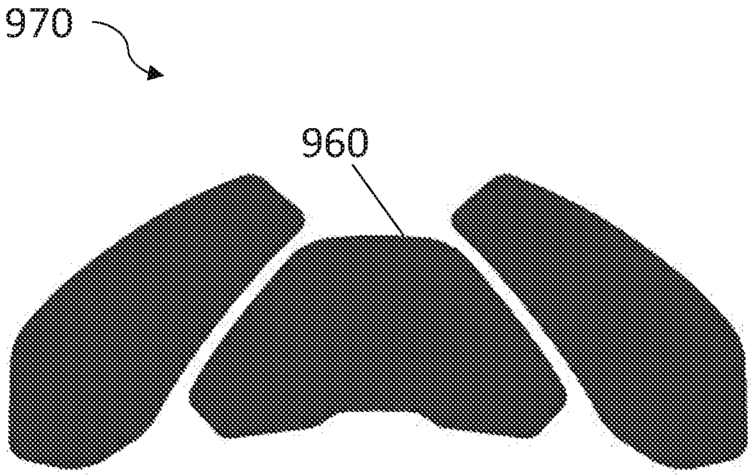


FIG. 23B

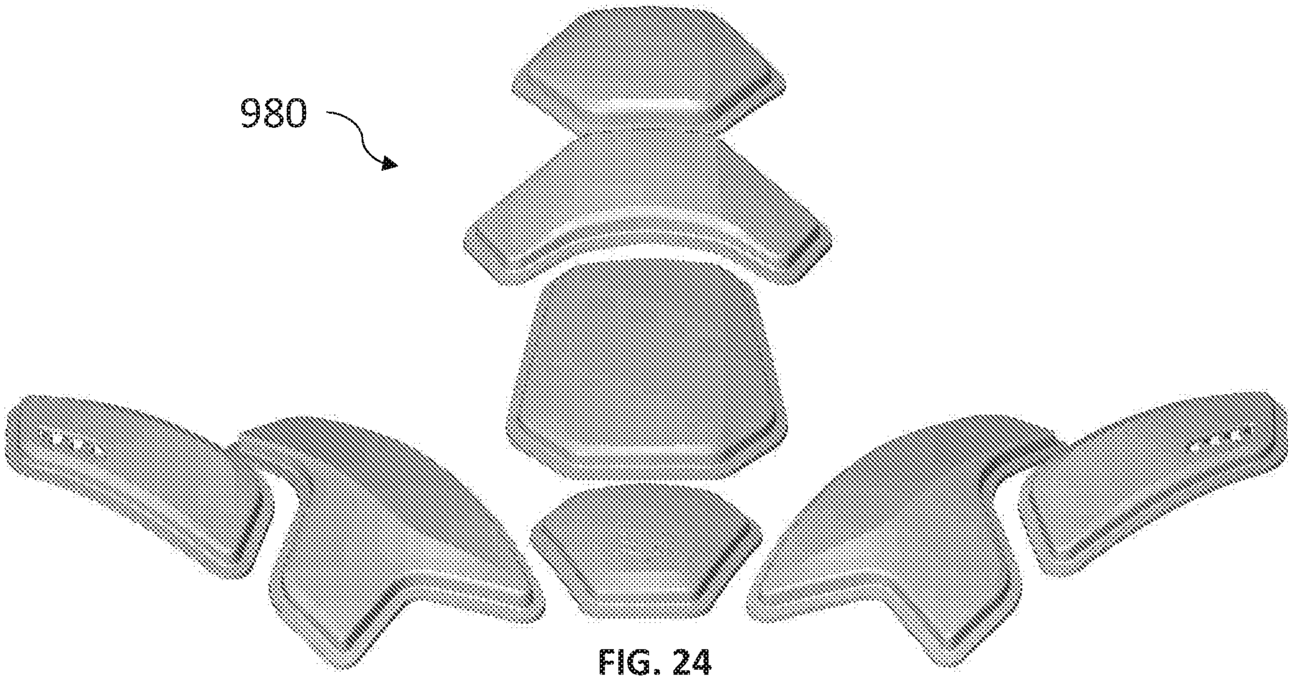


FIG. 24

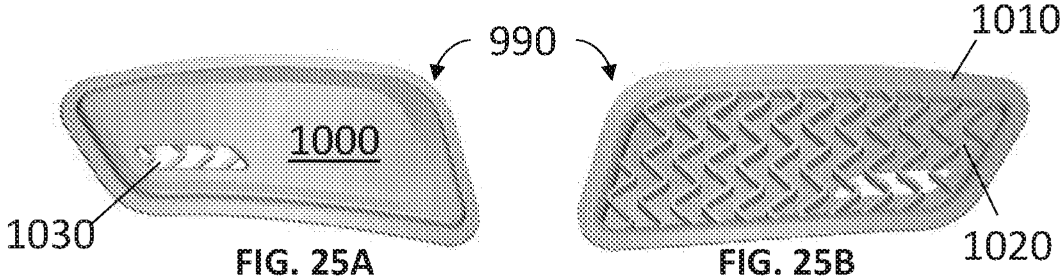


FIG. 25A

FIG. 25B

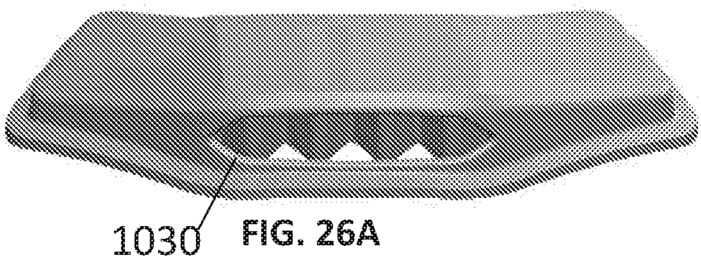


FIG. 26A

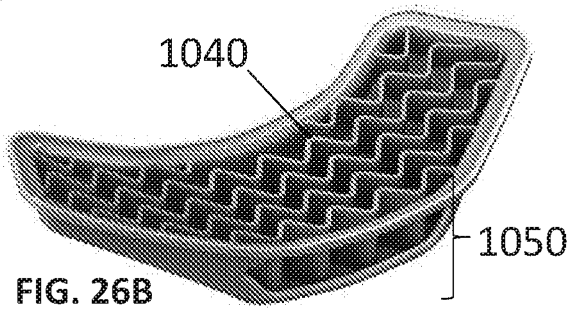


FIG. 26B

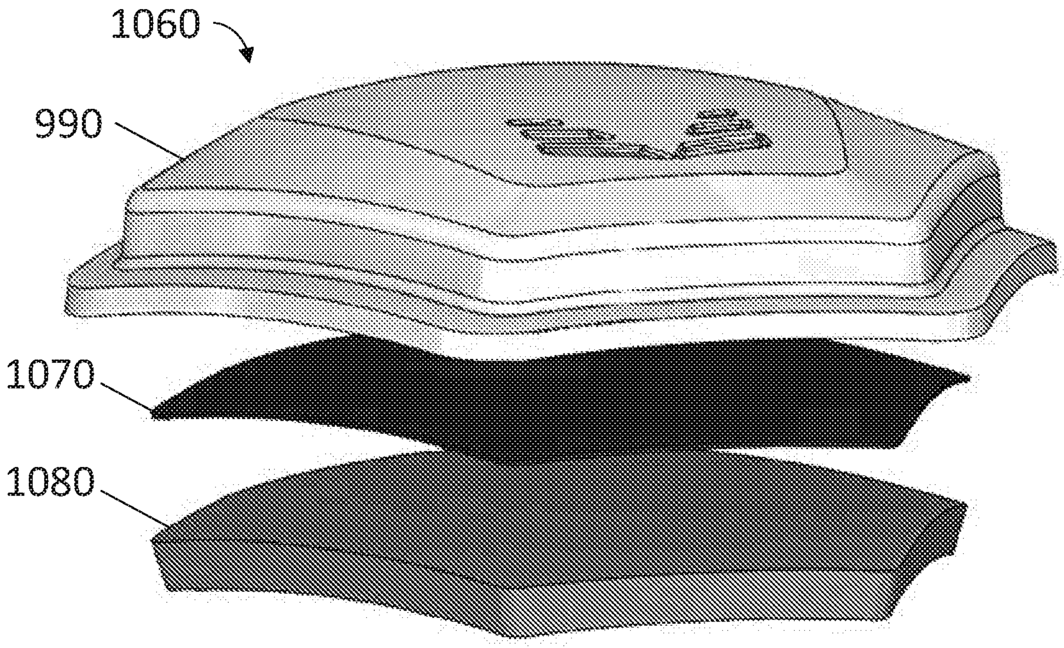


FIG. 27A

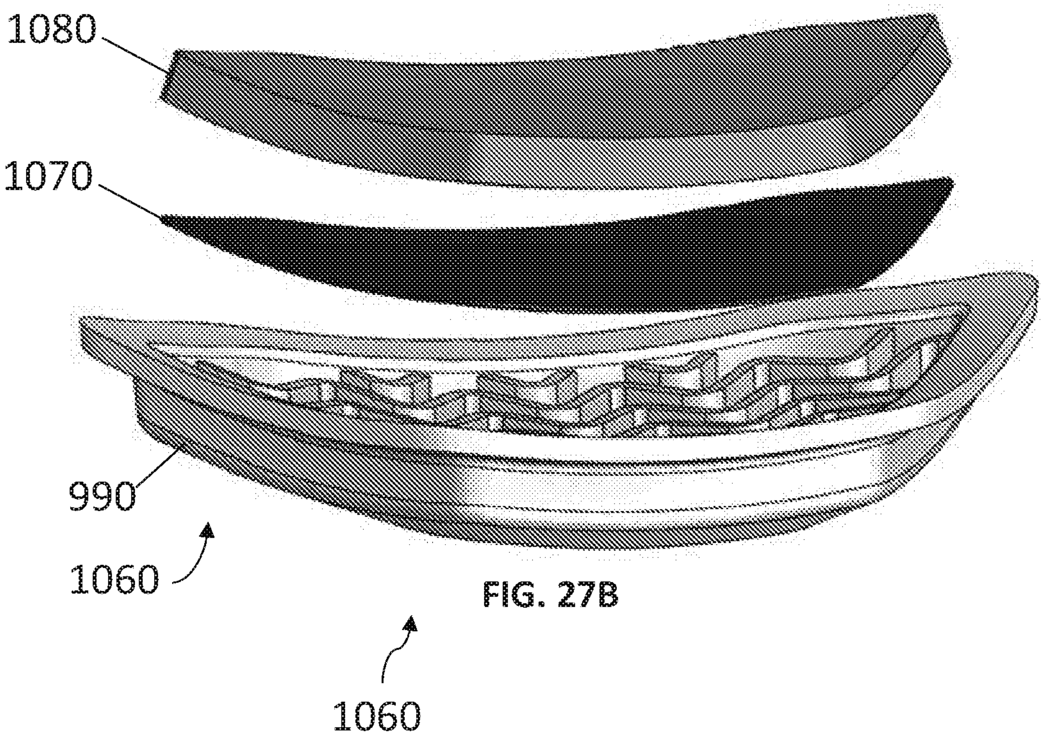


FIG. 27B

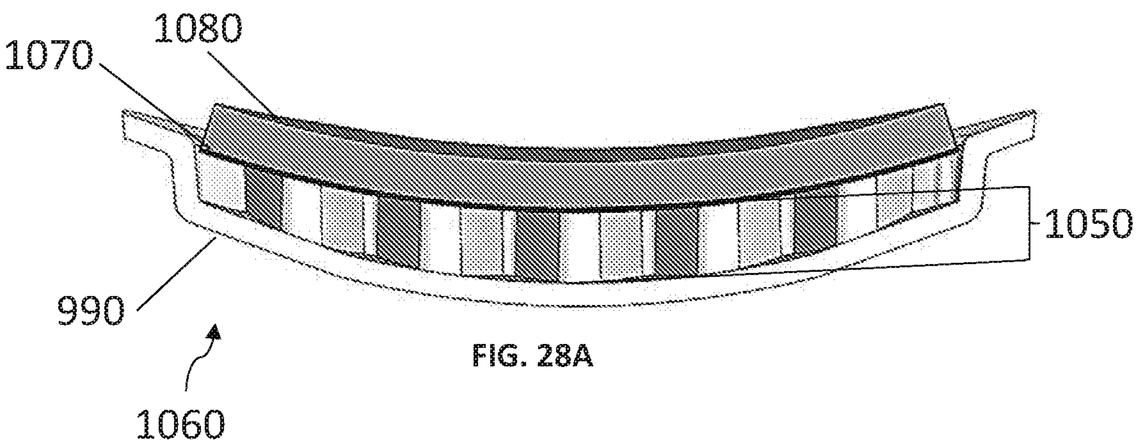


FIG. 28A

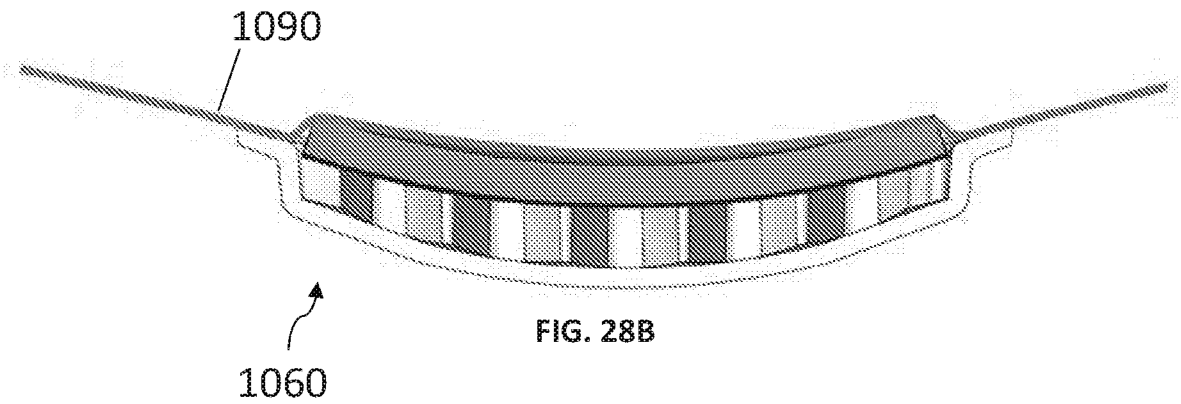


FIG. 28B

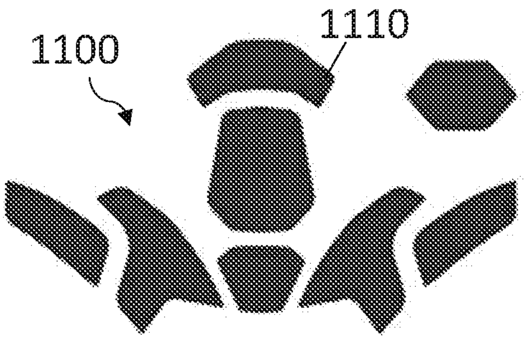


FIG. 29A

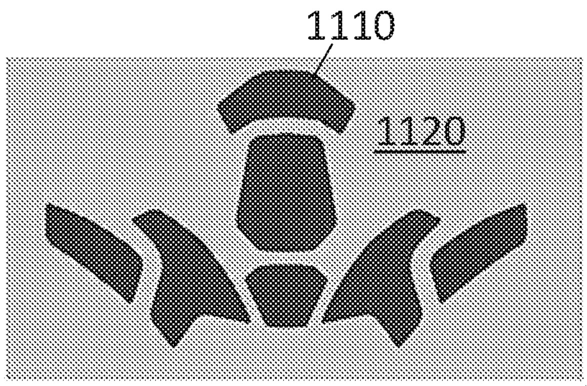


FIG. 29B

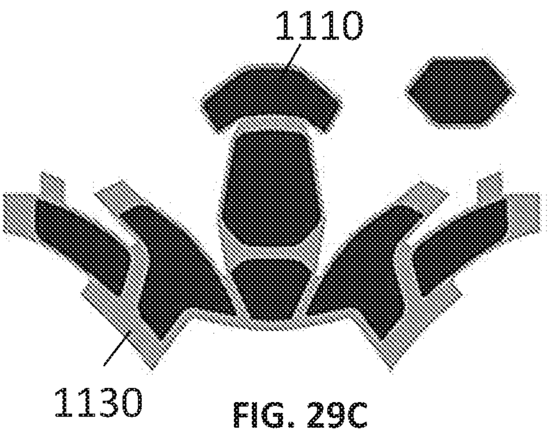


FIG. 29C

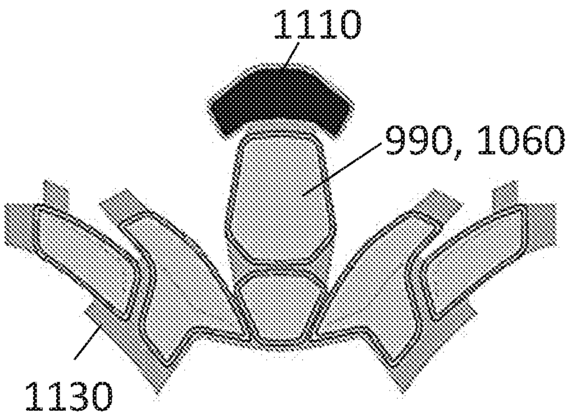


FIG. 29D

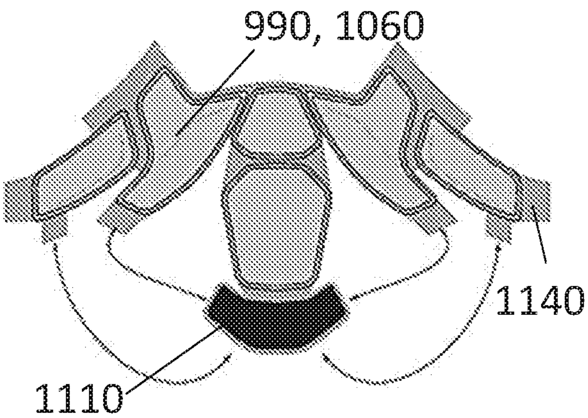


FIG. 29E

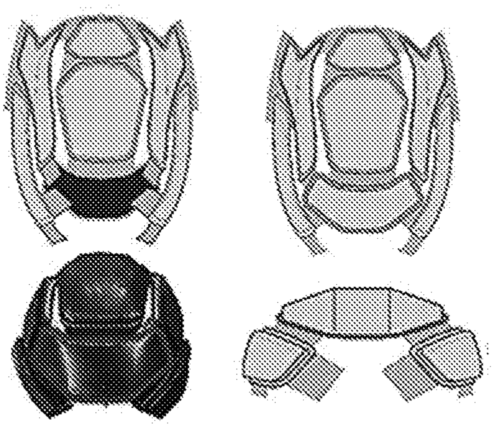


FIG. 29F

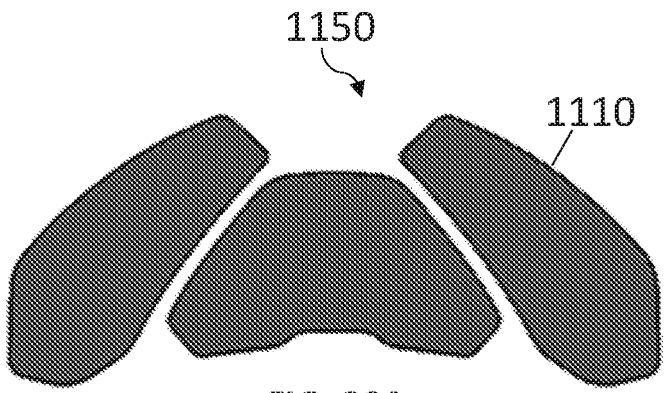


FIG. 30A

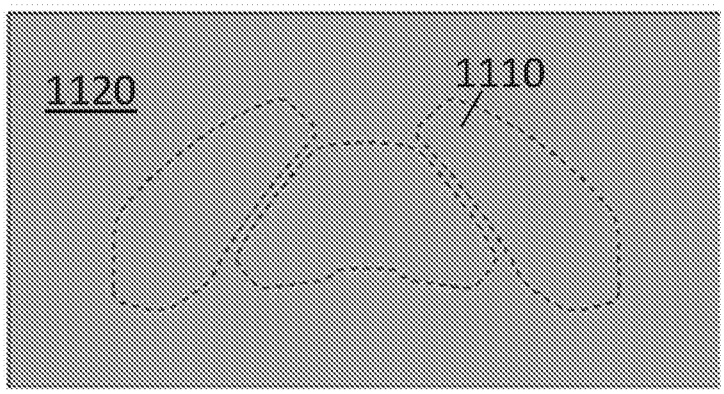


FIG. 30B

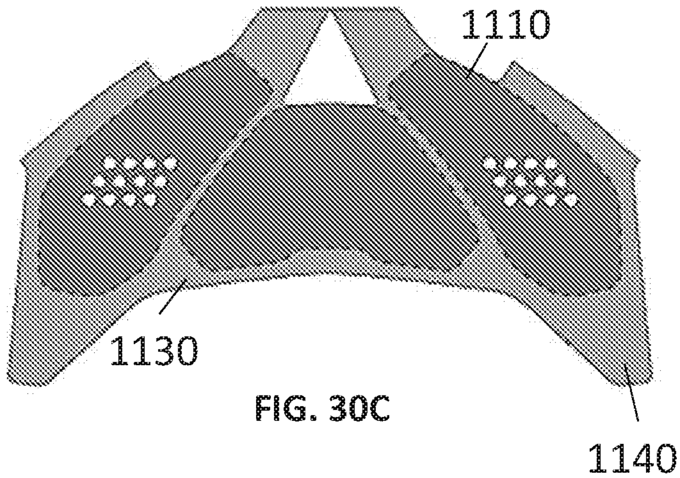


FIG. 30C

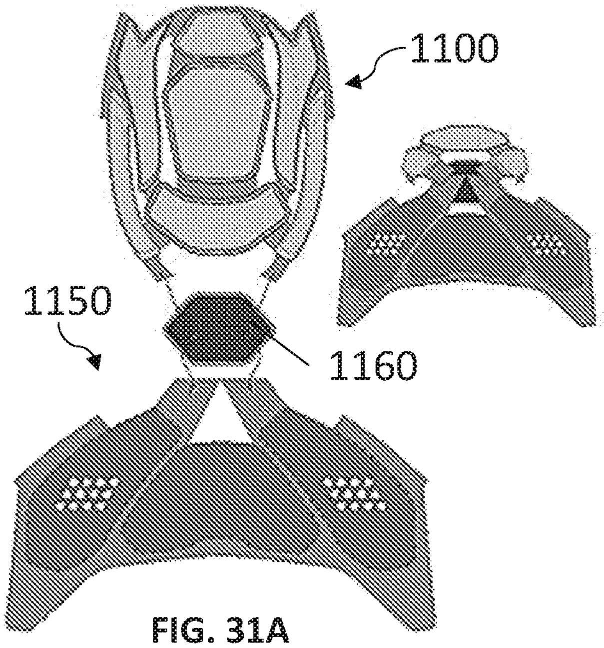


FIG. 31A

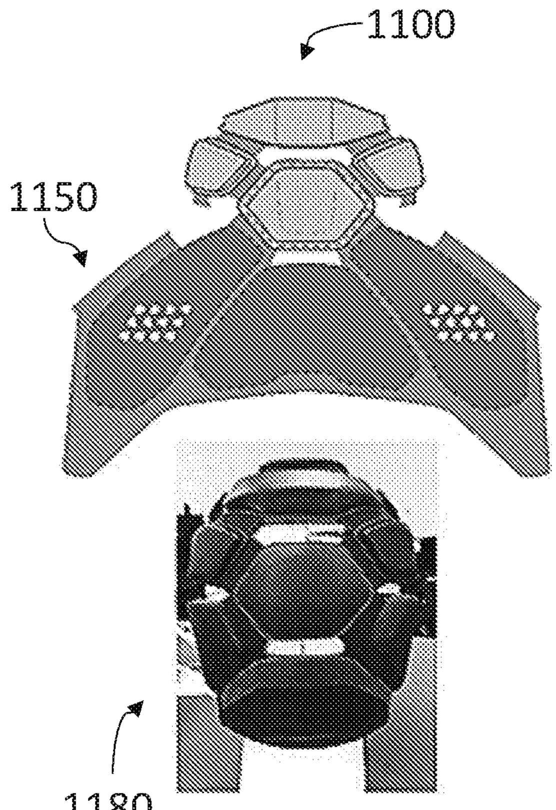


FIG. 31B

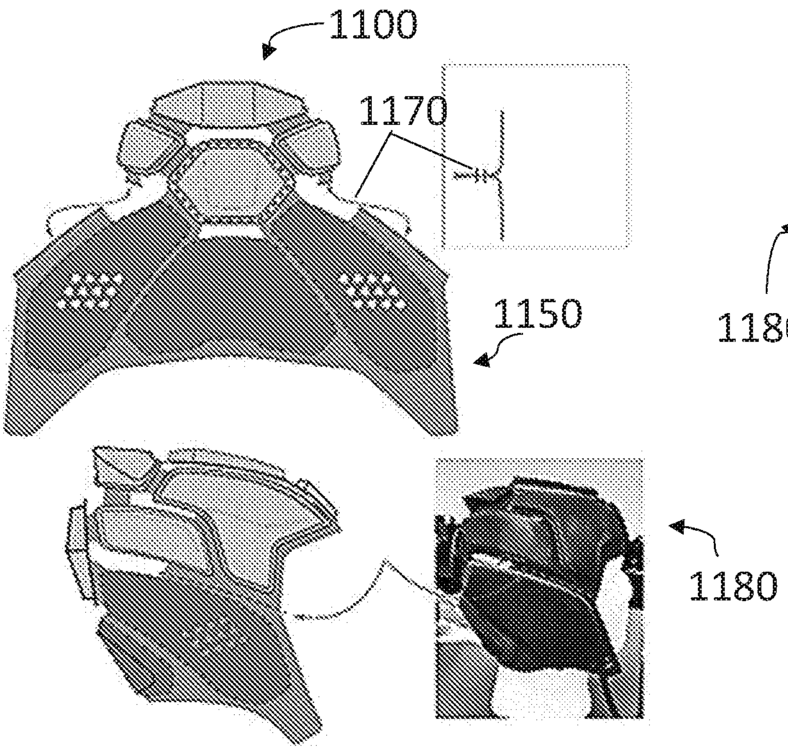


FIG. 31C

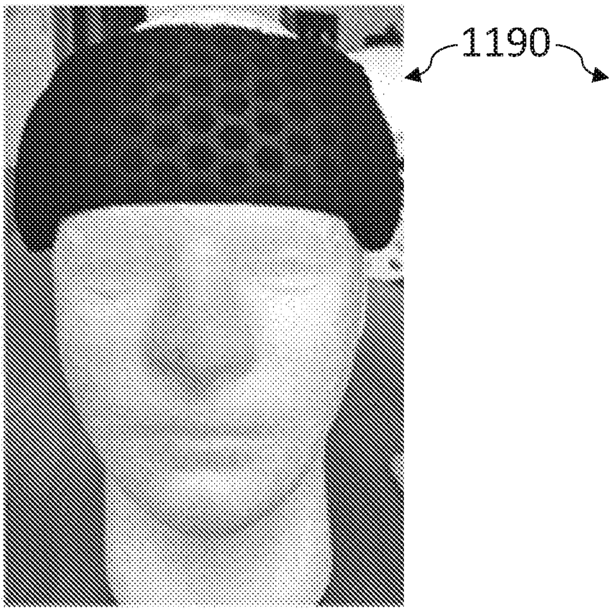


FIG. 32A

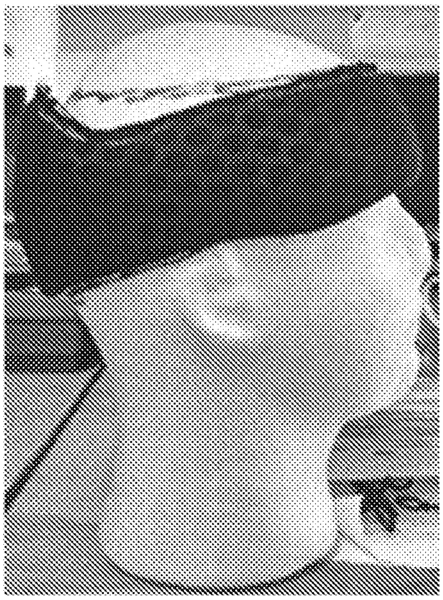


FIG. 32B

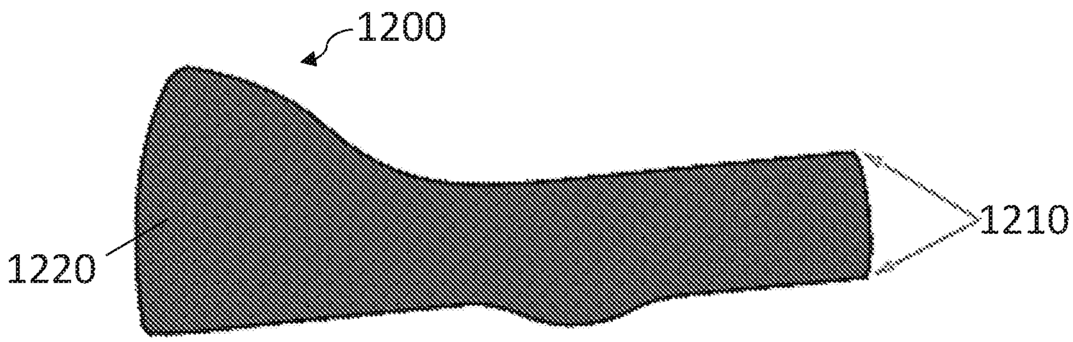


FIG. 33A

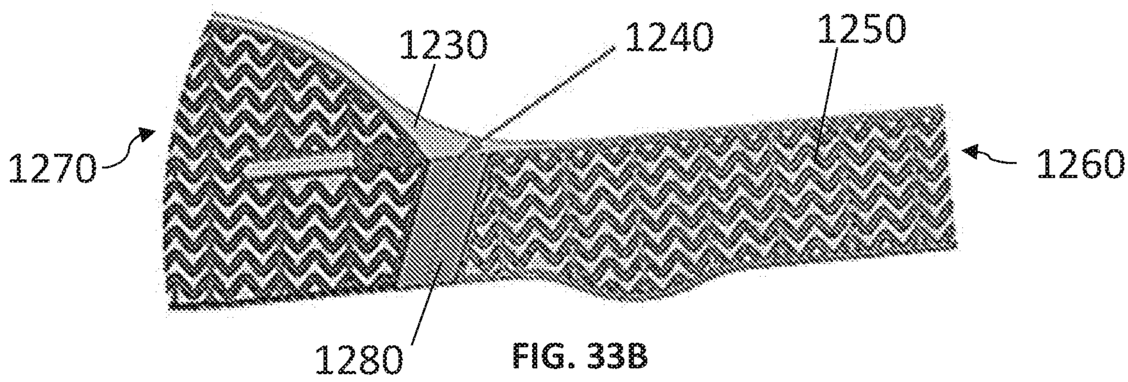


FIG. 33B

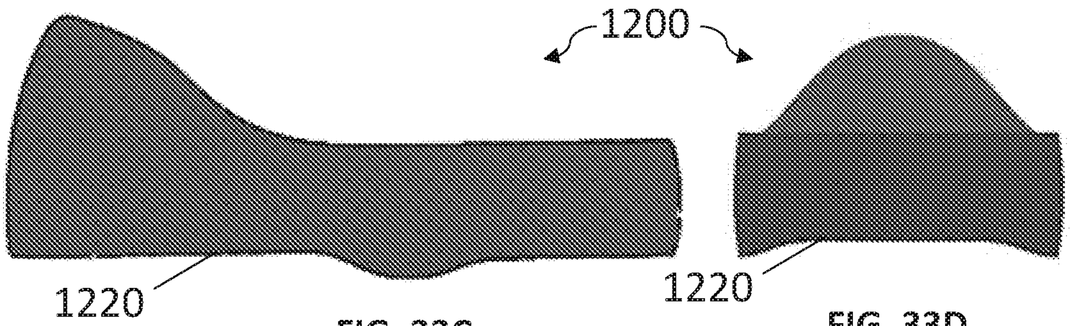


FIG. 33C

FIG. 33D

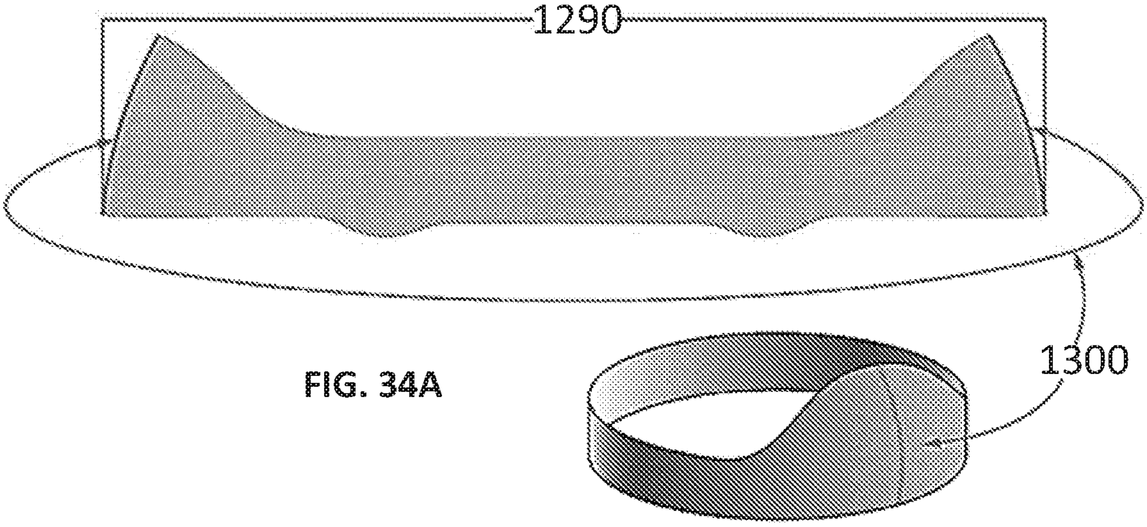


FIG. 34A

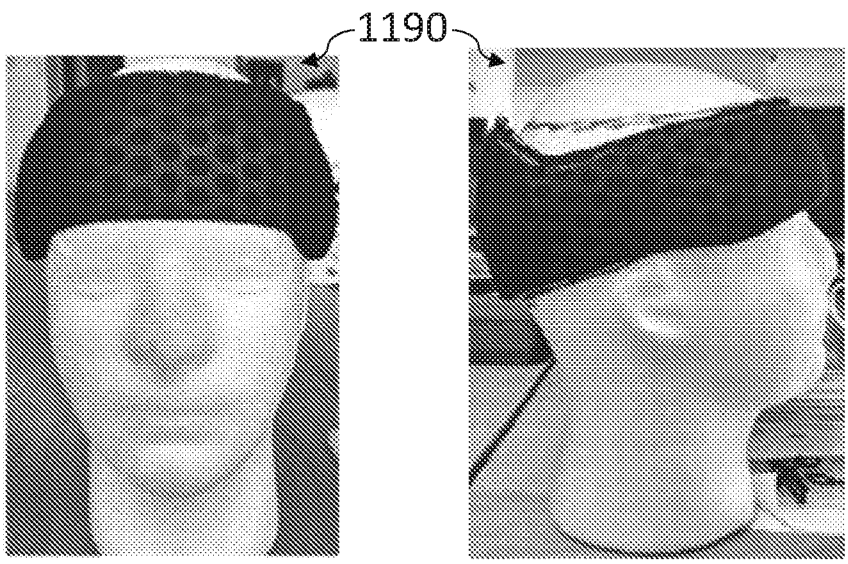


FIG. 34B

FIG. 34C

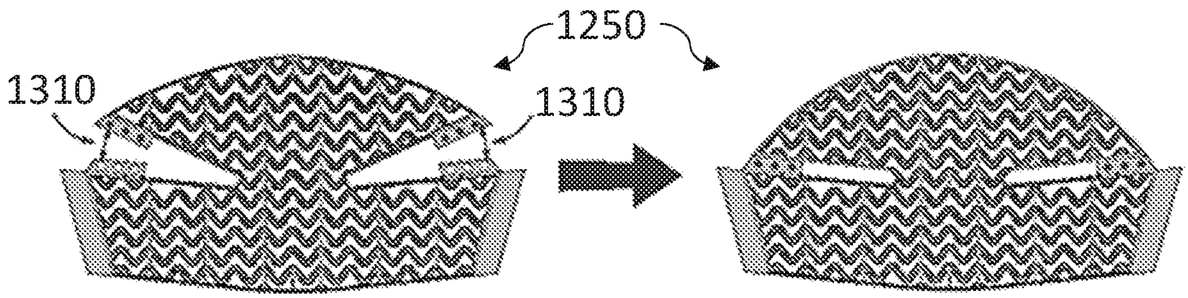


FIG. 35A

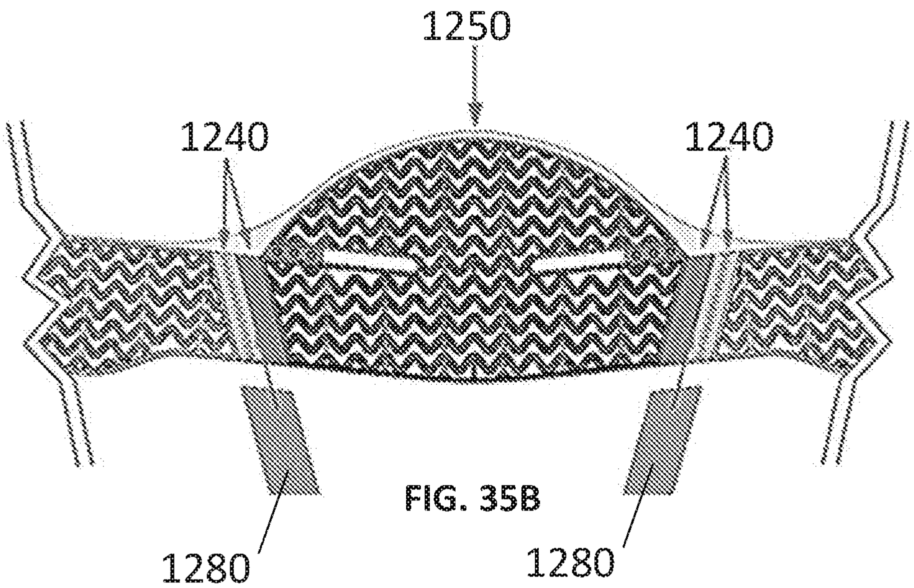


FIG. 35B

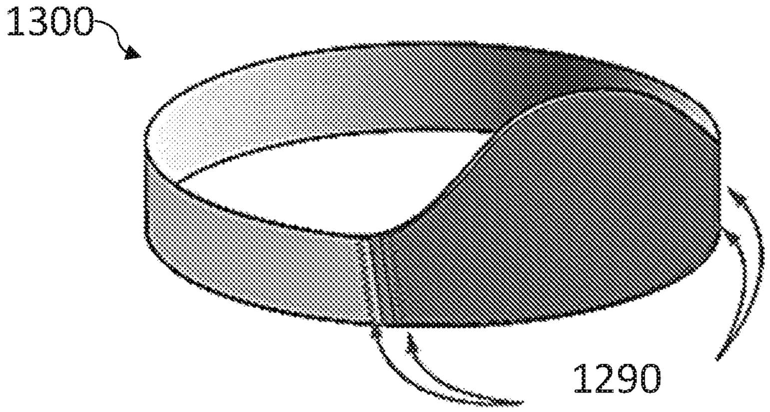


FIG. 35C

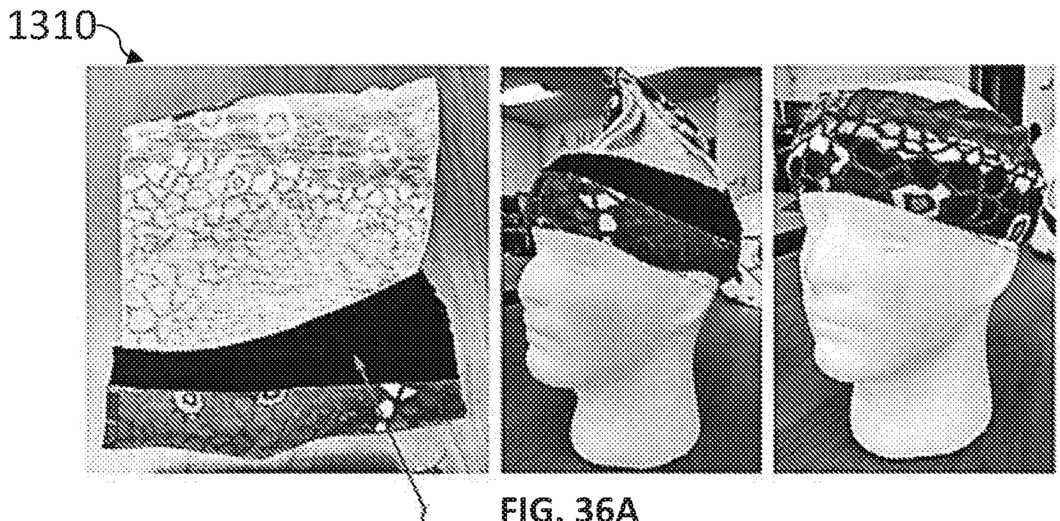


FIG. 36A

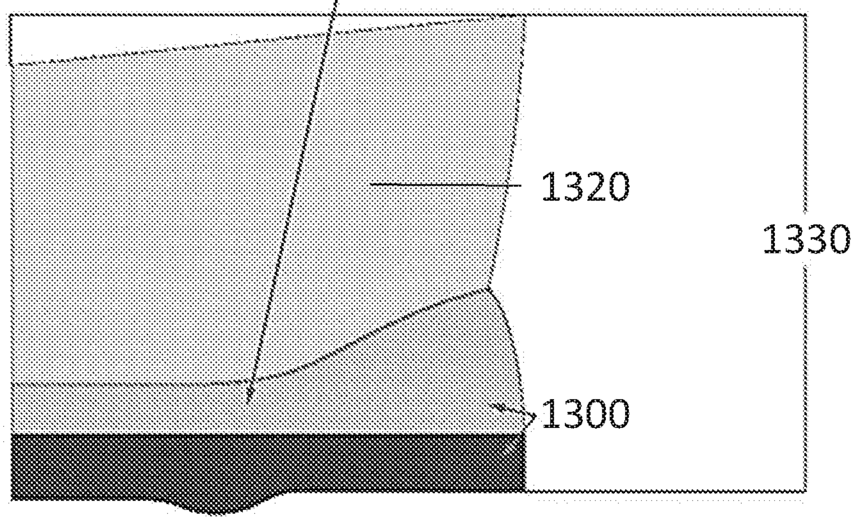


FIG. 36B

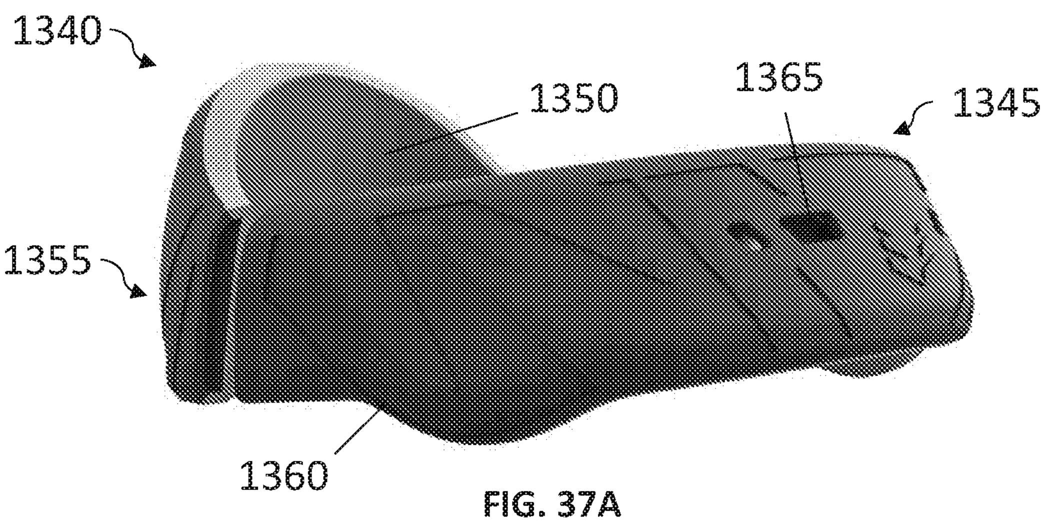


FIG. 37A

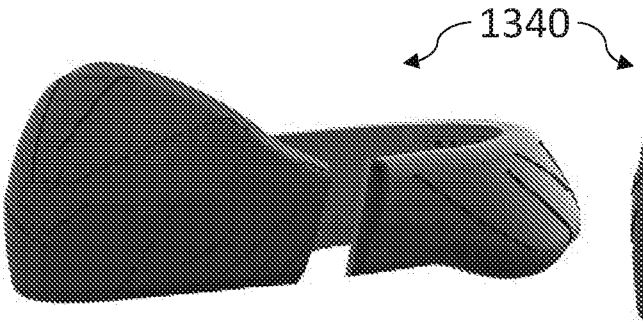


FIG. 37B

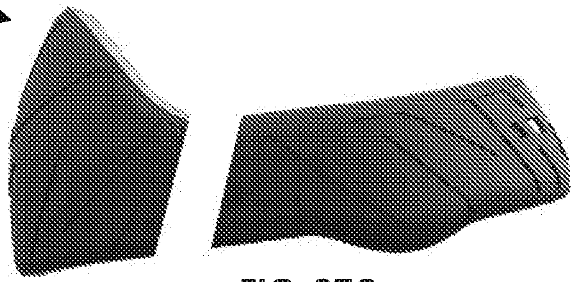


FIG. 37C

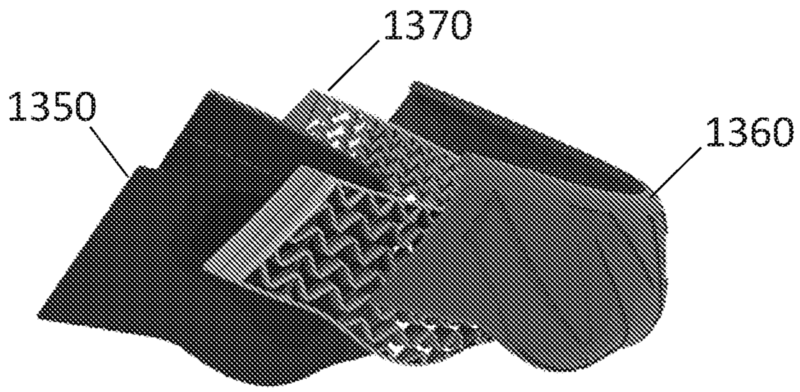


FIG. 37D

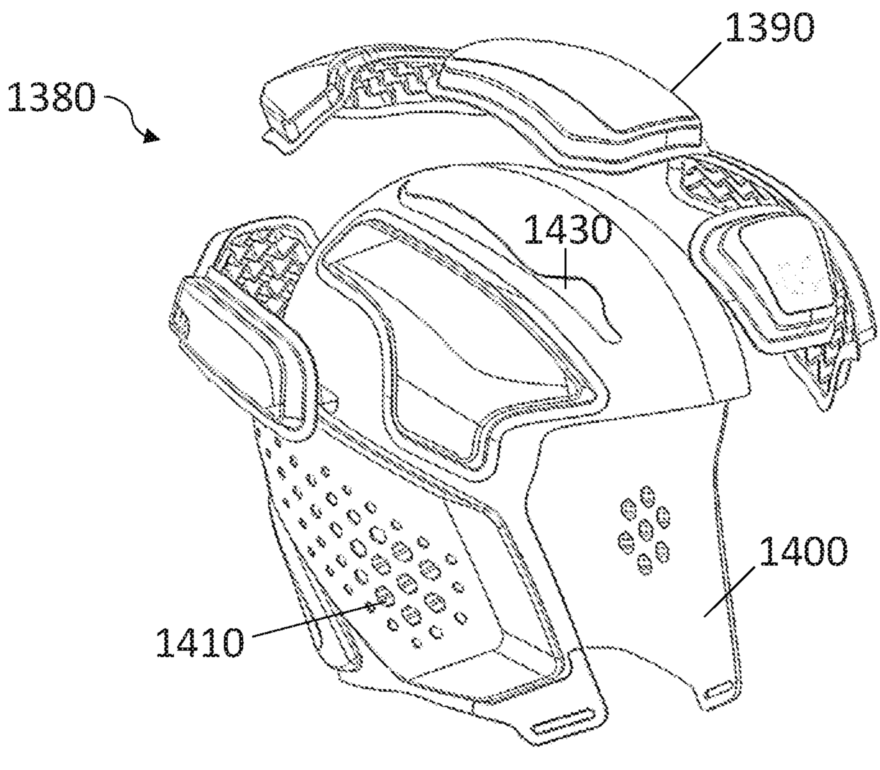


FIG. 38A

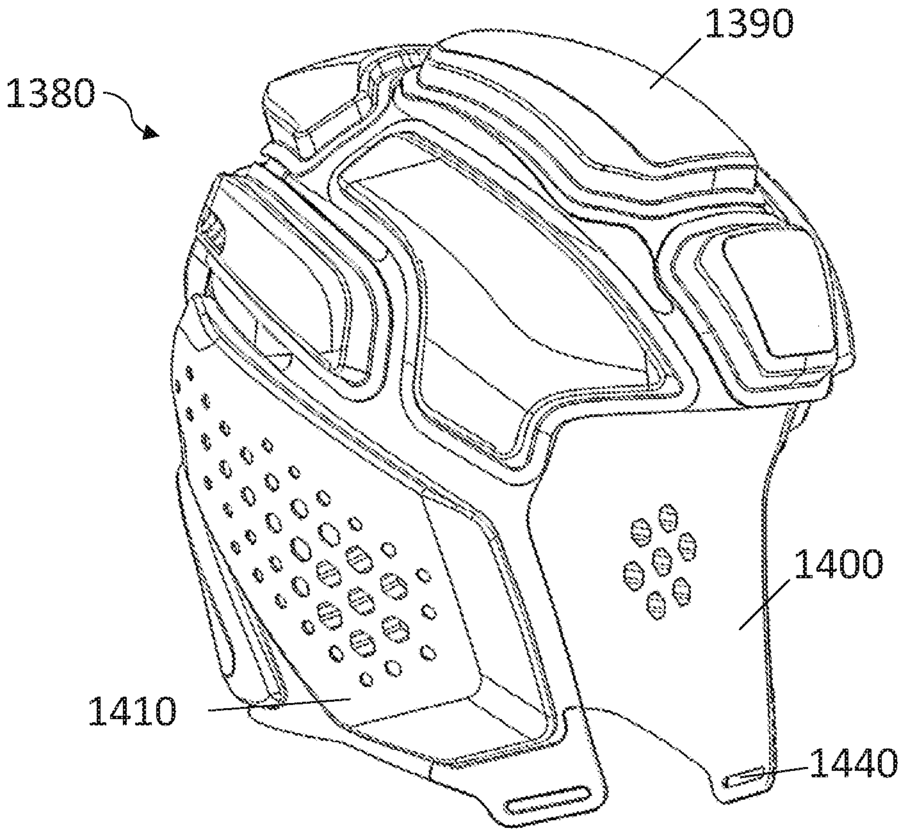


FIG. 38B

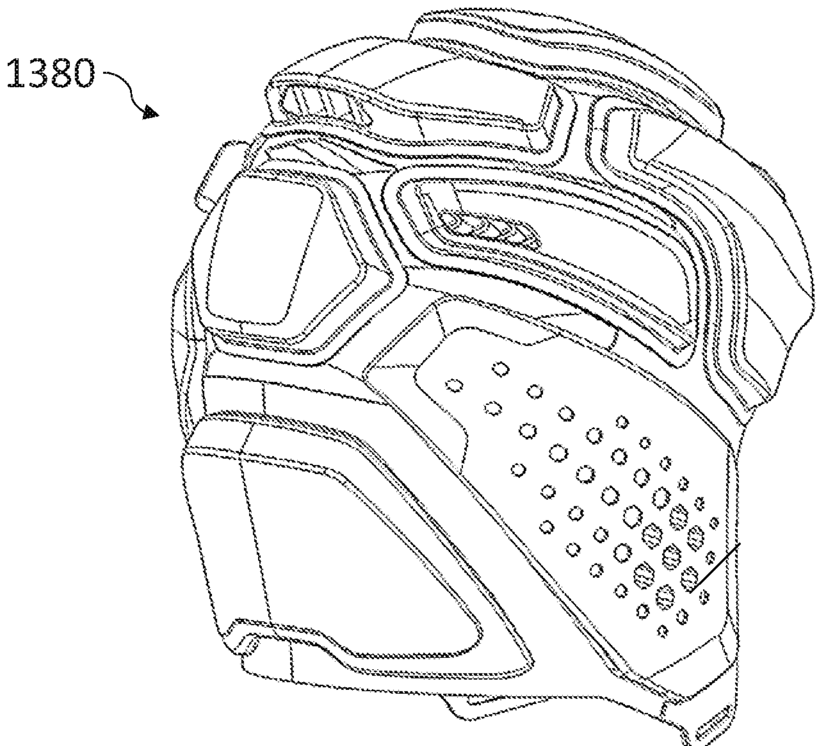


FIG. 38C

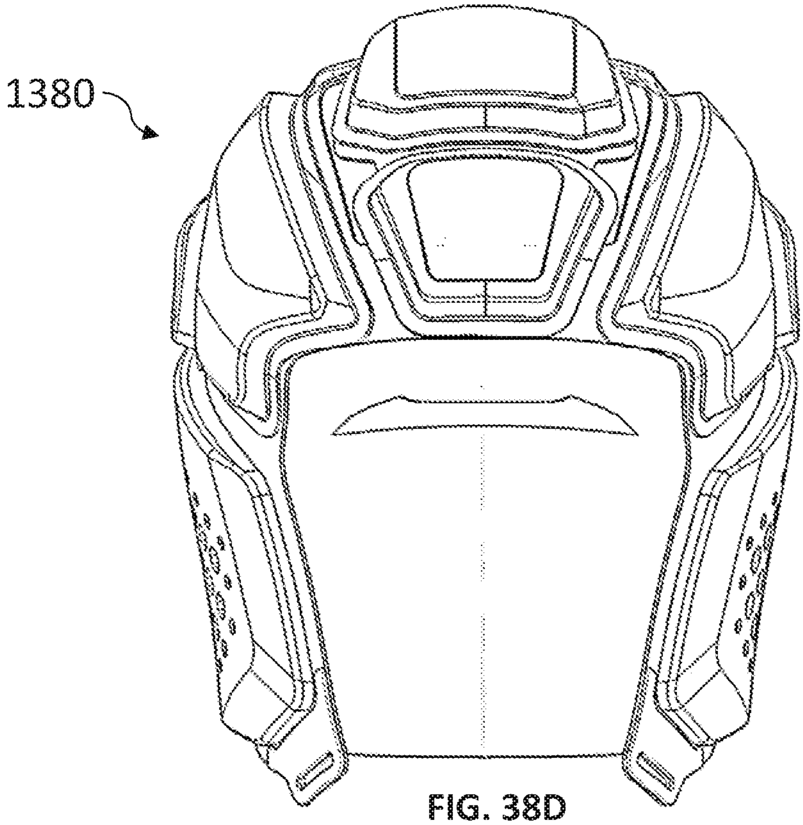


FIG. 38D

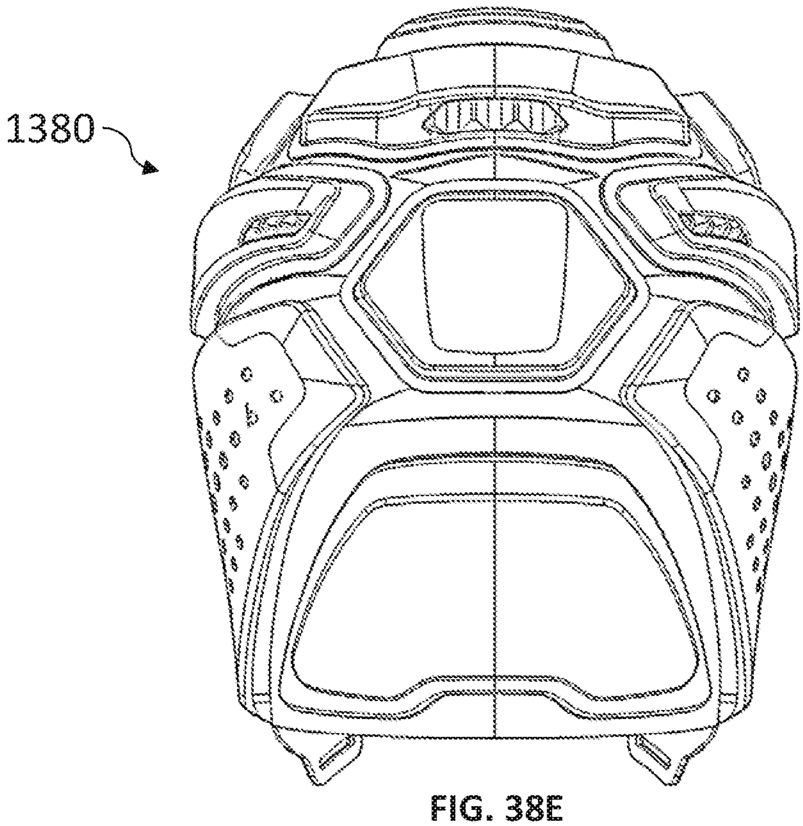


FIG. 38E

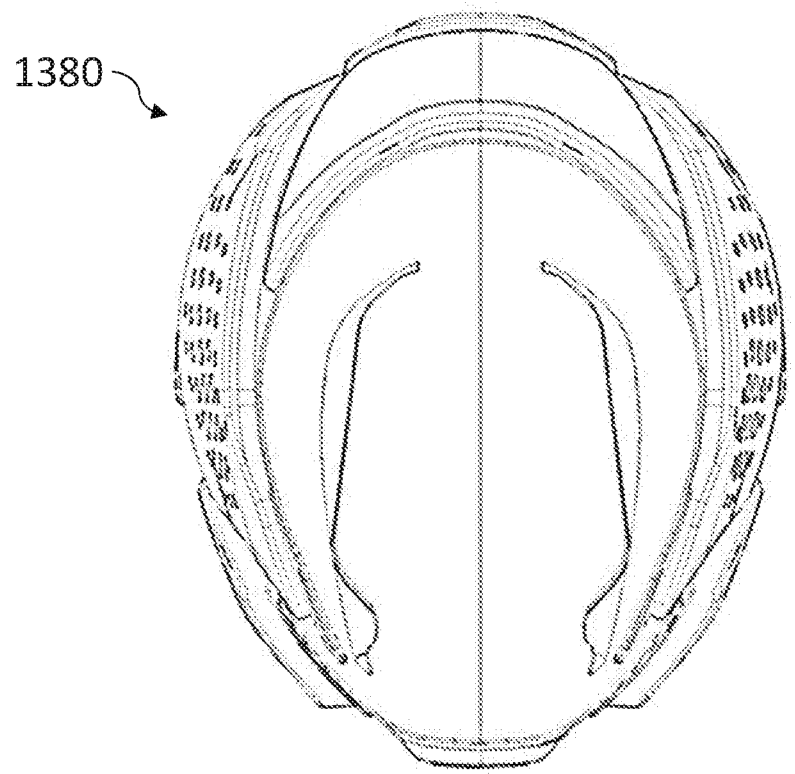


FIG. 38F

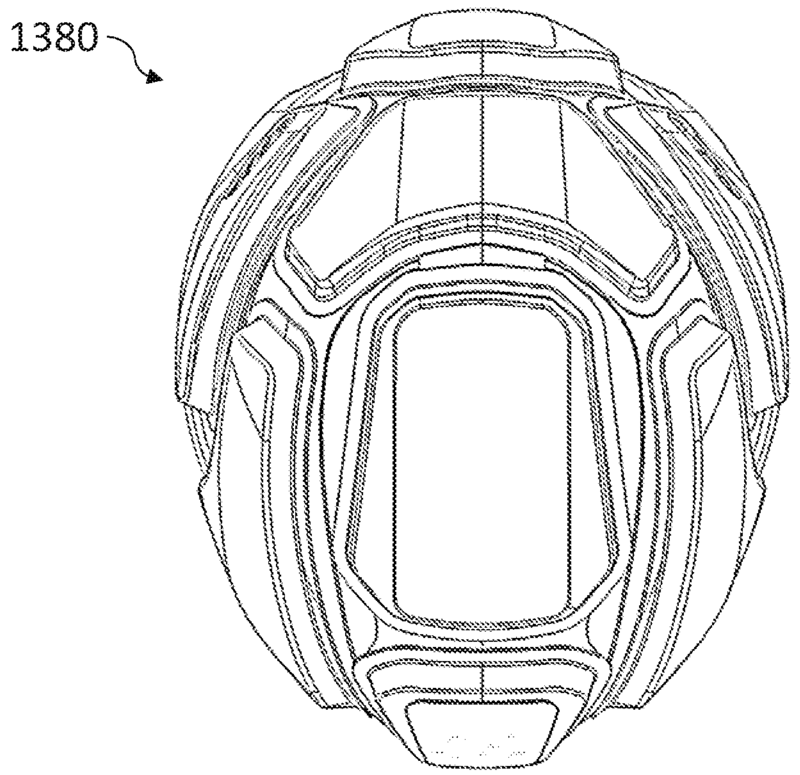


FIG. 38G

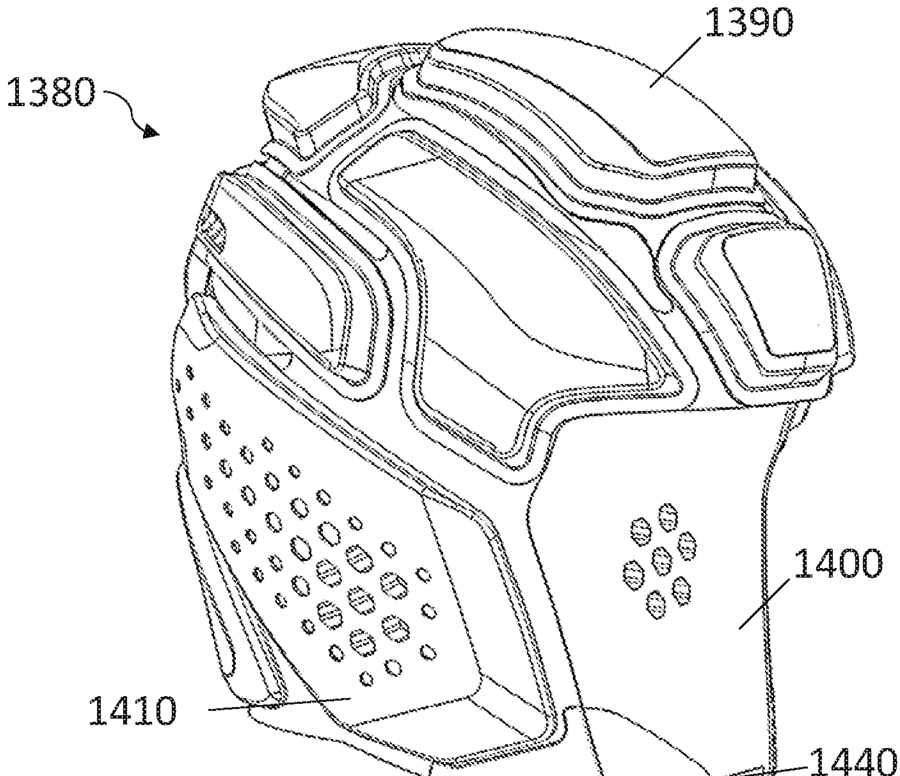


FIG. 38B