(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 May 2018 (17.05.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/089310 A1

(51) International Patent Classification:
A42B 3/04 (2006.01) *F41H 1/04* (2006.01)

(21) International Application Number:
PCT/US2017/060220

(22) International Filing Date:
06 November 2017 (06.11.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

62/419,271	08 November 2016 (08.11.2016)	US
62/481,640	04 April 2017 (04.04.2017)	US
62/483,836	10 April 2017 (10.04.2017)	US
15/712,084	21 September 2017 (21.09.2017)	US

(71) Applicant: **JMH CONSULTING GROUP, LLC** [US/US]; 2 Curtis Street, Winchester, MA 01890 (US).

(72) Inventors: **HERBERT, John, Michael**; 2 Curtis Street, Winchester, MA 01890 (US). **HOTALING, Bryan, R.**; 263 Old Littleton Road, Harvard, MA 01451 (US). **DEVINE, Patrick, J.**; 10 Alyssa Drive, Townsend, MA 01469 (US).

(74) Agent: **AMUNDSEN, Eric, L.**; Wolf, Greenfield & Sacks, P.C., 600 Atlantic Avenue, Boston, MA 02210-2206 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME,

(54) Title: HELMET

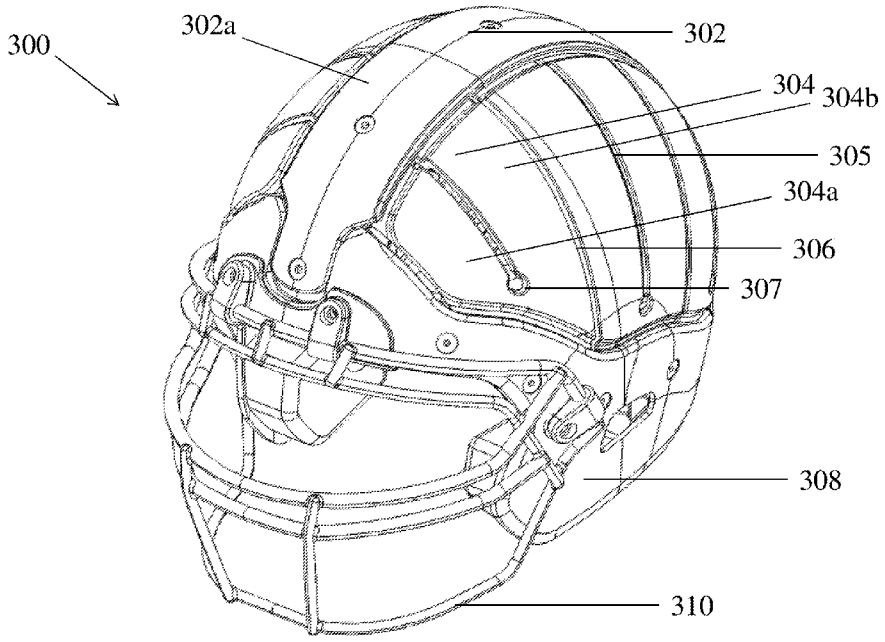

Fig. 20

(57) Abstract: A helmet assembly includes an upper member, a lower member, and rigid or semi¬ rigid plates connected between the two members. The helmet may include a series of fluidly connected air compartments beneath the plates is disclosed. Embodiments of the helmet may dissipate impact energy in multiple ways including deformation of the plates, shifting of the plates, cushioning of the plates against a resilient compressible material present in the upper member, compression of air within the air compartments, movement of air within the air compartments, and/or expansion of air in non-impacted sections of the air compartments which causes the shifting of non-impacted plates. Springs with or without resilient, compressible inserts may be positioned between movable plates and a frame member. A spine including compressible material may extend along a top section of the helmet and connect plates on opposite sides of the helmet.

WO 2018/089310 A1

[Continued on next page]

MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

HELMET

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 U.S.C. § 119(e) of U.S. Non-Provisional Application No. 15/712,084, filed September 21, 2017, U.S. Provisional Application No. 62/483,836, filed April 10, 2017, U.S. Provisional Application No. 62/481,640, filed April 4, 2017, and U.S. Provisional Application No. 62/419,271, filed November 8, 2016, each of which is hereby incorporated by reference in its entirety.

FIELD

The disclosed embodiments relate generally to helmets designed to protect against impacts. More specifically, the disclosed embodiments relate to helmets designed for impact sports such as football, and more specifically to helmets with discrete plates.

DISCUSSION OF THE RELATED ART

Football helmets are designed to protect players from skull fractures and other possible head injuries endemic to the game. Such helmets typically include a hard unitary shell covering a protective foam and/or an air bladder layer such that hard impacts are buffered via distribution over the hard shell deformation of the softer inner layers. Other sports and activities often include the use of protective helmets.

SUMMARY

According to one embodiment, a helmet includes an upper frame member, a lower frame member, and a plurality of plates that are semi-rigid or rigid, the plates being movable relative to one another. The upper frame member and the lower frame member limit movement of the plates. A resilient, compressible material is positioned between the plates and the upper frame member.

According to another embodiment, a helmet includes a plurality of plates that are semi-rigid or rigid, the plates being movable relative to one another. The helmet also includes a first rigid frame member and a second rigid frame member, each of the plurality of plates being connected to the first and second rigid frame members, and each of the plurality of plates having a home position. The plates are movable relative to at least one of the first and second rigid frame members and out of their home positions.

According to another embodiment, a helmet includes a first frame member and a plurality of plates that are semi-rigid or rigid, where each plate has a first end region and is movably connected at the first end region to the first frame member. The helmet also includes a resilient, compressible material positioned between the first end regions and the first frame member such that an impact to an external surface of one of the plates compresses the resilient, compressible material positioned between the first frame member and the first end region of the plate.

According to a further embodiment, a helmet includes an upper frame member, a lower frame member, and a plurality of plates that are semi-rigid or rigid and form at least a portion of an outer shell of the helmet. The plates are movable relative to one another, and the upper frame member and the lower frame member limit movement of the plates. The plates are arranged in opposing pairs separated by the upper frame member. The helmet also includes a plurality of springs, with one or more springs being positioned between each plate and the upper frame member.

According to yet another embodiment, a helmet includes a frame member and a plurality of plates that are semi-rigid or rigid, the plates being movable relative to one another. The helmet also includes a plurality of springs coupled to the plates such that the plates are movable relative to the frame member. The helmet also includes a plurality of resilient, compressible inserts positioned within the springs.

According to a further embodiment, a helmet includes a rigid lower frame member and

a plurality of plates that are semi-rigid or rigid, the plates being movable relative to adjacent plates of the plurality of plates, and the plates are movably attached to the lower frame member.

According to another embodiment, a helmet includes a protective shell and an air bladder positioned under the shell, the air bladder having a first compartment with an outwardly-facing side facing toward the protective shell, and an inwardly-facing side facing toward an interior of the helmet. The inwardly-facing side has a different flexibility than the outwardly-facing side.

BRIEF DESCRIPTION OF DRAWINGS

The accompanying drawings are not intended to be drawn to scale. In the drawings, each identical or nearly identical component that is illustrated in various figures is

represented by a like numeral. For purposes of clarity, not every component may be labeled in every drawing. In the drawings:

Fig. 1 is perspective top view of a helmet according to one embodiment;

Fig. 2 is a top, front perspective view of the helmet of Fig. 1;

Fig. 3 is a top, front, right side perspective view of the helmet;

Fig. 4 is a bottom view of the helmet showing air bladders;

Fig. 5. is a cross-sectional view of an upper frame member of one embodiment showing first and second plates held by the upper frame member;

Fig. 6 is a cross-sectional view of the upper frame member of one embodiment showing first and second plates held by the member via fastening wires;

Fig. 7 is a perspective view of an upper frame member and attached helmet plates according to one embodiment;

Fig. 8 is a cross-sectional view of the upper frame member of one embodiment showing first and second plates held by the member via an anchor;

Fig. 9 is a cross-sectional view of an upper frame member of one embodiment showing a first and a second plate constrained within the upper member's recess;

Fig. 10 is a cross-sectional view of a lower frame member of one embodiment showing a plate held by a compressible material attached to the member;

Fig. 11. is a cross-sectional view of a lower frame member of one embodiment showing a plate connected to the member;

Fig. 12 shows a football helmet according to a second embodiment;

Fig. 13 is a cross-sectional view taken along line 13-13 of Fig. 12;

Fig. 14 is a rear view of a portion of the helmet shown in Figs. 12 and 13.

Fig. 15 is a top, front, right perspective view of a helmet according to another embodiment;

Fig. 16 is a top, front, right perspective view of a helmet according to a further embodiment;

Fig. 17 is a top, front, right perspective view of the springs shown in Fig. 17;

Fig. 18 is a top, front, right perspective view of a spring arrangement according to another embodiment;

Fig. 19 is an exploded view of resilient, compressible inserts and springs according one embodiment;

Fig. 20 shows a football helmet according to another embodiment;

Fig. 21 shows a top, front, right side perspective view of a compressible material according to one embodiment;

Fig. 22 is a top, front, right side perspective view of the helmet of Fig. 20 with an upper panel removed so that the compressible material is exposed;

Fig. 23 is a top view of the helmet of Fig. 20;

Fig. 24 is a front view of the helmet of Fig.20;

Fig. 25 is a rear view of the helmet of Fig. 20;

Fig. 26 is a side view of the helmet of Fig. 20;

Fig. 27 shows a football helmet according to another embodiment;

Fig. 28 shows a football helmet according to another embodiment;

Fig. 29 shows a football helmet according to another embodiment;

Fig. 30 shows a football helmet according to another embodiment;

Fig. 31 shows a football helmet according to another embodiment;

Fig. 32 shows a football helmet according to another embodiment;

Fig. 33 is a cross-sectional view of air bladders below the plates of a helmet according to one embodiment;

Fig. 34 is a top perspective view of interconnected air bladders usable with helmets disclosed herein;

Fig. 35 is a bottom perspective view of the air bladders;

Fig. 36 is a cross-section front view of a helmet with air bladders;

Fig. 37 is a cross-sectional view of a first air bladder channel;

Fig. 38 is a cross-sectional view of a second air bladder channel;

Fig. 39 is a cross-sectional view of a second air bladder channel;

Fig. 40 is a perspective view of a helmet with a resilient outer sleeve according to one embodiment; and

Fig. 41 is a perspective view of a helmet with a resilient outer band according to one embodiment.

DETAILED DESCRIPTION

It should be understood that aspects of the invention are described herein with reference to certain illustrative embodiments and the figures. The illustrative embodiments described herein are not necessarily intended to show all aspects of the invention, but rather are used to describe a few illustrative embodiments. Thus, aspects of the invention are not intended to be construed narrowly in view of the illustrative embodiments. In addition, it should be understood that aspects of the invention may be used alone or in any suitable combination with other aspects of the invention.

Various embodiments are described in connection with a helmet assembly, such as a football helmet. However, the invention is not necessarily so limited, and may be employed with other types of helmets, particularly helmets used for high impact sporting activities. Examples of helmets for other sports and activities include bicycle helmets, hard hats, hockey helmets, lacrosse helmets, skateboarding helmets, snowboarding helmets, other extreme sports helmets, cricket helmets, motorcycle helmets, horse racing helmets, ski helmets, climbing helmets, and mining helmets. One or more aspects disclosed herein may be used with these type of helmets or with other types of protective helmets. Aspects disclosed herein may be used with helmets that include face guards and with helmets that do not include face guards.

Helmets are worn for participating in many contact sports, including football, to help reduce the risks of head injury. Traditional football helmets are comprised of a single hard plastic unitary shell that fully or mostly encompasses the head other than the face. The hard plastic shell is typically supplemented with padding, straps, and/or air bladders along the inside surface to provide cushioning during impact. Energy transfer from impacts to the helmet are blunted by deformation of the rigid outer shell, and further dissipated by compression of the cushioning lining the helmet cavity.

Applicant has recognized that a non-unitary helmet structure having discrete plates which are semi-rigid or rigid may provide improved protection as compared to a unitary

helmet structure can provide better head injury protection than traditional helmets. The plates may be stiff and solid, but not inflexible, and may be constructed to maintain their own shape when unsupported. The plates, when attached to one or more frame members, may provide additional modes of energy dissipation as compared to unitary helmet structures. Gaps may be provided between the plates such that the plates can shift relative to each other while still protecting against skull fractures. The plates also may be of different thicknesses to create different levels of flexibility and protection in different areas of the helmet as needed. A layer of stretchable material partially or completely attached to the plates may be included to facilitate return of the plates to their original arrangement after impact.

Applicant has also recognized that including one or more air bladders that permit air to move within the helmet can buffer impacts in at least two manners. The compression of air within an impacted bladder absorbs energy in some embodiments. The air bladders may be arranged to permit air to move to non-impacted bladders to cause expansion and/or stretching of other portions of the helmet, thereby dissipating energy. In one embodiment, the helmet is composed of a frame that has a central upper member spanning the head from the frontal region to the upper cervical region. The upper member is connected at its dorsal end with a lower member of the frame. The lower member may extend from the rear base of the helmet along both jawlines, ending at a faceguard.

Plates may be held at their upper ends by the upper member and at their lower ends by the lower member. The upper member may include a resilient, compressible foam or other material that serves as a damper when the plates are moved relative to the upper member. When a plate is impacted or moved by another plate, the plate compresses the material, dissipating energy. Movement of a plate or plates on one side of the helmet may displace a plate or plates on an opposite side of the helmet. In some embodiments, the displacement is caused by a force transmitted through the compressible material.

The plates may be spaced from one another such that a small gaps exists between adjacent plates; the gaps being small enough to prevent an adult finger from fitting between the plates.

The helmet may include a plurality of interconnected air bladders attached to the inside cavity wall of the helmet. In some embodiments of the helmet, the air bladders are inflatable via an inlet located on the back of the helmet. Compression of the air within the bladders upon helmet impact may serve to improve cushioning. In some embodiments, upon impact, air also moves between the fluidly connected bladders and causes them to expand.

The air bladders may be arranged such that an impact on one side of the helmet expands an air bladder on the opposite side of the helmet, thereby moving energy to the opposite side of the helmet. The plates may be biased against expansion (e.g., with a resilient, stretchable fabric) such that the plate movement dissipates energy by stretching the fabric.

Turning now to the figures, Fig. 1 shows one embodiment of a helmet 100 according to the present disclosure. Plates 104 are separated by gaps 106 and are attached to an upper member 102. Gaps 106 allow plates 104 to move relative to one another such that when an object impacts the helmet, energy can be dissipated. The upper member 102 spans or partially spans the shape of a head depending on the embodiment. In some embodiments, plates 104 are spaced such that gaps 106 are approximately a half inch or smaller so to as to inhibit penetration by objects. For example, in some embodiments, only objects smaller than an adult-sized finger can fit through a gap 106 when the plates are in a non-expanded state. The plates can be made of any suitable polycarbonate, metal, hard plastic, or any suitable material or combination of materials to maintain the integrity of the helmet.

As may be seen in Figs. 2 and 3, plates 104 are connected to a lower member 108, which in this embodiment extends from the rear base of the helmet along both jawlines, ending at a faceguard 110. The lower member 108 may be positioned at a higher or lower location on the helmet in various embodiments. The upper member 102 and lower member 108 may be constructed of any appropriate polycarbonate, metal, hard plastic, or any other suitable material or combination of materials to maintain the structural integrity of the helmet.

A chinstrap 112 may be attached to the lower member 108 to help maintain the stability of the helmet.

A layer of stretchable, resilient material (not shown in Fig. 4) may be attached to the underside of plates 104. When plates 104 are impacted, their movement relative to each other can stretch the resilient material, further dissipating impact energy. After impact, the resilient material may return plates 104 to an original configuration. The resilient material may include spandex, elastane, rubber, polyester-polyurethane, or any other suitable resilient material. The spandex or other material may be combined with cotton, polyester, or any other suitable material to form a sheet or other configuration of the resilient material. In some embodiments, threads of resilient material may be used to bias the plates toward an original configuration.

In the embodiment shown in Fig. 4, the resilient material layer is positioned on the entire inner cavity. In other embodiments, the resilient material may include bands attached at only parts of plates 104, or may be a series of stretchable patches forming a network of connected plates, or any other suitable attachment configuration to bias the plates 104 toward their original orientation relative to each other. In some embodiments, instead of, or in addition to a resilient material positioned on an inner side of the helmet, a resilient material layer may be positioned over the outer surfaces of the plates. For example, a resilient, stretchable material may be placed around the entire outer helmet in some embodiments. The resilient stretchable material can further be colored or otherwise patterned for cosmetic purposes. For example, logos, colors, advertising, or other graphics may be included on the resilient, stretchable material and thereby to the entire helmet. A resilient, stretchable material layer as described herein may be applied to conventional helmets in some embodiments. For example, the material may be pulled over a conventional football helmet and attached to an interior of the helmet with snaps, hook and loop fasteners, a hook and grommet arrangement, or any other suitable fastening arrangement.

One or more air bladders 116, 117, 119 may be included in embodiments of the helmet. The bladders may be connected to each other by air channels 116a, forming one continuous air chamber such that air can flow between the bladders. When a plate 104 is impacted, the plate deforms inwardly, compressing the air bladder. This compression forces air within the air bladder to move through the air channels and into the other air bladders, causing local expansion in those bladders. That expansion causes plates 104 adjacent to the expanding air bladders to shift, additionally dissipating impact energy. Any suitable number of air bladders may be used, and the bladders can be of any suitable shape. The air bladders can be made from any polyvinyl plastic, elastane, rubber, or any other suitable material, such as an elastic material that is tear-resistant and can house air and be attached to the inside cavity of the helmet. The illustrated air bladders are attached to the undersides of plates 104 in this embodiment, but could also be attached to the resilient material, or both, or integrated into the helmet in any other suitable manner. The air bladders can contain gases or mixtures of gases other than air. For purposes herein, a bladder containing a gas or a mixture of gases that is different than the composition of air is considered to be an air bladder.

As illustrated in Fig. 33, in some embodiments, the air bladders 172 may be made of different materials with varying elasticities in different parts of the air bladder. For instance, an outwardly-facing side *A* may be made to be more elastic than an inwardly-facing side *B*.

With such an arrangement, impact in one area of the helmet could permit greater expansion of side *A* as compared to side *B*. Such an arrangement allows some areas to expand more than others when the air bladder 172 is impacted and fluid shifts to expand non-impacted sections. The more compliant areas may be located below the plates 170 to encourage additional reversible deformation of the helmet upon impact via shifting of plates 170, thus increasing dissipated energy. The air bladders do not have to be formed of different materials and may simply be comprised of one material with different thicknesses in different areas to accomplish a similar effect. In some embodiments, the same material may be used, and different shapes of the bladder portions may provide different flexibilities in different areas.

Fig. 5 shows a cross-sectional view of upper member 102 where opposing plates 104 are attached to upper member 102 via a compressible material 114. Each plate 104 may be adhered to the compressible material, which in turn is adhered to an inner surface of a channel 109 in upper member 102. Within upper member 102 is compressible material 114 located between plates. When plates 104 are impacted, ends 115 of the plates press inwardly on compressible material 114, which absorbs energy. Compressible material 114 can be made of any suitable foam, rubber, synthetic rubber, silicone, urethane, neoprene, nitrile, thermoplastic elastomer, set foam, formable foam, set elastomer, formable elastomer, latex, or other suitable material, or a combination thereof.

In some embodiments, a top portion 102a and a bottom portion 102b of upper member 102 extend sufficiently laterally and are sufficiently closely fitted to ends 115 tips of plates 104 such that even without an adhesive or fastener, plates 104 are connected to the upper member by being constrained against removal.

Fig. 6 shows one embodiment of one manner of connecting plates 104 to upper member 102 with a compressible material 114 between plates 104 and upper member 102. In this embodiment, wires 120 are anchored to plates 104 and upper member 102 to limit the distance that the plates can travel from the upper member. The wires may be run through compressible material 114, or around pieces of compressible material 114. While the wires 120 limit plate movement away from the upper member 102, the plates can press inwardly on compressible material 114 to dissipate impact energy.

Fig. 7 is a perspective cutaway view of one section of upper member 102 and two attached plates 104 extending from the upper member. The plates may be attached to the upper member 102 in a manner similar to that shown in Fig. 6, or in any other suitable manner.

Fig. 8 shows another embodiment of how plates 104 may be connected to upper member 102. In this embodiment, plates 104 have anchors 122 at their upper ends. The anchors may be integral with the plates, or may be distinct elements which are attached to the plates. Anchors 122 are set into compressible material 114, which is in turn connected to upper member 102 in any suitable manner. For example, compressible material 114 may be adhered to upper member 102, connected with one or more fasteners to upper member 102, or constrained by recesses and/or walls within upper member 102.

Fig. 9 shows another embodiment plates 104 connected to upper member 102. In this embodiment, plates 104 have extensions 125 at their upper ends which are set into upper member 102. Upper member 102 has a recess 127 that physically constrains extensions 125 so that plate 104 cannot be easily removed through normal use. Compressible material 114 may be adhered to upper member 102, and buffers medial movements of plate 104 from impacts. While Figs. 5, 6, 8, and 9 show three different embodiments of attaching plates 104 to upper member 102, other manners of connection may be implemented.

Fig. 10 is a cross-sectional view showing a lower end of plate 104 connected to lower member 108. In this embodiment, plate 104 is non-removably fastened to a compressible material 128 located within a channel 107 in lower member 108, the compressible material in turn non-removably fastened to lower member 108. A downward force on the plate 104 presses the plate into channel 107, compressing compressible material 128, which dampens the impact. Compressible material 128 can be composed of any compatible foam, rubber, polyurethane, latex, other suitable material, or a combination thereof . Additional compressible material 111a may be positioned along a channel inner wall that is on an inner side of the plate 104. Similarly, a compressible material 111b may be positioned along a channel inner wall that is on an outer side of the plate 104. Compressible materials 111a, 111b may dampens lateral forces experienced by plates 104.

Fig. 11 is a cross-sectional view of an alternative connection between plate 104 and lower member 108. In this embodiment, plate 104 positioned within a slot in lower member 108, and the two components are directly connected via an adhesive 130. Other direct connections may be employed, such as welding plate 104 to an inner surface of lower member 108. Such an arrangement may provide a more rigid attachment as compared to the embodiment of Fig. 10. The upper ends of plates 104 may be cushioned within upper member 102 in embodiments that include a rigid connection of plates 104 to lower member 108. In

some embodiments, a direct, rigid connection may be used to connect plates 104 to upper member 102.

Figs. 10 and 11 show two possible attachment arrangements for plates 104 and lower member 108. Other attachment arrangements may be employed with various embodiments disclosed herein. In some embodiments, lower member 108 may be integrally formed with some or all of plates 104, while the upper ends of plates are movable relative to upper member 102. In some embodiments, lower ends of plates 104 may be movable along a longitudinal direction of channel 107, but restricted from moving up or down relative to the lower member.

Energy absorbing elements may be positioned at other location of the helmet in some embodiments. For example, in the embodiment shown in Fig. 12, a resilient, compressible material 138 is located between upper frame member 102 and a front frame member 136. With such an arrangement, the compressible material 138 may absorb some of the force of an impact to faceguard 110 and permit front frame member 136 to move relative to upper frame member 102.

Fig. 13 shows a cross-section taken along line 13-13 of Fig. 12, and Fig. 14 shows a rear view of certain components. Upper frame member 102 and front frame member 136 are able to move relative to each other, and a stop is provided to prevent the front frame member and the upper frame member from detaching. A bolt 140 or other protrusion is mounted to the front frame member and is slidable within a slot 142 which is connected to upper frame member 102. The bolt 140 prevent the upper frame member from separating from the front frame member, but allows the front frame member and upper frame member to move toward each other while being cushioned by compressible material 138. In some embodiments, a similar arrangement may be employed at the rear of the helmet between the upper frame member and the lower frame member.

In some embodiments, instead of an upper member 102 running along the mid-sagittal plane, there is instead one or more upper members running along one or more coronal planes. Plates are connected to the upper members and one or more lower members that travel along a base of the helmet. Similar to other embodiments described herein, resilient, compressible material may be positioned between the plates and the upper and/or lower members.

The rigid or semi-rigid plates may be made of any suitable material or combination of materials. In some embodiments, ABS and/or polycarbonate may be used. A carbon fiber

composite material, or any other suitable material may be used to form all or part of the plates.

In some embodiments, plates 104 and/or underlying air bladders 116 have small coverage gaps, such as slits or holes 126 to allow heat or moisture accumulated during physical activity to exit the helmet, while the helmet retains its protective qualities. The holes 126 as shown in Figs. 1, 2, and 3, or other gaps, may be spaced at various locations on the helmet to allow airflow into and out of the helmet cavity.

In some embodiments, the faceguard 110 includes a small visor attaching member on either side of the frame at approximately a wearer's eye level. An optional visor comprised of clear polycarbonate or any other suitable material may be attached to the helmet with these attaching members.

In some embodiments, compressible, resilient elements include springs positioned between the plates and the frame member(s). Fig. 15 shows one arrangement where a pair of springs 144, 145 are positioned between opposing plates 104 and the upper frame member 102. In such an arrangement, the springs 144, 145 may absorb some of the force of an impact to the plates 104 by compressing, thereby allowing the plates 104 to move from their original positions relative to the upper frame member 102. When the force is removed, the springs 144, 145 may expand to their original lengths and the plates 104 may move back to their original positions.

The springs 144, 145 may be constructed and arranged such that they can extend. For example, as described above, air bladders within the helmet may expand on a side of the helmet that is opposite to the side of impact. The air bladder expansion may push plates 104 away from the frame member, thereby extending one of the springs. Once the air bladders return to their original arrangements, the spring pulls the plate 104 back to its original position. In some embodiment, the springs 144, 145 allow up to four mm of displacement in either direction (expansion and compression), although other maximum distances are possible. In some embodiments, the maximum possible compression distance may be different from the maximum possible extension distance.

The springs 144, 145 may be separate elements or they may be joined together at a junction 158 using an adhesion, bonding, or any suitable attachment method. In some embodiments, the springs 144, 145 may be a unitary piece of material. The junction 158 can be formed at a single point between the springs or along a length of the springs, as shown in

Fig. 15. In one embodiment, the junction 158 is fixed to an inner surface 146 of the frame member and/or an underside of an upper portion of the frame member. The junction 158 may be equidistant between opposing plates 104. In other embodiments, the junction 158 may be positioned closer to one plate so opposing plates 104 may have asymmetric responses to an impact force.

The upper frame member 102 may enclose the springs 144, 145 such that the springs are not exposed . A helmet may include at least two springs, or any suitable number of springs. The springs 144, 145 may be any type of suitable spring, such as a leaf spring or a compression spring, among others. Springs 144, 145 with the same or different properties may be used within a helmet, such as springs with varying lengths, stiffnesses, or shapes. Further, the springs 144, 145 may be formed of any suitable resilient material, such as stainless steel, copper, plastic, and so on. In some embodiments, springs 144, 145 may be positioned between some or all of the opposed plate pairs, and/or at other locations of the helmet.

In Fig. 16, another embodiment of a spring arrangement for the helmet system is shown. Each of springs 148, 149 is in the shape of an irregular hexagon which allows expansion and compression. Each spring 148, 149 surrounds an area that may hold a resilient material insert 150. The resilient material insert 150 may be foam or a compressible bladder filled with gas. In some embodiments, the foam may be a memory foam such as a polyurethane memory foam. When one or both of the springs 148, 149 are compressed due to impact on the plate 104, compression of the resilient material insert 150 absorbs part of the impact. When the impact force is removed, the resilient material insert 150 expands to push its surrounding spring outward, helping return the spring and the plate 104 to their original positions quickly. In some embodiments, the resilient material insert 150 is sized and shaped to match the inner walls of the spring 148, 149. In some embodiments, the resilient material may be a different shape or size than the spring 148, 149 when the resilient material insert 150 is removed from the spring 148, 149.

Fig. 17 is a magnified view of the springs 148, 149 and resilient material inserts 150 shown in Fig. 16. The resilient material inserts 150 may be adhered or otherwise suitably attached to the springs 148, 149 such that when a spring 148, 149 extends, the resilient material insert 150 is stretched and tends to pull the spring 148, 149 back toward its original position. The resilient material insert 150 is not covered on its top surface by the spring 148,

149, but in some embodiments, a protective cover and/or further spring elements may be included over the top of the resilient material insert 150.

Spring 148 is shown as not entirely surrounding the perimeter of the resilient insert 150. In particular, spring 148 has a gap 156 between hooks 160, 162. In some embodiments, some or all of the springs may have gaps, or all of the springs may not have gaps. Gap 156 may allow the spring 148 to expand to facilitate placement of the resilient material insert 150 in the spring 148. The opening 156 also may improve the compression and expansion of the spring 145.

A bridge 152 connects adjacent sides of spring 148 to spring 149. The bridge 152 may be formed of the same material as the springs 148, 149, or may be made of a different material. A protrusion from the helmet body may fit between springs 148, 149 and under bridge 152. With such an arrangement, the inner portions of the springs 148, 149 are fixed relative to one another.

Fig. 17 also shows attachment features such as hooks 160, 162 that attach the springs 148, 149 to the plates 104. In the illustrated embodiment, the hooks 160, 162 fit into a corresponding slot on the plate 104, similar to the slot 166 shown in Fig. 15. In other embodiments, the spring 148, 149 may attach to plates 104 at a single point, along a length of the plate 104, or at multiple points. The attachment may be configured to distribute the spring force symmetrically across the plate 104. In some configurations, however, it may be desirable to have an asymmetric distribution of spring force across the plate 104. As will be appreciated, any suitable attachment method can be used between the spring 148, 149 and plate 104, including but not limited to welding, screws, rivets, adhesives, fasteners, and integral formation.

Fig. 18 shows an alternative embodiment of a six-sided spring 148, 149 without a resilient material insert 150. In some embodiments, a helmet may include springs 148, 149, such as the springs 148, 149 disclosed herein, which are encased within a resilient material. For example, a resilient foam may be molded around a spring 148, 149 in some embodiments.

In Fig. 19, resilient material inserts 150 are shaped to fit the springs 148, 149 and are removable from the springs 148, 149. As described above, the resilient material insert 150 may or may not be attached to its respective spring 148, 149, for example with an adhesive or in any other suitable manner. In some embodiments, the resilient material insert 150 may be

attached to only a portion of a spring 148, 149. In one embodiment, the resilient material insert 150 is attached to a spring 148, 149 on the three spring walls opposite the bridge 152. In another embodiment, a resilient material such as foam encases the spring 148, 149. Multiple springs 148, 149 may be encased in a single piece of resilient material, or each spring 148, 149 may be individually encased in resilient material.

Although six-sided springs 148, 149 are shown, springs with any suitable dimension and/or ratio of side lengths may be used. Other spring geometries may also be used, such as springs with different numbers of sides, including but not limited to four- and eight-sided springs.

Fig. 20 shows a helmet 300 with plates that are movable relative to each other. In this embodiment, plates 304 are separated by gaps 306, and are attached to an upper member 302. Gaps 306 allows the plates 304 to move relative to each other for energy dissipation upon impact as described above. In this embodiment, plates 304 are further split further into two elongate fingers joined at the bottom of the plates where they moveably attach to a lower member 308. The depicted embodiment has a single continuous lower member 308, but other embodiments may have lower members that are formed with of multiple pieces. The two elongate fingers 304a and 304b are separated by slots 305, which end in a circular hole 307 such that the elongate fingers are free to move slightly relative to each other (though constrained by upper member 302 and the lower end of plate 304). Circular hole 307 provides stress release at the junction of the two elongate fingers. While the depicted embodiment shows two elongate fingers per plate, other embodiments could have more divisions of each plate, or could have differing numbers of sub-divisions per plate. In some embodiments, some or all of the plates do not have fingers, and simply include a single piece plate. The depicted embodiment also shows three plates for each lateral side of the head, but differing numbers of plates comprising the outer shell of the helmet are also contemplated.

As with earlier embodiments, upper member 302 of helmet 300 spans or partially spans the shape of the head from front to back, and lower member 308 extends from the rear base of the helmet and along both jawlines. However, each of the upper and lower members could comprise multiple segments in other embodiments, or could be wider or thinner, thicker or thinner, and in general are not limited to the arrangements depicted.

Figs. 21-26 show a compressible material 314 according to some embodiments of the helmet. In these embodiments, compressible material 314 is housed between an upper and lower housing section 302a and 302b of upper member 302. The compressible material 314

includes two outer rails 362 and an inner rail 363 attached together with chevrons 364 running between the rails. Chevrons 364 are shaped to dissipate impact energy as described below. Some embodiments have two rails joined together at the center to join the two sections of chevron shapes (or other intermediate shapes). Other embodiments have the two sections of chevron shapes attached to a section of upper member 302 spanning between the two. Ends 368 and 370 of compressible material 314 attach to corresponding features on the helmet. To maintain positioning of the compressible material element, circular gaps 366 are intermittently positioned along the center of compressible material 314 and capture corresponding cylindrical protrusions 367 extending from the bottom housing section 302b of upper member 302, as seen in Figs. 22-25. This arrangement prevents compressible material 314 from substantially shifting. Interlocking members 360 line lateral rails 362 and interlock with interlocking features 361 of the plates 304 to keep the plates attached to the compressible material.

In some embodiments, for example those shown in Figs. 25 and 26, compressible material 314 is also included inside the lower member 308, interconnecting in a similar manner with the bottom of plates 304.

While compressible material is depicted a certain configuration in the figures, it should be understood that it is not limited as such. Interlocking members 362 may be of any shape that allow them to interlock or otherwise attach to plates 304. Dovetail shapes, bulbs, T-shapes, Y-shapes, triangular protrusions, or other interlocking shapes are also contemplated. Instead of interlocking members, the compressible material may be attached to plates 304 using fasteners, springs, adhesives or other attachment arrangements. Embodiments with more or fewer rail sections are also contemplated.

Compressible material 314 can be made of any suitable foam, rubber, synthetic rubber, silicone, urethane, neoprene, nitrile, thermoplastic elastomer, set foam, formable foam, set elastomer, formable elastomer, latex, or other suitable material, or a combination thereof.

Energy dissipating connectors having inner shapes other than chevrons may be used. For example, diamond shapes, zig-zag shapes with varying numbers of teeth, saw-tooth shapes, ovoid shapes, circular shapes, or other suitable shapes may be used. A solid piece of compressible material may be used in some embodiments.

The present disclosure is not limited to circular holes and circular protrusions for attachment of the compressible material to the upper member and could instead use fasteners including staples, screws, bolts, nails, or other similar penetrating fasteners, adhesives, or compression between the upper and lower housing sections of the upper member to maintain the position of compressible material 314.

When a plate 304 sustains an inward impact, several responses may help dissipate and/or distribute energy. If the impact is focused on one of the elongate fingers, that finger may reversibly deform and dissipate energy. The finger shifts inwardly with the force of the impact, deforming the air bladder 172 below the shell, further dissipating energy. Air in the air bladder is forced into other compartments, causing them to inflate and push other plates outwards, further dissipating energy. Additionally, the inward movement of plate 304 reversibly deforms compressible material 314, causing the chevrons 364 near the plate to compress.. The expanding air bladders cause other plates 304 to expand outwardly, thereby producing a pulling force on the attached chevrons 364 which stretches the chevrons and dissipates energy.

In this manner, compressible material 314 may form a spine along a top center of the helmet. In some embodiments, the spine permits movement of the discrete plates relative to each other, while also limiting the overall movements of the plates. The spine may facilitate the dissipation and distribution of impact energy in one or more of the manners described above.

In some embodiments, the helmet does not have an upper member, or the has an upper member but the rigid or semi-rigid plates do not translate relative to the upper member.

For example, as shown in Fig. 27, the helmet 200 includes a frame member, such as a lower frame member 202 that spans a user's head from the frontal region to the upper cervical region running down the outside of the face and in the dorsal direction along both jawlines, ending at the base of the skull. In some embodiments, faceguard 110 is attached to the ventral side of the frame member. In various embodiments, different types of plates may be attached directly or indirectly to the frame member 202, or may integral to the frame member 202. The frame member 202 may be made of any suitable polycarbonate, metal, hard plastic, or any suitable material or combination of materials to maintain the integrity of the helmet.

Rigid or semi-rigid plates 204 in the embodiment of Fig. 27 are U-shaped and travel from one side of the helmet to the other side, passing over the crown of the helmet. Gaps 206 may be present between the plates 204, though gaps may not be present in some embodiments. The gaps may have a width that is smaller than a typical human finger to help prevent fingers from penetrating the helmet or getting caught in the gaps. In some embodiments, gaps 206 may be 1cm or less.

The plates 204 may be attached at their ends to frame member 202 via compliant connections. The plates may be movable relative to the frame member 202 in the longitudinal direction of the ends of the plates to a limited extent. For example, the plates may be attached to the frame member via one of the various connections described herein.

Compliant spacers 264 may be positioned between the plates and/or between a plate and the structural member 202 along a front-to-back mid-line of the helmet. The compliance of the spacers 264 allows the plates to shift forward and backward. In other embodiments, the spacers may be rigid and not allow forward and backward movement, and may be slidingly engaged to the plates so that the plates can move side-to-side on the helmet. The compliant spacers 264 may be formed from any flexible material that allows the plates 204 to reversibly shift frontwards or backwards by deforming the spacers 264 upon impact to the helmet. The plates 204 may be made of any suitable polycarbonate, metal, hard plastic, or any suitable material or combination of materials to maintain the integrity of the helmet. The spacers 264 may be located at positions other than the mid-line. For example, two spacers may be positioned between two given plates 204 – one spacer on each side of the mid-line.

In Fig. 28, a helmet 800 with plates 804 integrally connected to a central arch 802 is illustrated. As with many of the other embodiment described herein, the plates may be movably attached at their ends to member 802. Gaps 806 may be provided between the plates to allow the plates to move toward and away from the wearer's head and/or to flex toward or away from adjacent plates. The gaps may be 1cm or less in some embodiments, though any suitable size may be used. In some embodiments, while there may be a gap present at an outer surface of the plates, an inner surface of the plates and/or interior padding may close the gap so that there is no clear opening to the inside of the helmet. In some embodiments, no gap or a very small gap on the order of 1mm may be present.

The combined structure of the central arch 802 and plates 804 may move front to back in some embodiments. For example a compliant member or sliding connection 808 may be positioned at a front end of the central arch 802 between the central arch and the frame

member 802. Such a connection also may be located along a forward edge of the forward most plates 804 between the plates and the frame member 802.

When the helmet 800 is impacted, the central arch and/or the plates may shift and reversibly deform the connections, thus dissipating impact energy. The central arch and plates may be made of any suitable polycarbonate, metal, hard plastic, or any suitable material or combination of materials to maintain the integrity of the helmet.

In the embodiment illustrated in Fig. 29, a helmet 400 includes a frame member 402 includes rigid or semi-rigid plates in the form of integrally extending fingers 404 that travel upwardly on the helmet. At their top ends, the fingers 404 may be slidingly engaged with a central arch 403. The fingers 404 may be slidingly engaged such that the fingers can move toward and away from the central arch. Additionally, the central arch 403 and the fingers 404 may be slidingly engaged so that the central arch 403 can move forward and backward on the helmet.

The fingers 404 may be separated from each other by gaps 406, for example, gaps of 1cm or less. Or, in some embodiments, there may be no gap, or a small gap on the order of 1mm. At ends of gaps 406, a rounded end may be provided, in some cases with a diameter larger than the slot width, to reduce stress concentrations and/or to allow more flexibility of the fingers 404 relative to the support member 402.

According to another embodiment of a helmet 500, plates 504 may be oriented in a forward-backward direction, as shown in Fig. 30. The panels may be connected to a frame member 502 at the front and back of the helmet via compliant connections such that impact to the helmet 500 allows the panels to shift from front to back. The panels 504 are spaced from each other by gaps 506, which in this embodiment also run from front to back. The gaps may be 1cm or less in some embodiments. Spacers 564 may be provided between the panels, and may be compliant or rigid. With compliant spacers, the plates can move from side to side as the spacers deform upon impact to sides of the helmet 500. The compliant spacers 564 may be formed from any suitable material, including materials that are resiliently flexible. In some embodiments, the compliant spacers include sufficient material to prevent adjacent plates from “bottoming out” under typically-experienced forces.

The spacers 564 may be configured such that the plates 504 can slide past the spacers. In some embodiments, each spacer may be non-slidingly attached to one adjacent plate but

not the other. In other embodiments, one or more of the spacers may be non-slidingly attached to both adjacent plates.

The embodiment shown in Fig. 31 includes an integral top component 601 which includes a central section 603 spanning the mid-coronal line of the helmet 600 with panels formed as fingers 604 branching off at points along its span. The fingers may be arranged such that separations (e.g., gaps 606) are substantially equidistant. In other embodiments, the separations may be present at differing intervals. Similar to various other embodiments disclosed herein, the gaps may be sized to prevent fingers from entering the gaps. In some embodiments, the gaps are 1cm or less at the outer surface of the panels.

The panels 604 travel dorsally or ventrally to form a portion of the helmet's outer shell and connect to the frame member 602 via compliant connections at the front and back of the helmet. The central section 603 connects to the frame member 602 via compliant connections at lateral ends of the central section 603. The panels may move front to back and/or upwardly and downwardly relative to a front section of frame member 602.

In Fig. 32, an embodiment is illustrated where rigid or semi-rigid panels 704 are provided in the form of rings. Each panel 704 is attached one or more adjacent panels via compliant connections 764 such that they can shift relative to one another by deforming the complaint connections 764. A lowermost panel 703 is attached to a frame member 702 via complaint connections 764, and an uppermost panel 701 is a substantially circular plate. The panels 704 may be made of any suitable polycarbonate, metal, hard plastic, or any suitable material or combination of materials to maintain the integrity of the helmet. In some embodiments, each panel 704 can deform inwardly or downwardly in order to compress an underlying air bladder upon impact. Other areas of the air bladders may expand outwardly to dissipate some of the energy of the impact.

As mentioned above with reference to Figs. 4 and 33, air bladders may be used with various helmet embodiments disclosed herein. Figs. 34 and 35 show one embodiment of a set of air bladders 172 formed into a layer of air bladders. The layer of air bladders may be positioned below the plates of the helmet. Some or all of the air bladders 172 may be connected to one or more other air bladders via connecting channels 174, 175, which channels allow airflow between the bladders. As described above, upon impact to the helmet, the plates shift/deform inwardly and compress some of the air bladders. Upon compression, air in the impacted bladder(s) shifts to other bladders via the connecting channels 174, 175, causing the connected bladders to expand and push outwardly on the plates above them. In

this manner, some of the energy from the impact can be dissipated through the expansion of air bladders and/or the movement of plates in an area outside of the impact region.

As can be seen in Fig. 36, outer walls 176 of the air bladders are thinner than inner walls 178 in the illustrated embodiment. Such an arrangement may permit the air bladders to expand outwardly more than inwardly when air is pushed into the bladders. Internal padding, such as foam padding 180 may be positioned inwardly of the air bladder layer. In some embodiments, air bladders may be used which are not interconnected with other air bladders.

The channels connecting air bladders may be tuned to provide varying levels of resistance to air flow between certain air bladders and/or limit flow to a single direction. For example, channel 174 may have a first cross-sectional area, while channel 175 has a second, different cross-sectional area, as shown in Figs. 37 and 38. In some embodiments, the channels may have different cross-sectional shapes. For example, as shown in Fig. 39, a channel 177 may have a trapezoid shape while other channels in the same helmet have rectangular cross-sections. By providing channels having different resistances to air flow, the rate of collapse and/or inflation of certain air bladders may be tuned to provide specific characteristics. In some embodiments, a check valve may be provided to allow flow in only one direction between two bladders.

In each of the embodiments described herein, a tight-fitting sleeve may cover the helmet. The sleeve may be resilient such that sleeve acts to return the plates to their home positions after an impact. Additionally, the sleeve may have an elasticity and such that it is arranged to limit the degree of movement of the plates. The sleeve can be constructed of any suitably elastic material that can reversibly stretch. A sleeve 182 is shown in cross-section on the outside of the plates in Fig. 40. Fig. 40 shows sleeve 182 wrapped around substantially the entire outer surface of the helmet with the boundaries between the underlying plates shown in dashed lines.

In some embodiments, a resilient fabric is formed as a band 184 which extends horizontally around the helmet, as shown in the embodiment of Fig. 41.

Instead of being positioned on the outside of the helmet, resilient fabric or other resilient material may be embedded in the plates and connect the plates such that when the plates are pulled apart, the resilient material urges the plates back toward each other. In some embodiments, the resilient fabric may be secured to an underside of the plates.

As described above, the resilient material may include spandex, elastane, rubber, polyester-polyurethane, or any other suitable resilient material.

In each of the embodiments described herein, some or all of the compliant connections may include springs without or without a resilient insert.

The use of springs and/or resilient material insert arrangements disclosed herein as energy absorbing elements may be used in other applications beyond helmets. The shapes, dimensions, and materials of the plates, springs, and resilient material inserts may be adapted for specific applications. For example, flame-retardant resilient material inserts and springs with large stiffness coefficients may be used for automotive safety.

While the present teachings have been described in conjunction with various embodiments and examples, it is not intended that the present teachings be limited to such embodiments or examples. On the contrary, the present teachings encompass various alternatives, modifications, and equivalents, as will be appreciated by those of skill in the art. Accordingly, the foregoing description and drawings are by way of example only.

Various aspects of the present invention may be used alone, in combination, or in a variety of arrangements not specifically discussed in the embodiments described in the foregoing and is therefore not limited in its application to the details and arrangement of components set forth in the foregoing description or illustrated in the drawings. For example, aspects described in one embodiment may be combined in any manner with aspects described in other embodiments.

Also, the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including,” “comprising,” or “having,” “containing,” “involving,” and variations thereof herein, is meant to encompass the items listed thereafter and equivalents thereof as well as additional items.

CLAIMS

What is claimed is:

1. A helmet comprising:

an upper frame member;

a lower frame member;

a plurality of plates that are semi-rigid or rigid, the plates being movable relative to one another;

wherein the upper frame member and the lower frame member limit movement of the plates; and

a resilient, compressible material positioned between the plates and within the upper frame member.

2. A helmet as in claim 1, further comprising an expandable, resilient material arranged to bias the plates toward a home position when the plates are moved away from the home position.

3. A helmet as in claim 1, further comprising a resilient, compressible material positioned between the plates and within the lower frame member.

4. A helmet as in claim 1, further comprising one or more air bladders positioned inside the plates such that an external impact on a first plate of the plurality of plates causes a second plate of the plurality of plates to move outwardly from the helmet.

5. A helmet as in claim 4, wherein the second plate is on an opposite side of the helmet as the first plate.

6. A helmet as in claim 1, further comprising elastic stretchable, resilient outer sleeve positioned over the plates.

7. A helmet as in claim 1, wherein the resilient, compressible material comprises a compliant rubber material.

8. A helmet as in claim 1, wherein the resilient, compressible material comprises one or more of: a silicone, and urethane, and a neoprene.

9. A helmet as in claim 7, wherein the compliant rubber material extends along a length of the upper rigid frame member.

10. A helmet as in claim 1, wherein the compressible material comprises one or more pairs of longitudinal rails with V-shaped joints between the rails.

11. A helmet as in claim 1, wherein the compressible material includes protrusions extending outwardly from the compressible material and interlock with corresponding openings in the plates.

12. A helmet as in claim 10, wherein an external impact on a first plate causes at least a portion of the V-shaped joints to reversibly compress together.

13. A helmet as in claim 12, wherein the movement of the first plate causes a second plate to shift outwardly, causing at least a portion of the V-shaped joints to reversibly expand.

14. A helmet as in claim 1, wherein the upper frame member comprises a lower section with protrusions that interlock with corresponding gaps in the compressible material, holding the compressible material to the lower section.

15. A helmet as in claim 9, wherein the longitudinal rails are reinforced with a length of plastic material.

16. A helmet comprising:

a plurality of plates that are semi-rigid or rigid, the plates being movable relative to one another;

a first rigid frame member and a second rigid frame member, each of the plurality of plates being connected to the first and second rigid frame members, and each of the plurality of plates having a home position;

wherein the plates are movable relative to at least one of the first and second rigid frame members and out of their home positions.

17. A helmet as in claim 16, wherein the plates are movable relative to both the first and second rigid frame members.

18. A helmet as in claim 16, further comprising resilient material positioned at least partially between the plates and the first rigid frame member.

19. A helmet as in claim 16, wherein an external impact to a plate at least partially compresses the resilient material against the first rigid frame member.

20. A helmet as in claim 19, further comprising one or more air bladders positioned inside the plates such that an external impact on a first plate causes a second plate to move outwardly from the helmet.

21. A helmet as in claim 19, wherein an external impact on a first plate causes a fluid compartment on an opposite side of the helmet from the impact to expand.

22. A helmet as in claim 16, further comprising a stretchable outer sleeve that fits over the helmet.

23. A helmet comprising:

a first frame member;

a plurality of plates that are semi-rigid or rigid, where each plate has a first end region and is movably connected at the first end region to the first frame member; and

a resilient, compressible material at least partially positioned between the first end regions and the first frame member such that an impact to an external surface of one of the plates compresses the resilient, compressible material positioned between the first frame member and the first end region of the plate.

24. A helmet as in claim 23, further comprising one or more air bladders positioned inside the plates such that an external impact on a first plate causes a second plate to move outwardly from the helmet.

25. A helmet as in claim 24, wherein the second plate is on an opposite side of the helmet as the first plate.

26. A helmet as in claim 23, further comprising a second frame member, wherein the first frame member is an upper frame member, and the second frame member is a lower frame member.

27. A helmet as in claim 23, further comprising an expandable, resilient material arranged to bias the plates toward a home position when the plates are moved away from the home position.

28. A helmet as in claim 23, further comprising an elastic outer sleeve attached to the helmet.

29. A helmet comprising:

an upper frame member;

a lower frame member;

a first semi-rigid or rigid plate positioned on a left side of the helmet and extending from the lower frame member toward the upper frame member, the first plate having an upper end;

a second semi-rigid or rigid plate positioned on a right side of the helmet and extending from the lower frame member toward the upper frame member, the second plate having an upper end; and

a resilient, compressible material positioned between the upper end of the first plate and the upper end of the second plate;

wherein the lower frame member limits movement of the first and second plates; and

the helmet is configured such that the upper end of the first plate moves toward and/or away from the upper end of the second plate when the helmet is impacted.

30. A helmet as in claim 29, further comprising:

a third semi-rigid or rigid plate positioned on a left side of the helmet and extending from the lower frame member toward the upper frame member, the third plate having an upper end;

a fourth semi-rigid or rigid plate positioned on a right side of the helmet and extending from the lower frame member toward the upper frame member, the fourth plate having an upper end; wherein

the resilient, compressible material is positioned between the upper end of the third plate and the upper end of the fourth plate;

wherein the lower frame member limits movement of the third and fourth plates; and

the helmet is configured such that the upper end of the third plate moves toward and/or away from the upper end of the fourth plate when the helmet is impacted.

31. The helmet of claim 29, wherein first plate comprises two elongate sections separated by a slot and joined at a lower end, and second plate comprises two elongate sections separated by a slot and joined at a lower end.

32. The helmet of claim 31, wherein the slot ends in a circular hole with a diameter larger than the width of the rest of the slot.

33. The helmet of claim 29, wherein the resilient, compressible material biases the plates towards a home position when the plates are moved away from the home position.

34. The helmet of claim 29, further comprising a resilient, compressible material positioned between the first and second rigid or semi-rigid plate and the lower frame member.

35. The helmet of claim 30, further comprising a resilient, compressible material positioned between the third and fourth rigid or semi-rigid plate and the lower frame member.

36. The helmet of claim 29, wherein the first and second rigid or semi-rigid plates are moveable relative to each other.

37. The helmet of claim 30, wherein the first, second, third, and fourth rigid or semi-rigid plates are moveable relative to each other.

38. A helmet as in claim 29, wherein the resilient, compressible material is a compliant rubber material.

39. A helmet as in claim 29, wherein the resilient, compressible material comprises one or more of: a nitrile, a thermoplastic elastomer, a set elastomer, and formable foam, and a set foam.

40. A helmet as in claim 29, wherein the resilient, compressible material extends along a length of the upper frame member.

41. A helmet as in claim 29, wherein the resilient, compressible material includes protrusions extending outwardly from the material interlock with corresponding openings in the first and second rigid or semi-rigid plates.

42. A helmet as in claim 38, wherein the resilient, compressible material comprises one or more pairs of longitudinal rails with V-shaped joints between the rails.

43. A helmet as in claim 42, wherein an external impact on the first or second rigid or semi-rigid plate causes at least a portion of the V-shaped joints to reversibly compress together.

44. A helmet as in claim 29, wherein the lower frame member comprises a first frame member portion on the left side of the helmet, and a second frame member portion on the right side of the helmet.

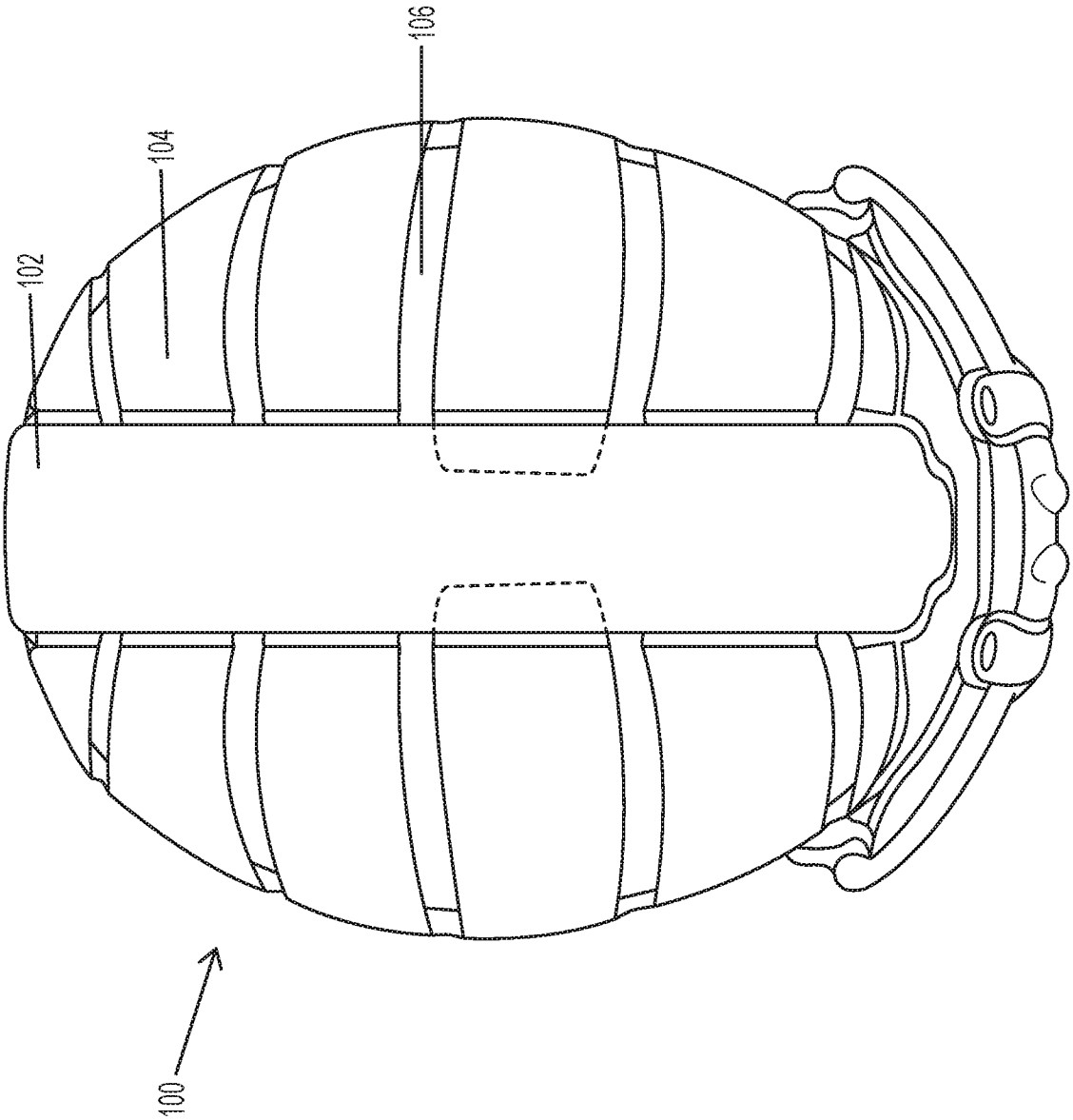

Fig. 1

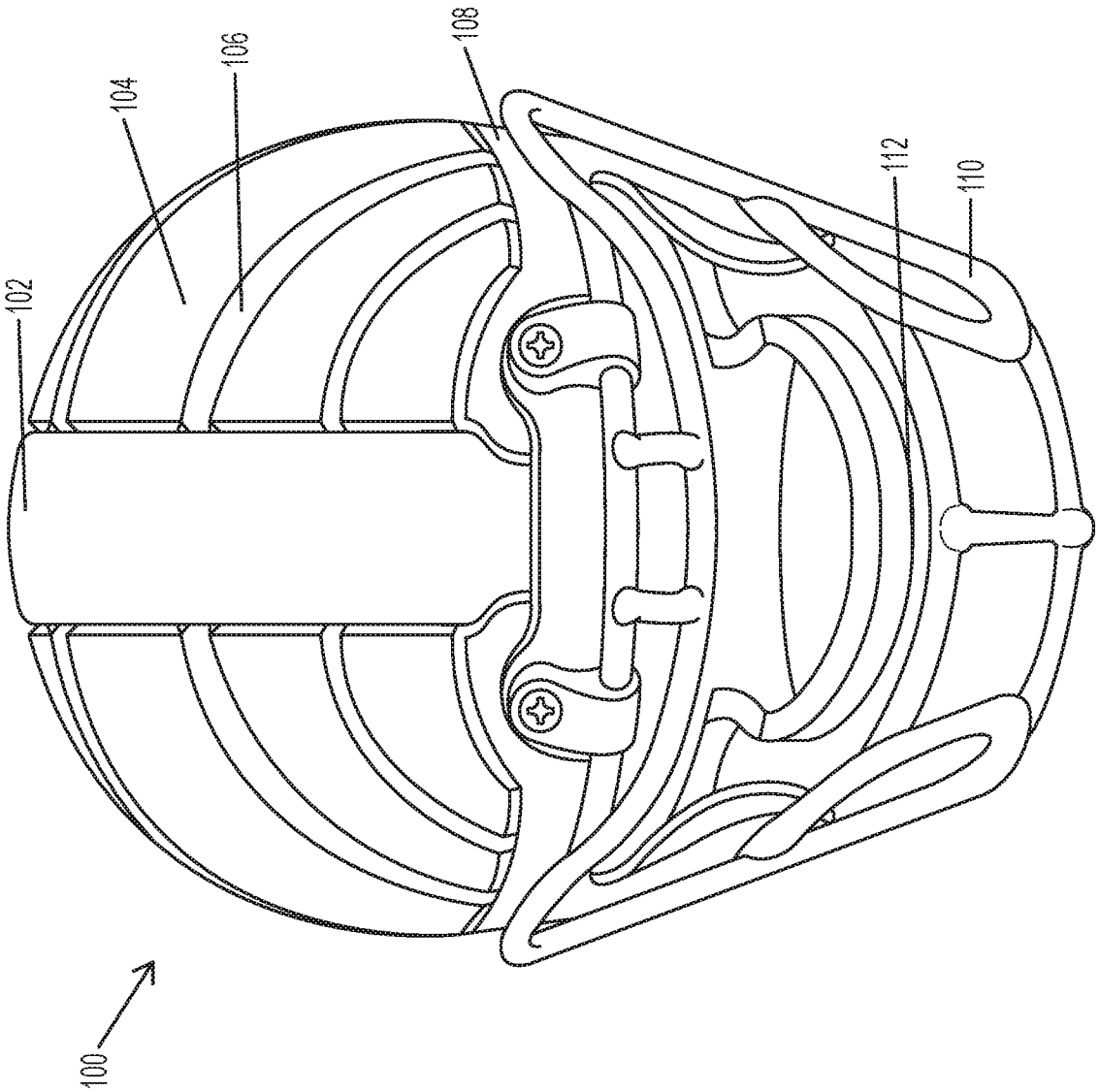

Fig. 2

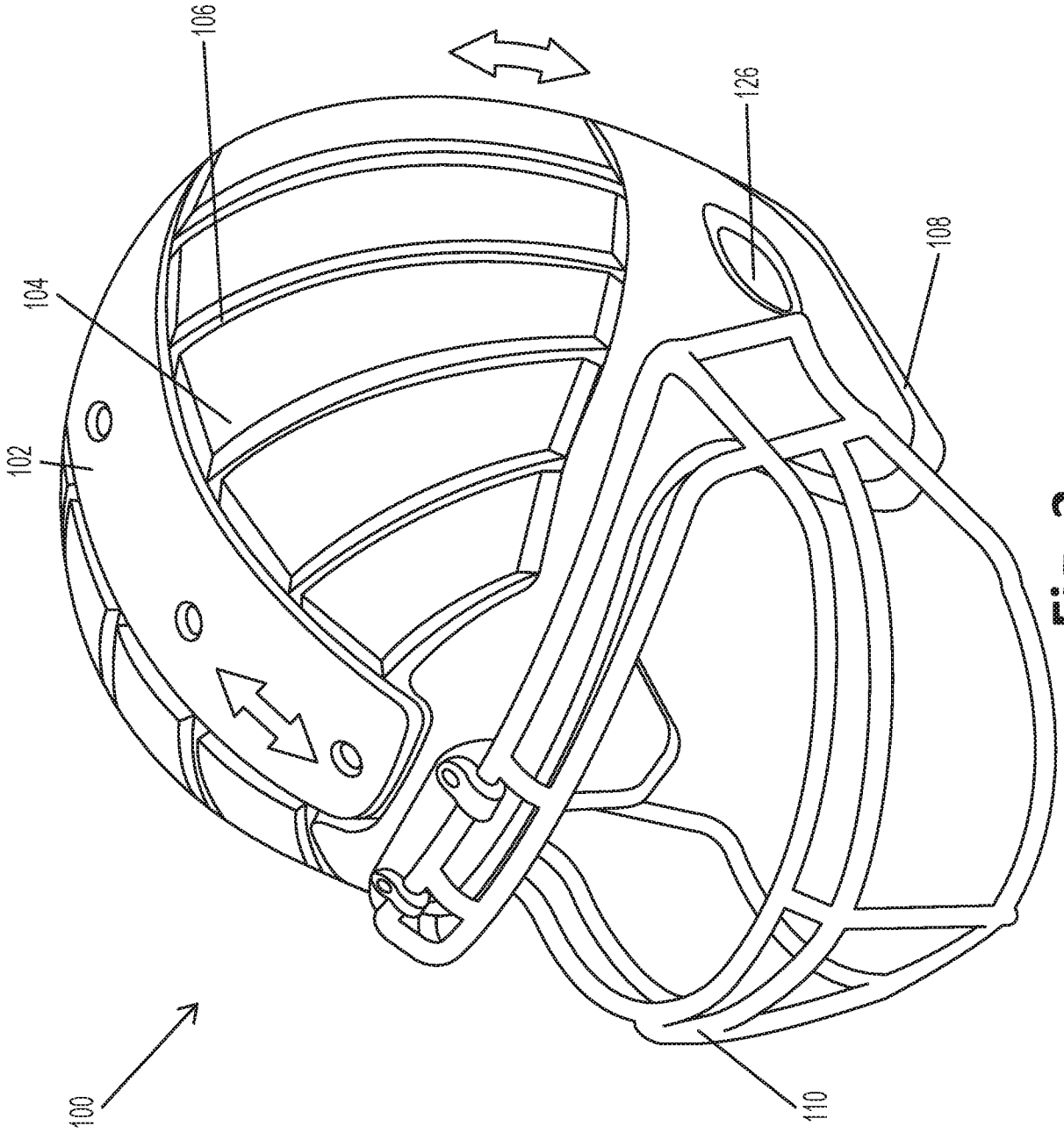

Fig. 3

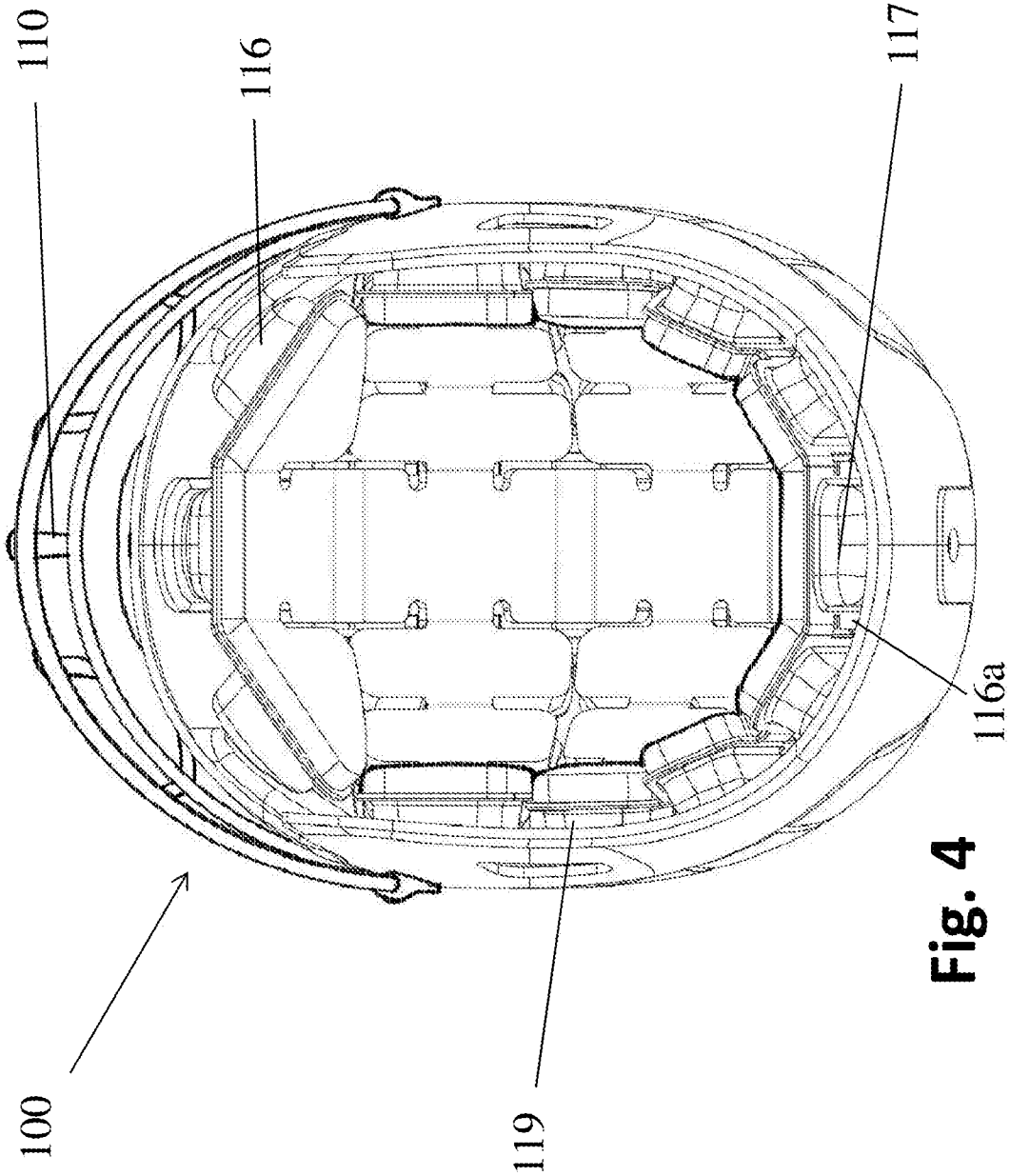

Fig. 4

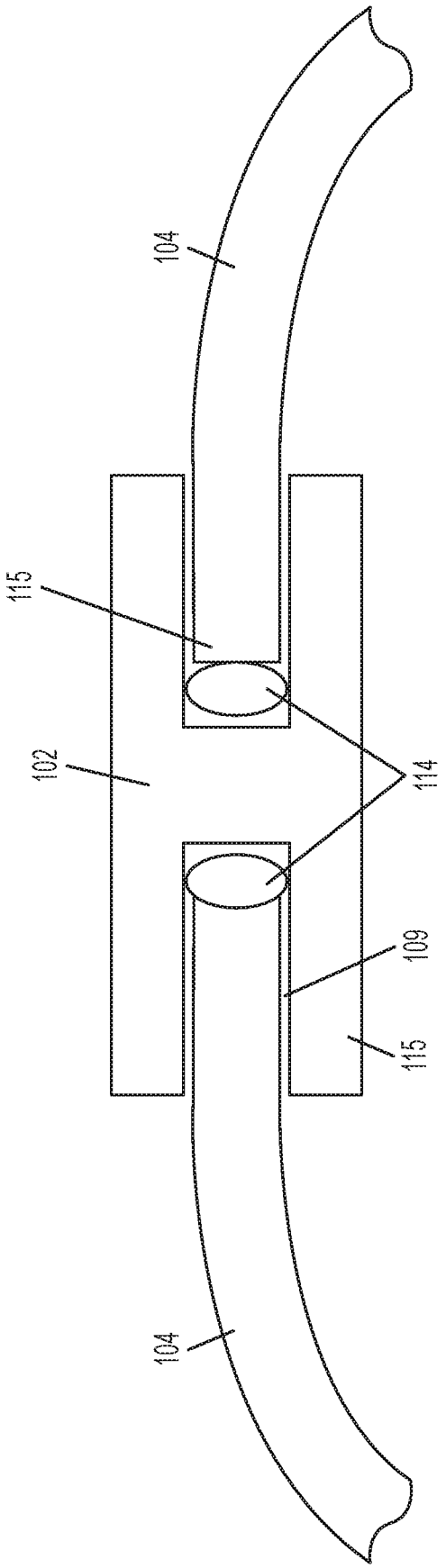

Fig. 5

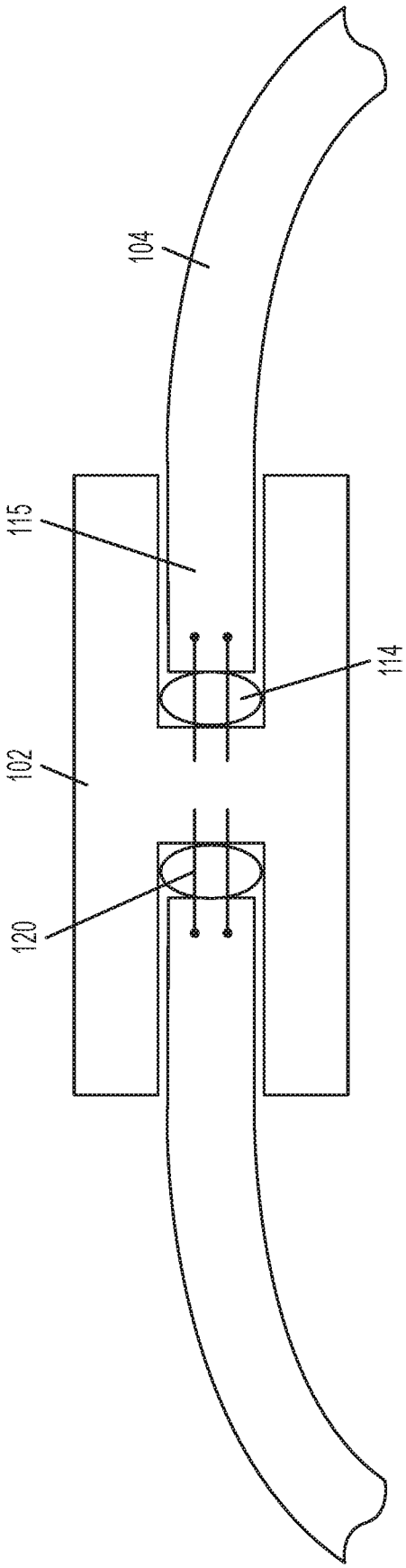

Fig. 6

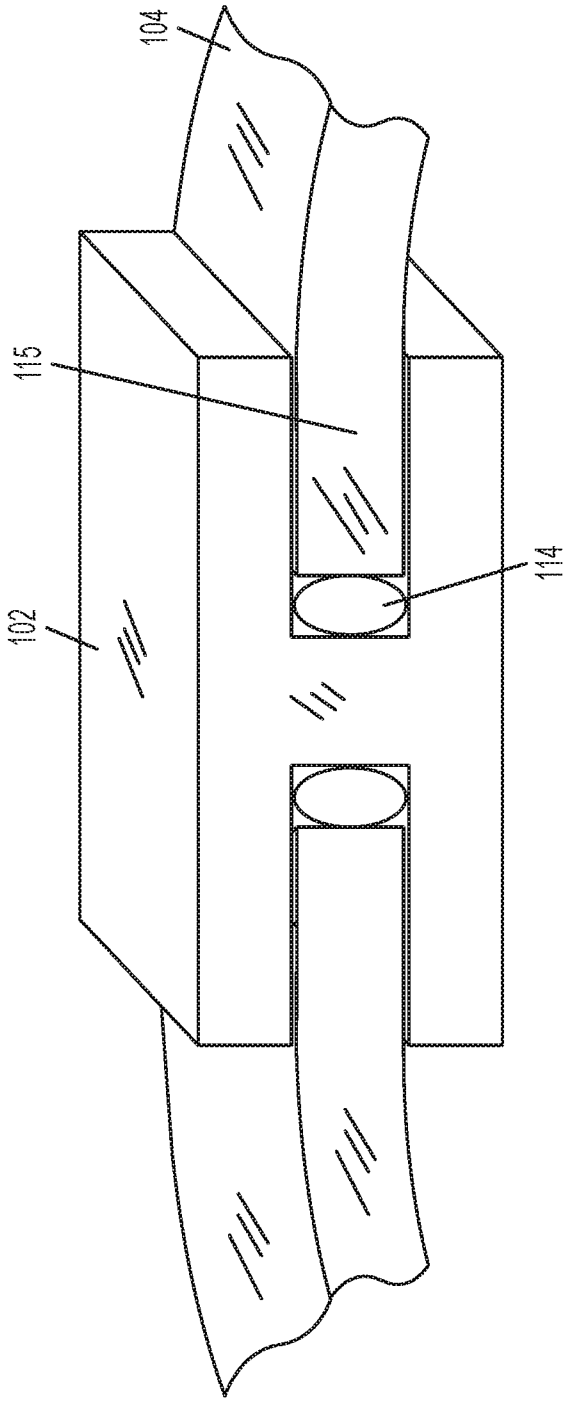

Fig. 7

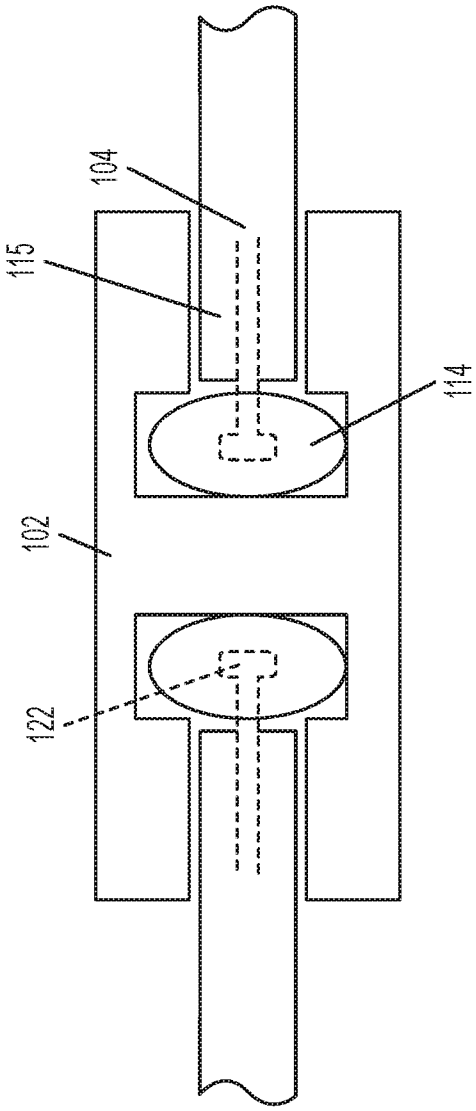

Fig. 8

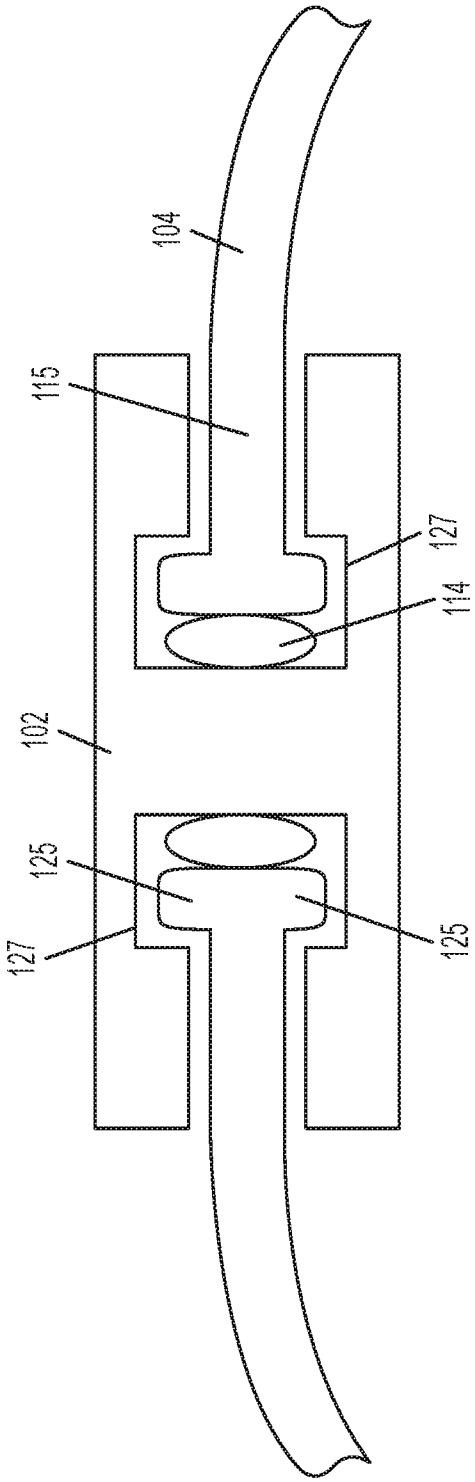

Fig. 9

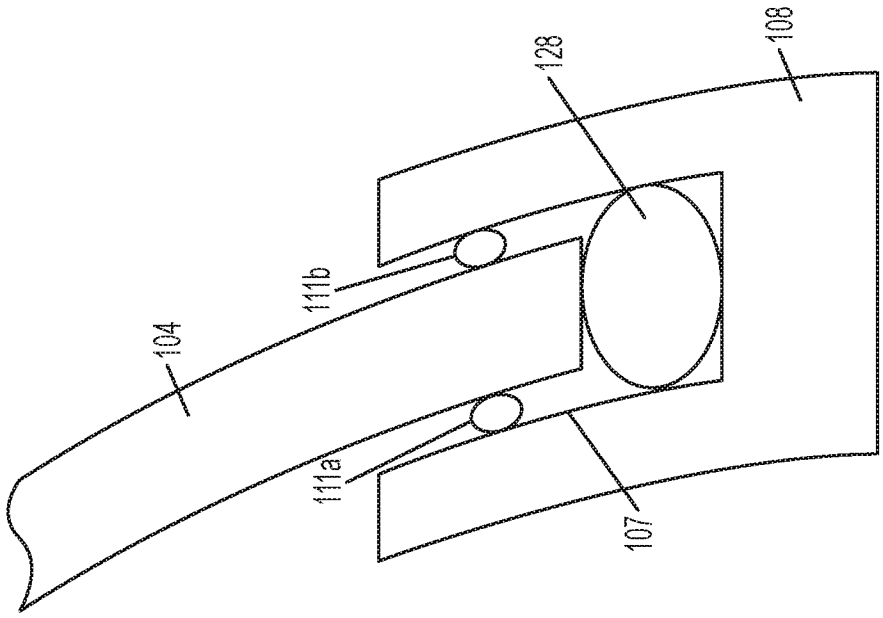

Fig. 10

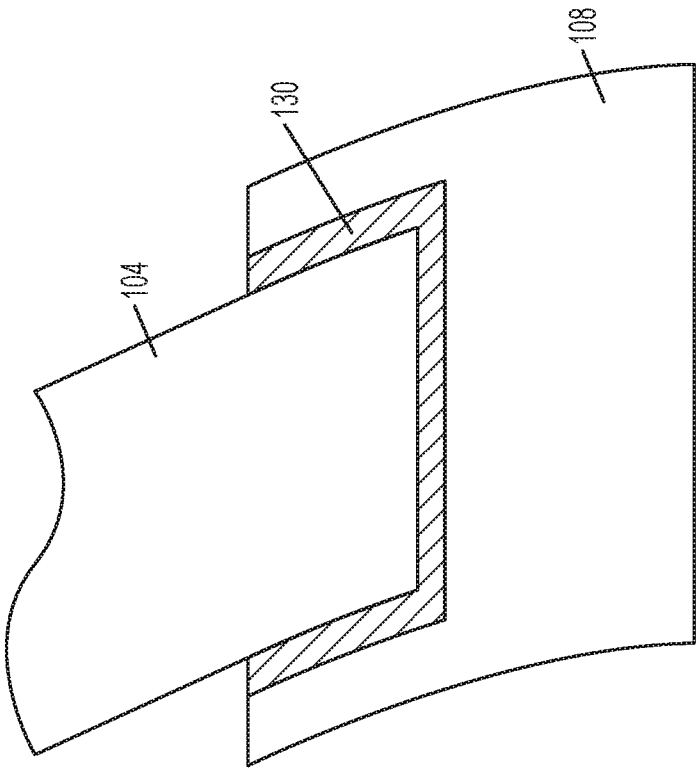

Fig. 11

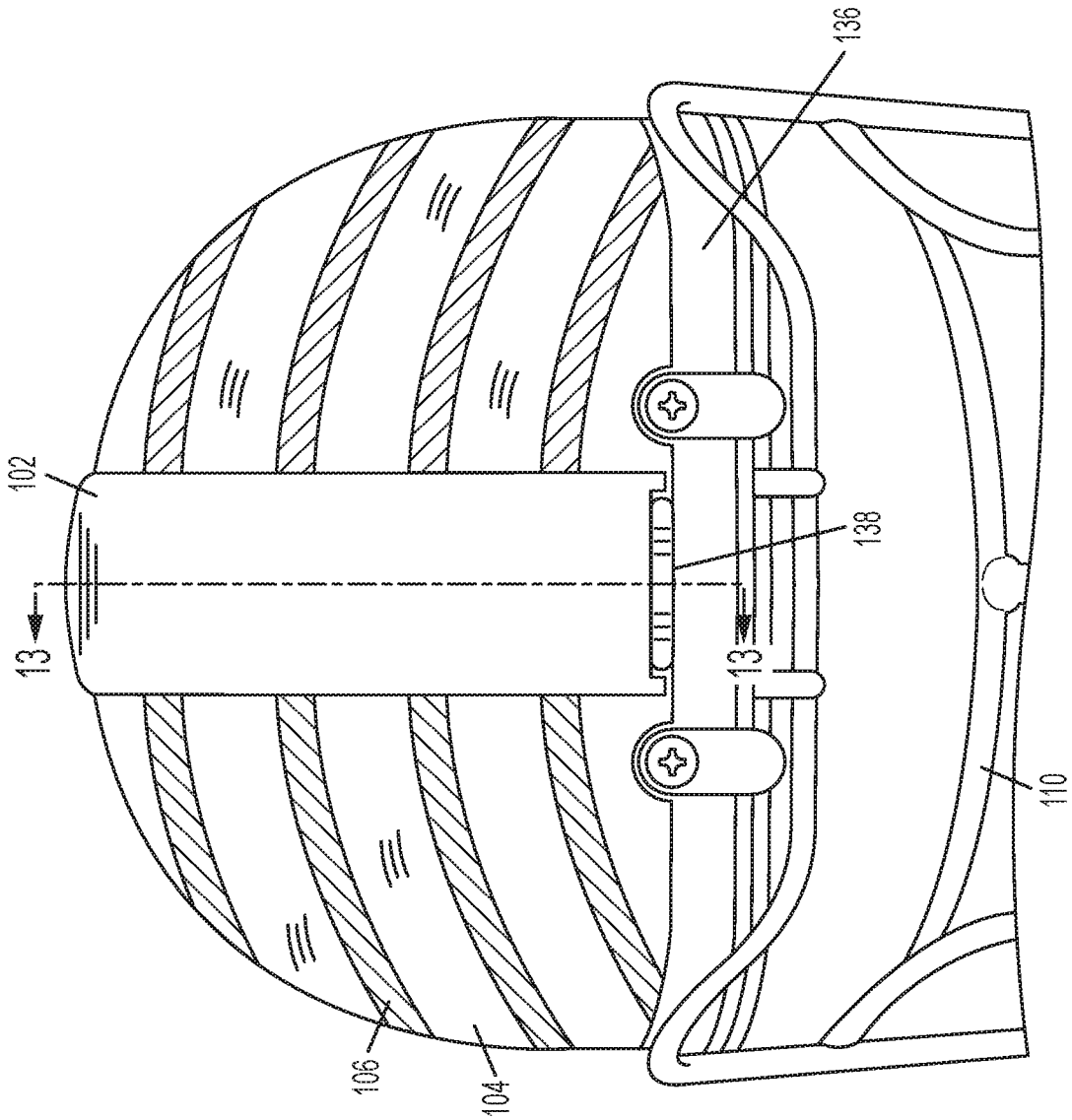

Fig. 12

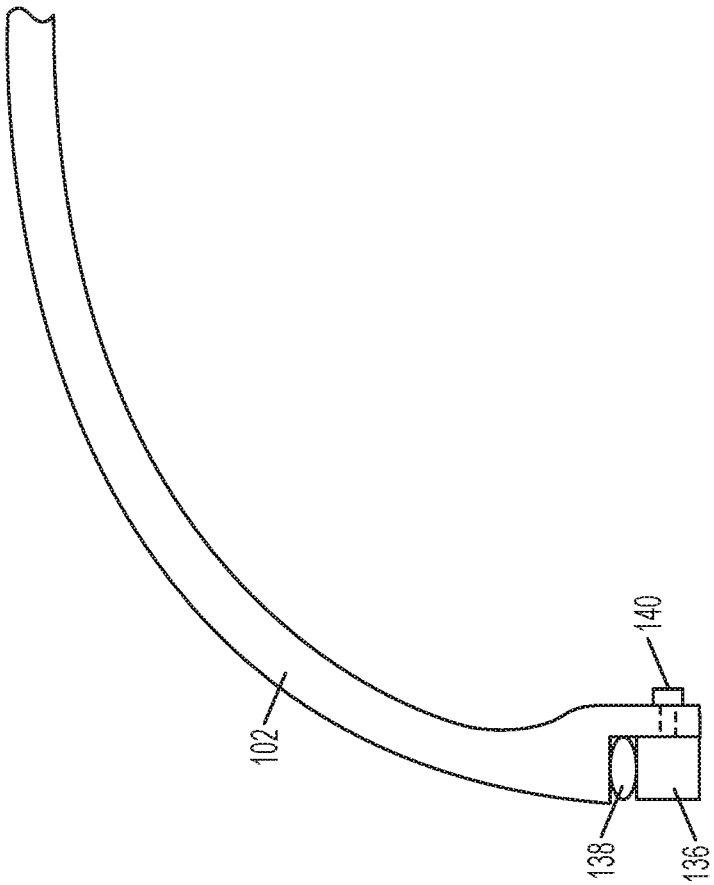

Fig. 13

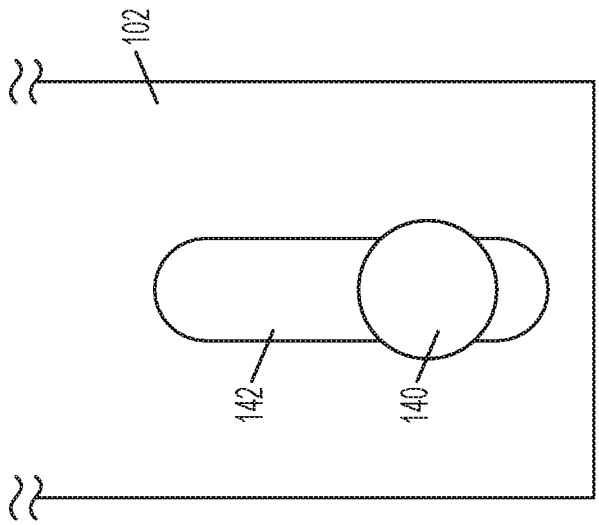

Fig. 14

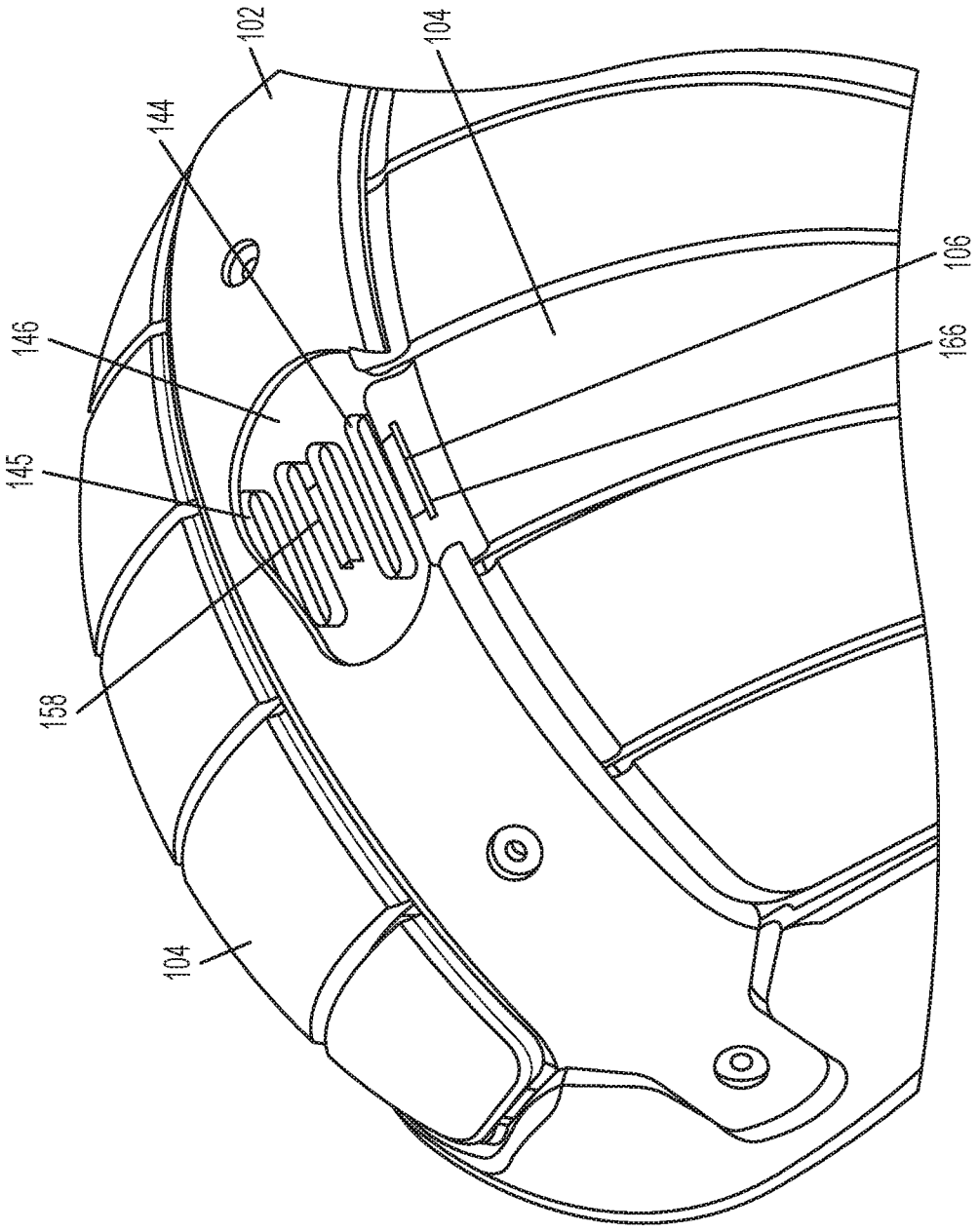

Fig. 15

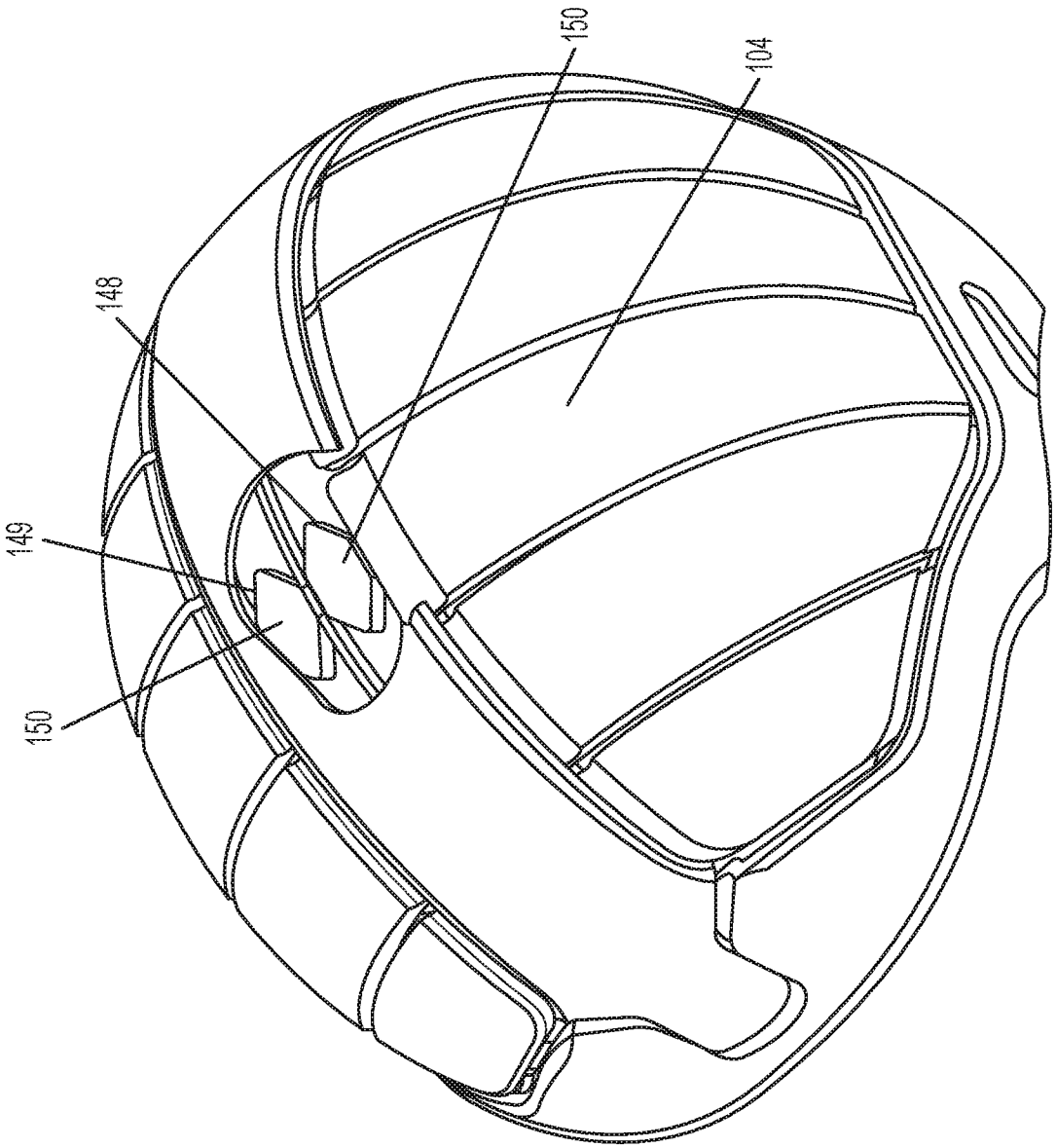

Fig. 16

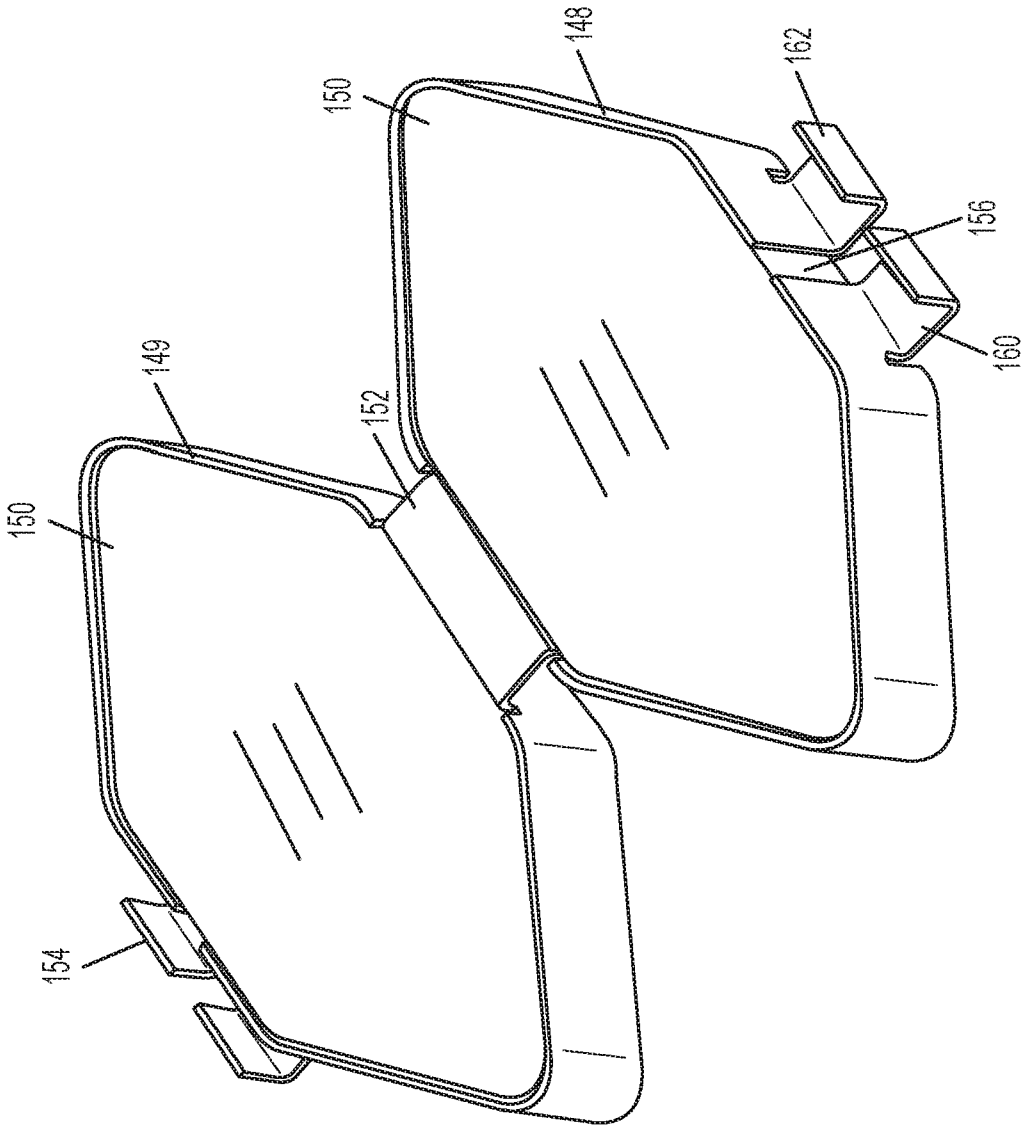

Fig. 17

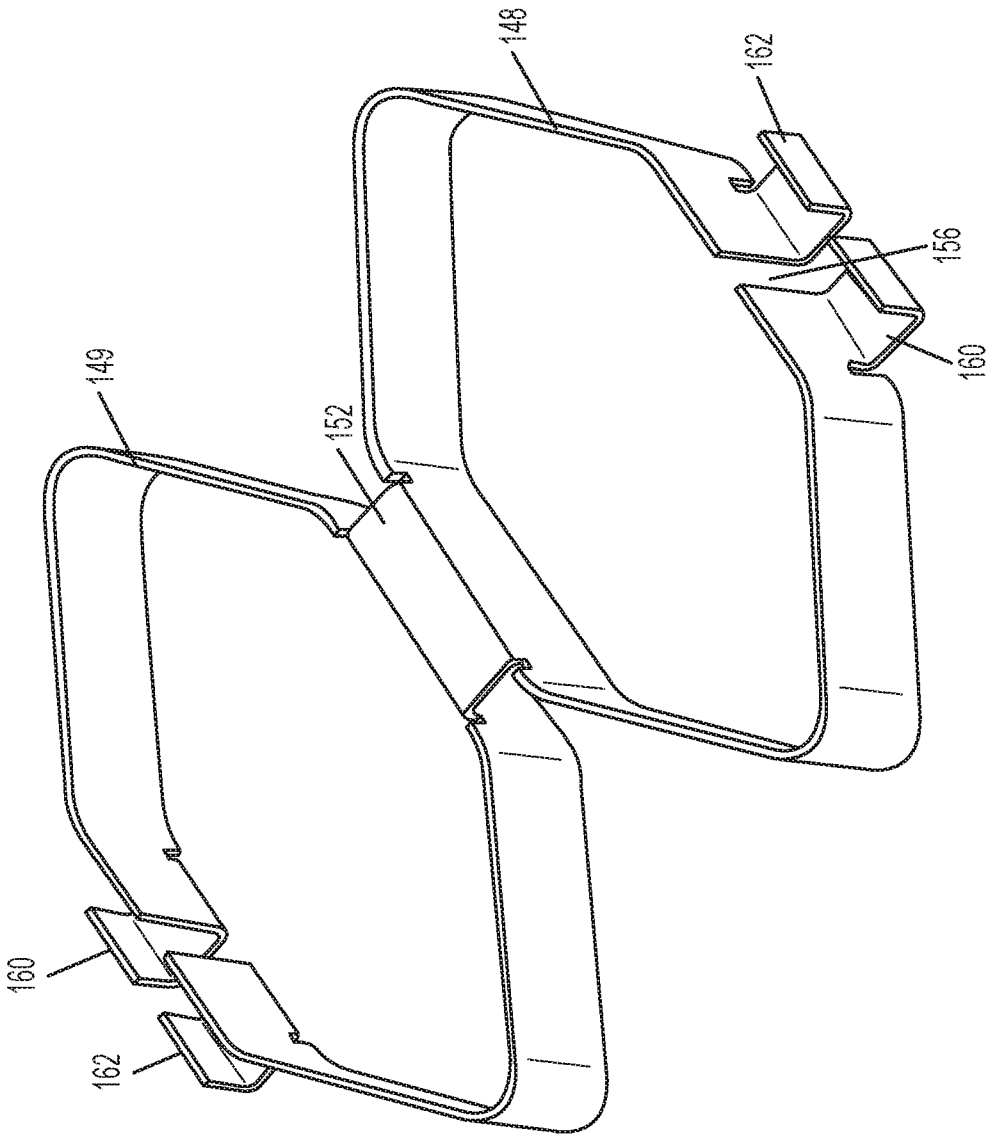

Fig. 18

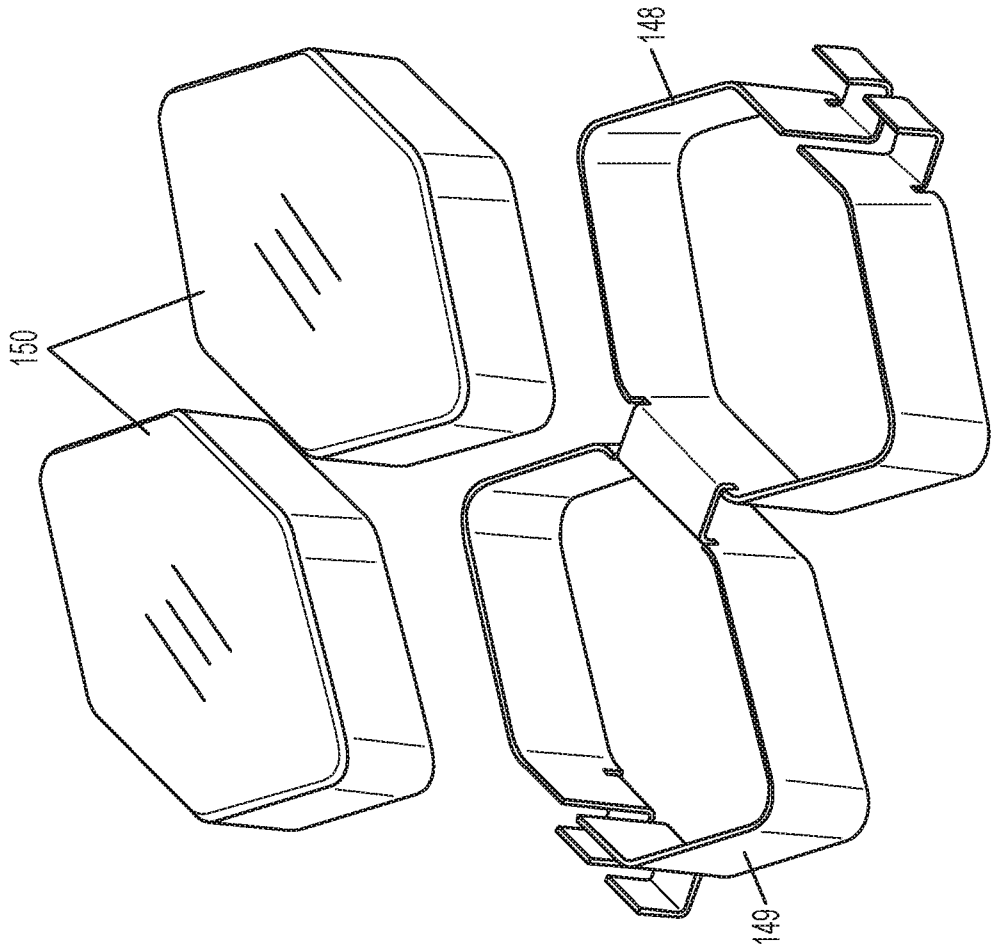

Fig. 19

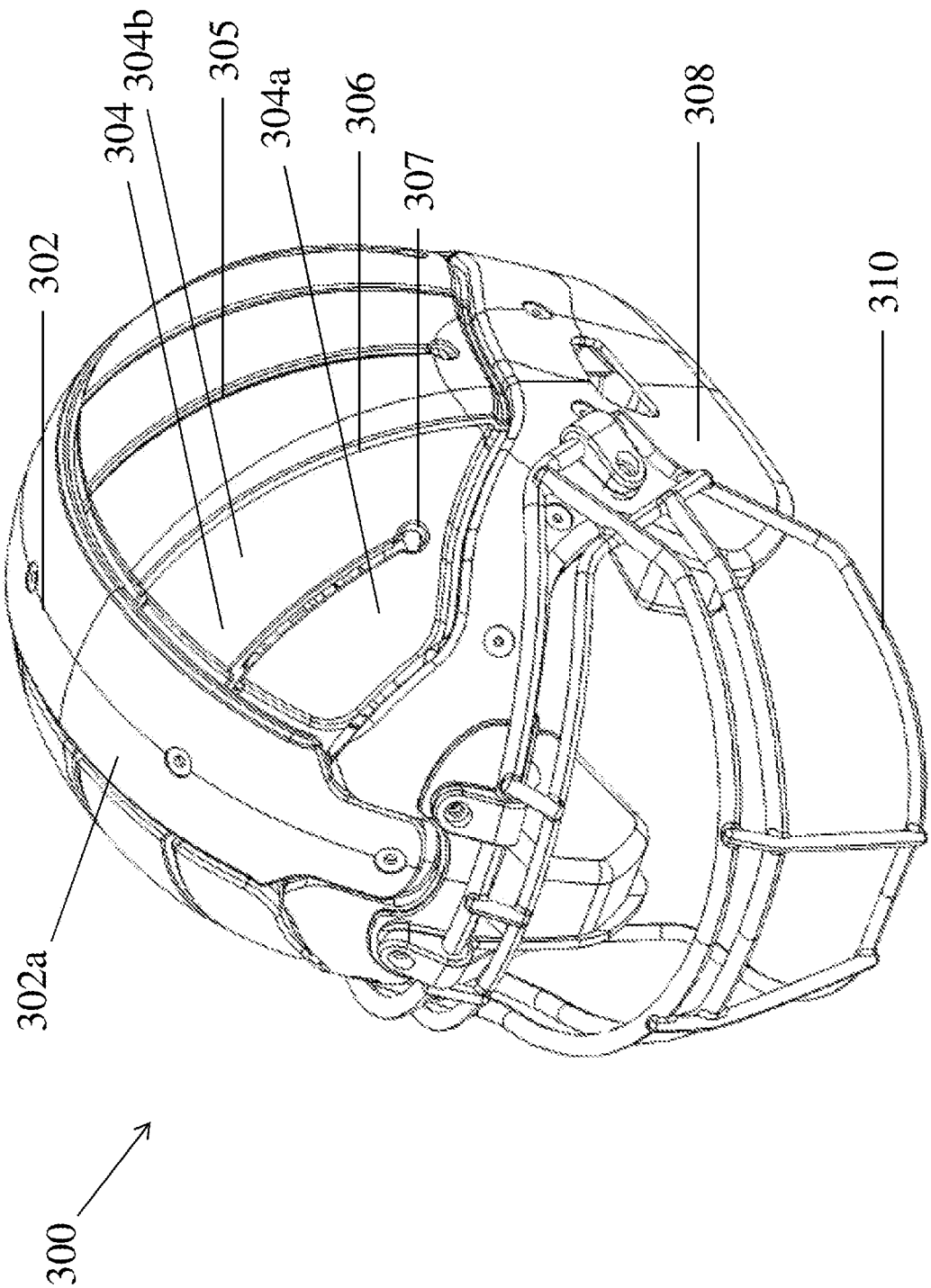

Fig. 20

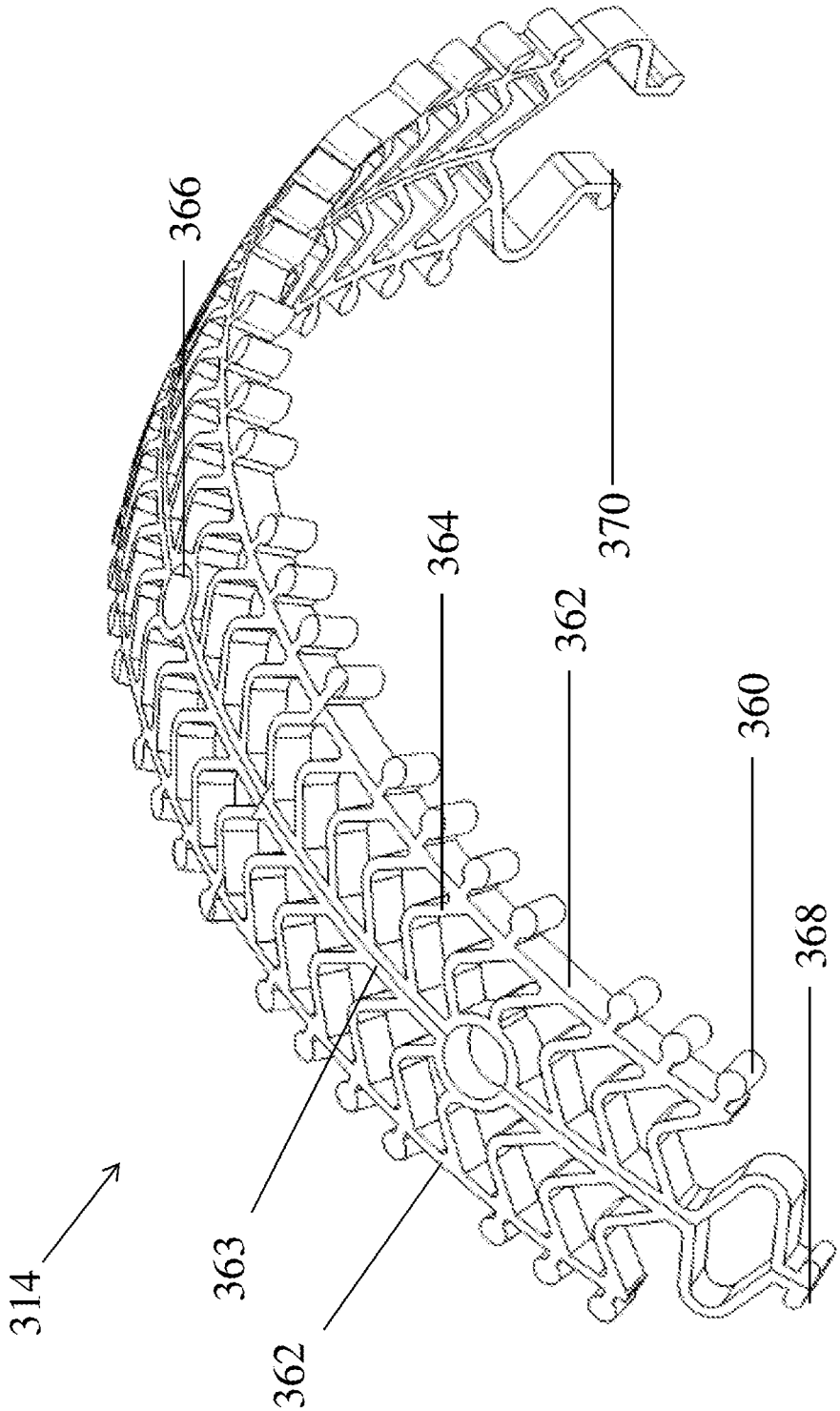

Fig. 21

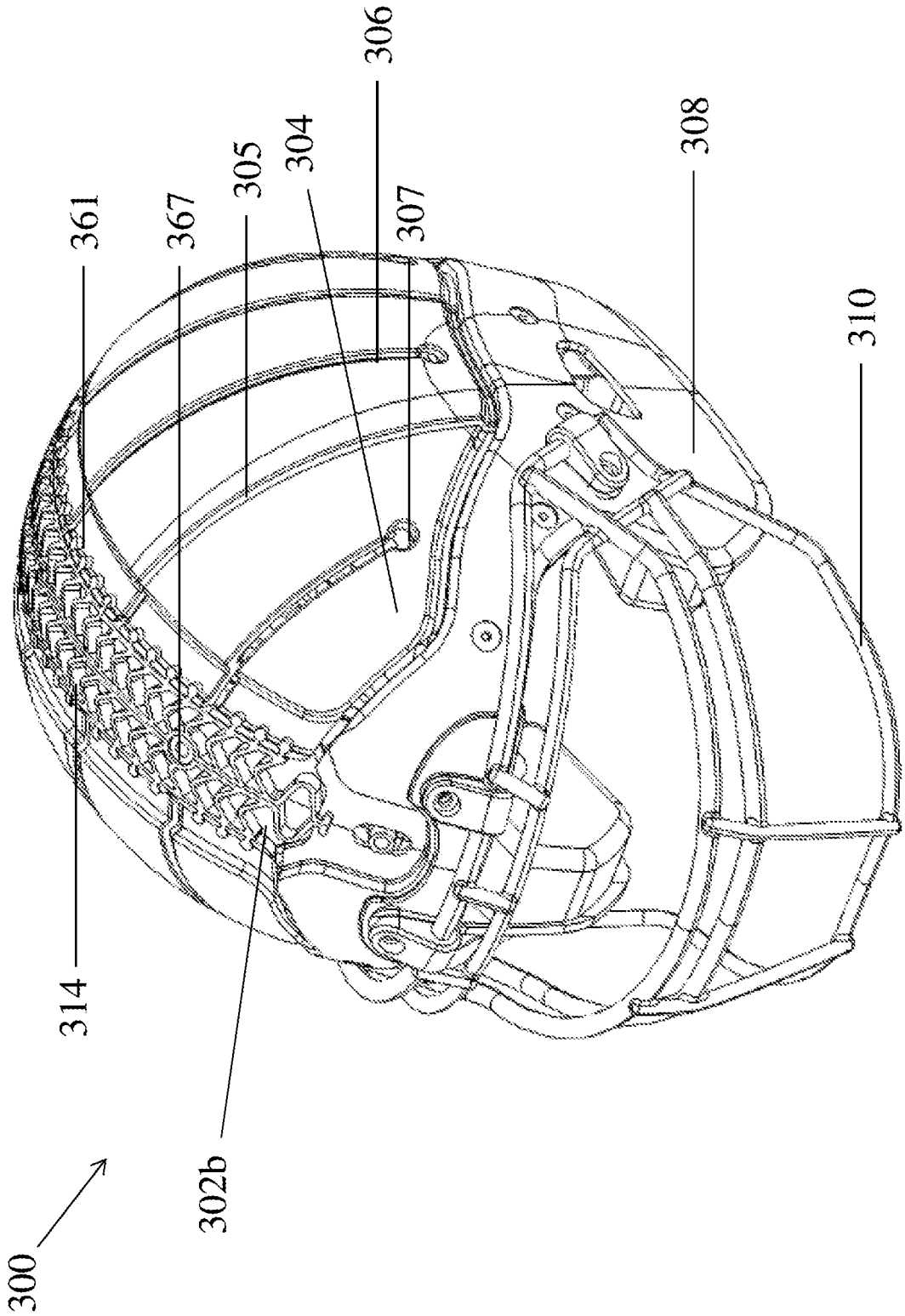

Fig. 22

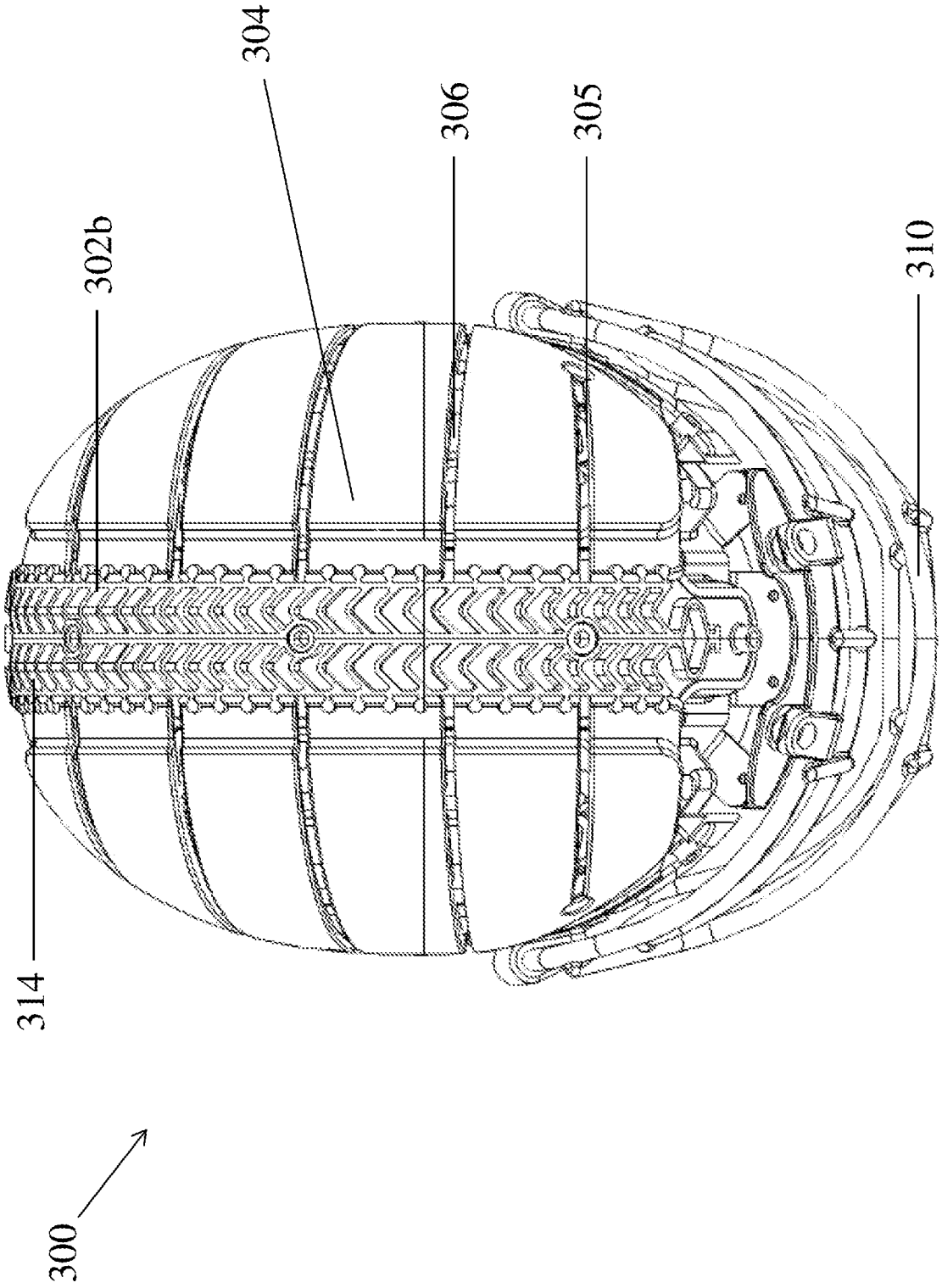

Fig. 23

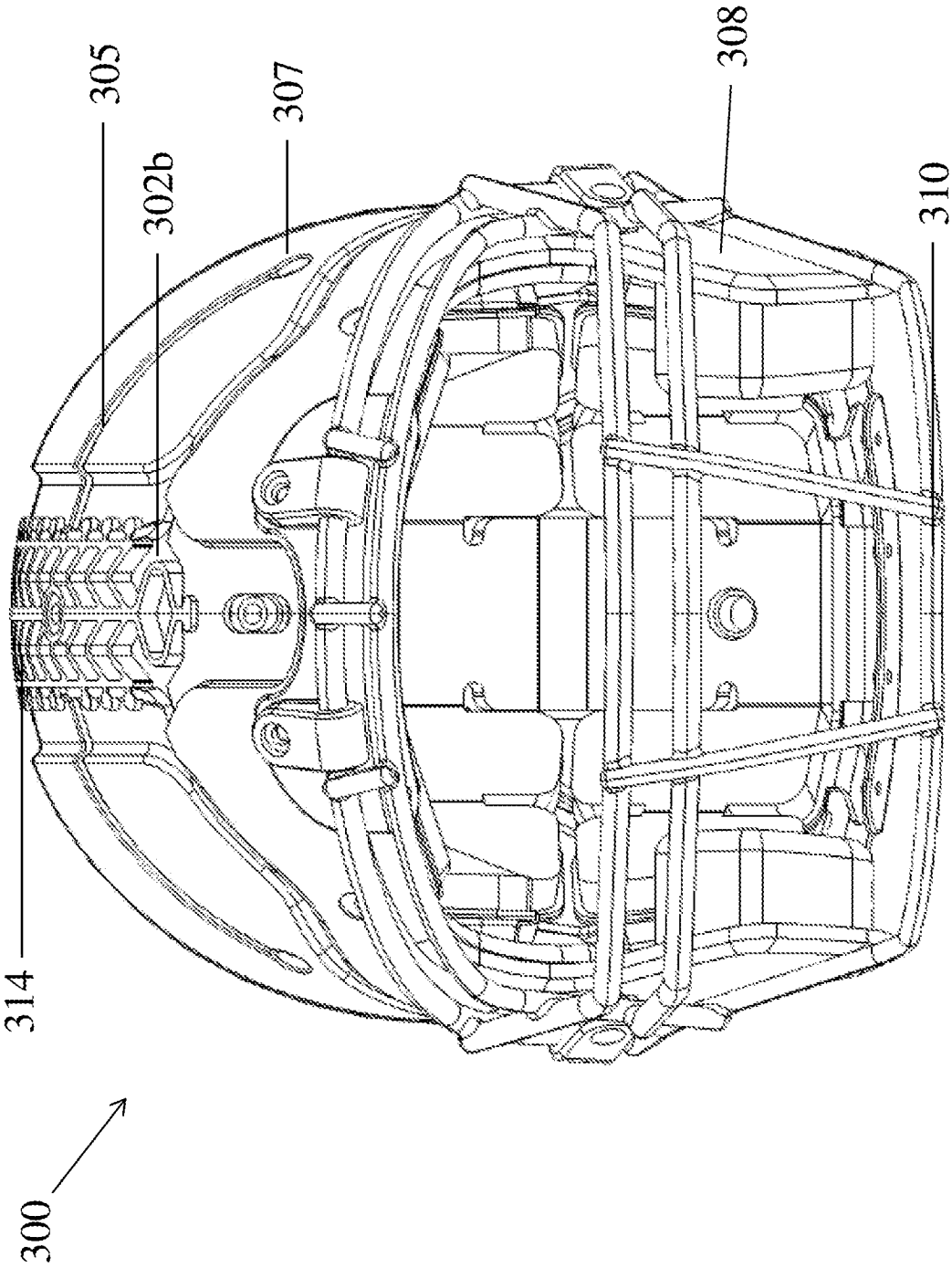

Fig. 24

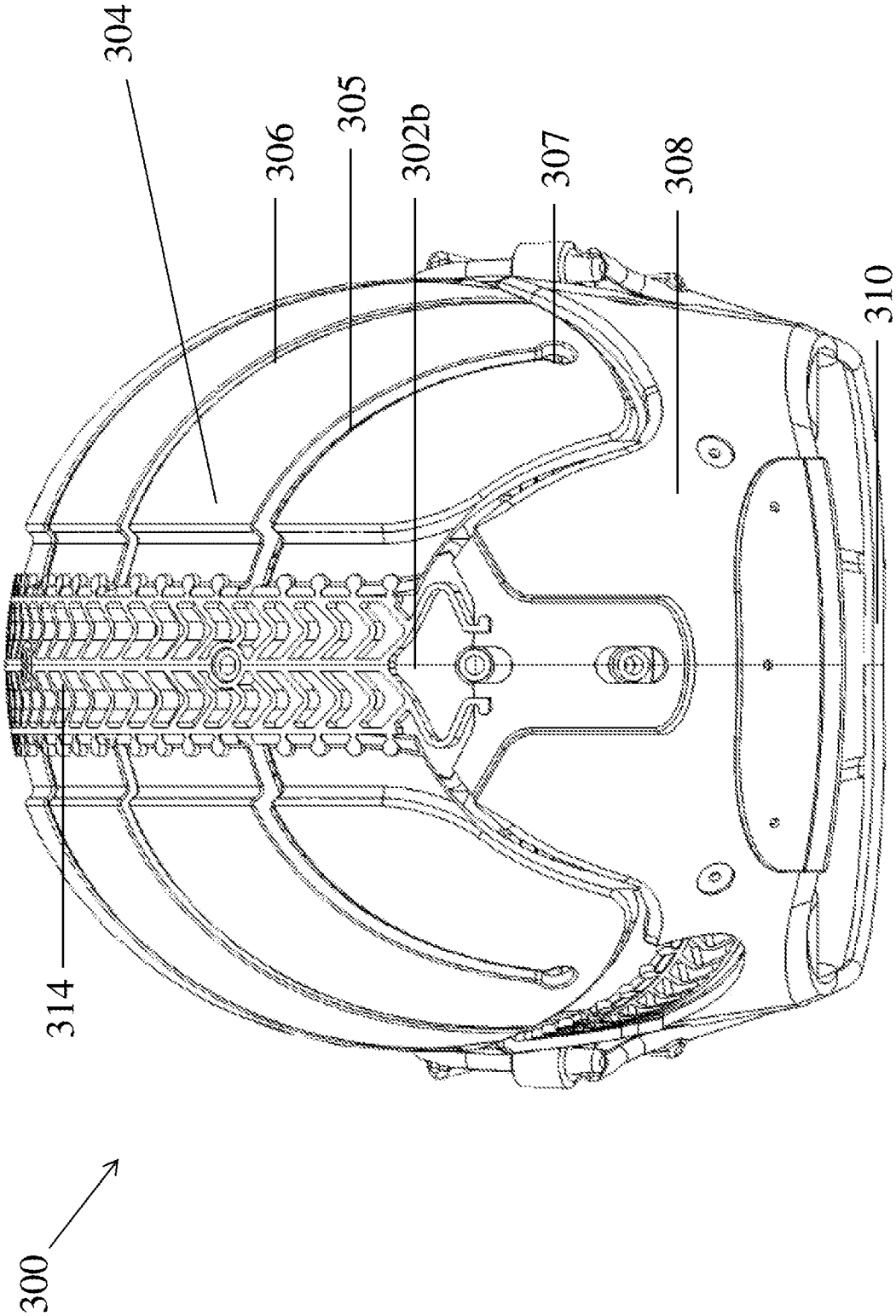

Fig. 25

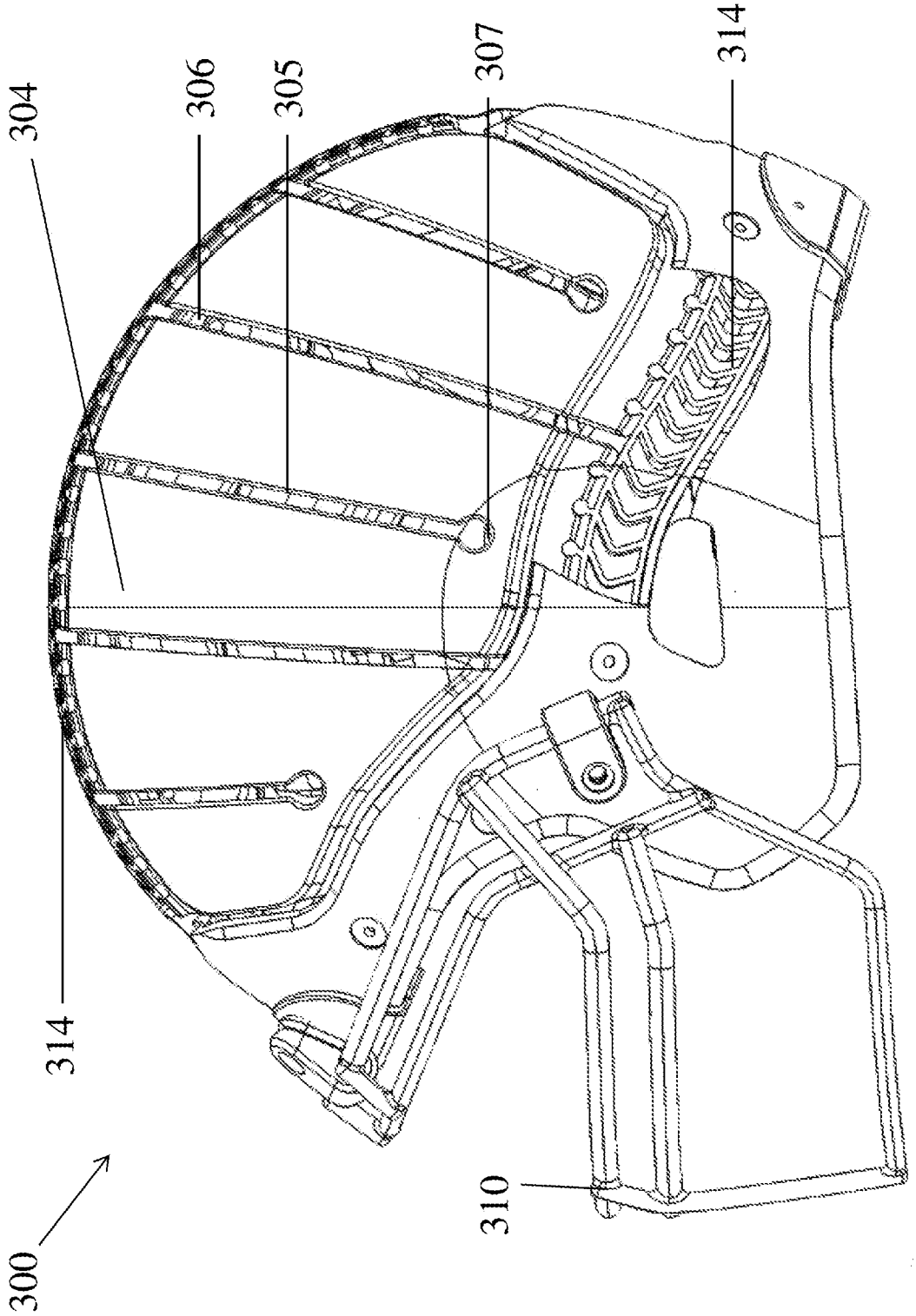

Fig. 26

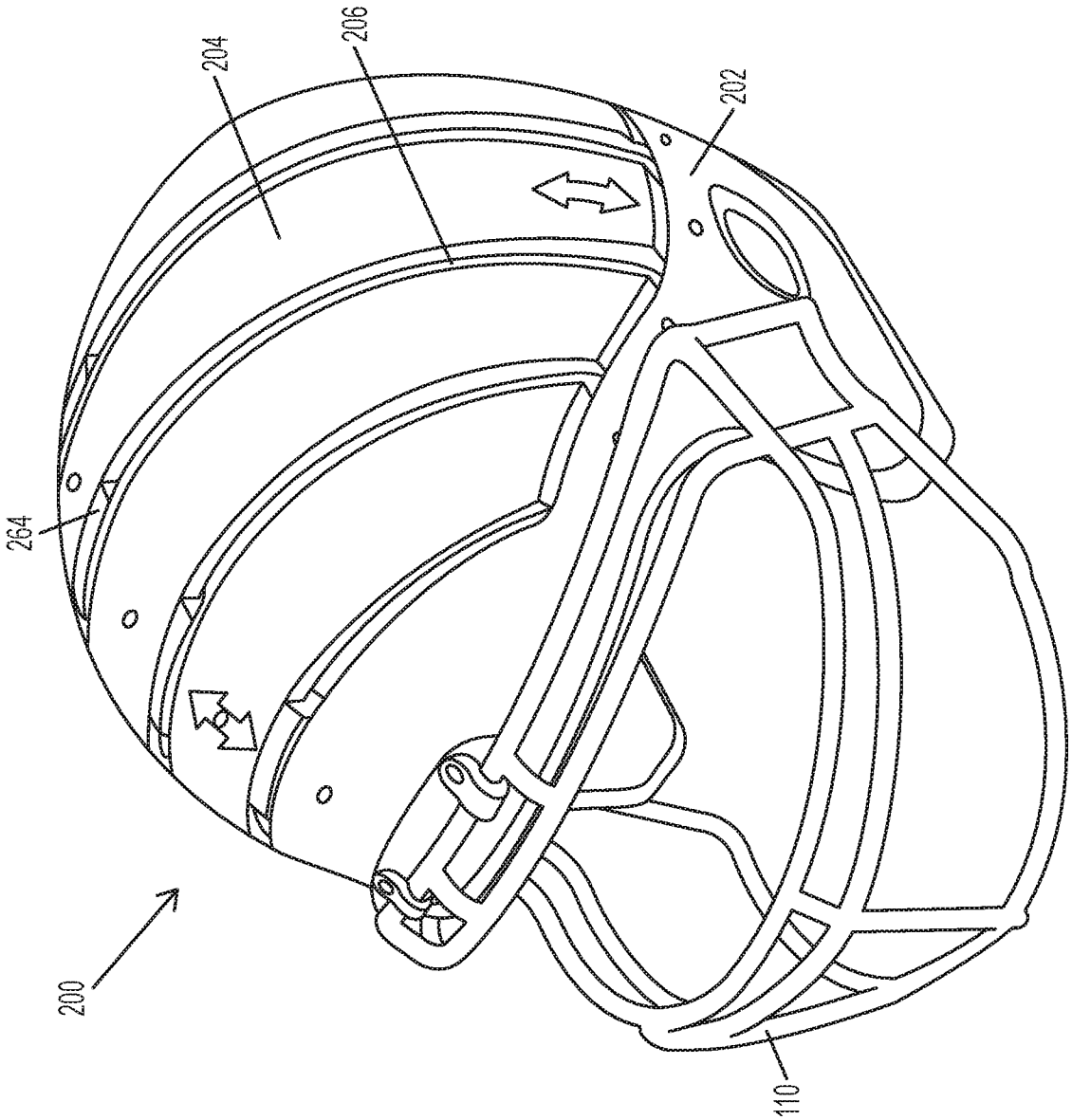

Fig. 27

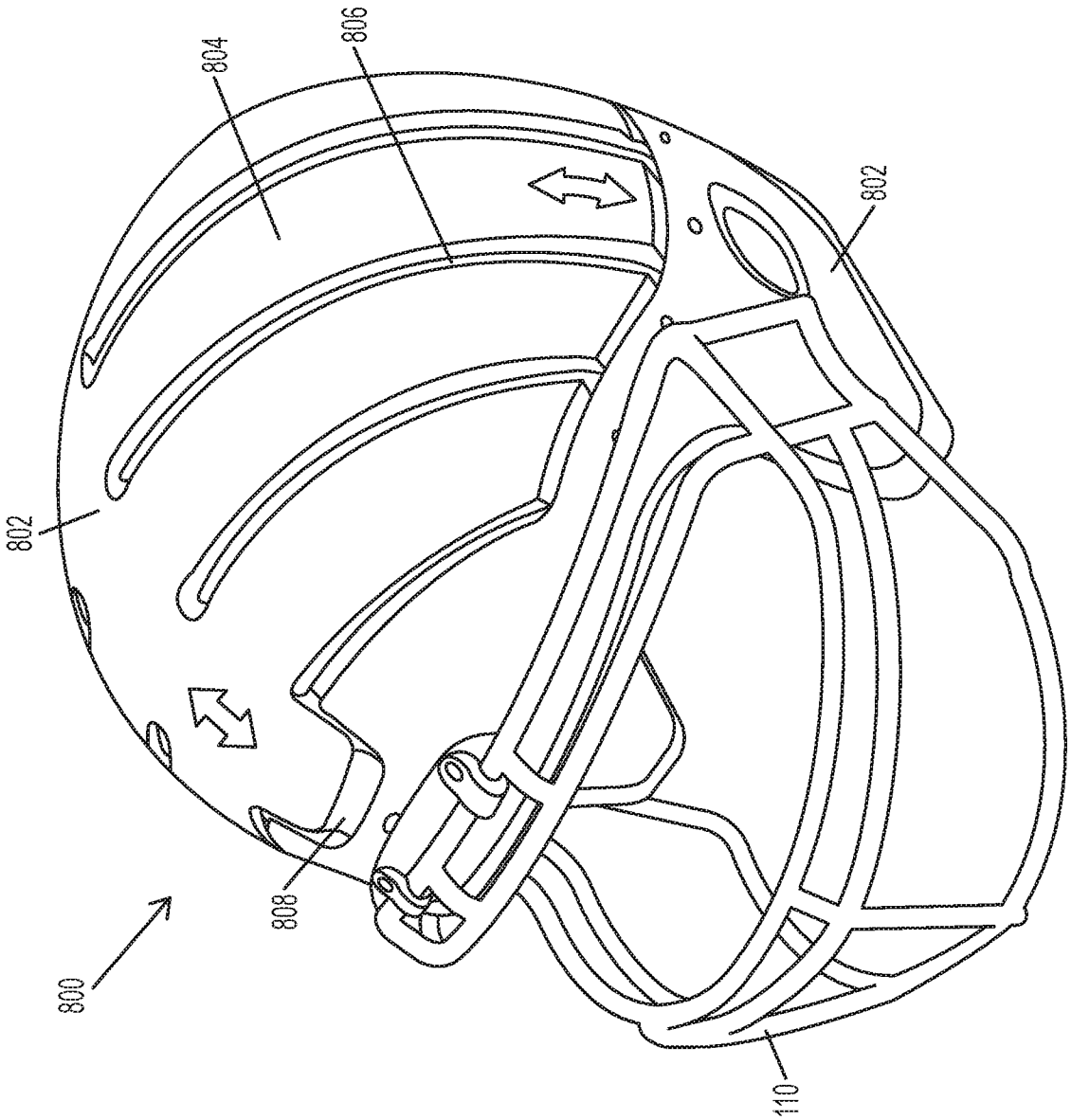

Fig. 28

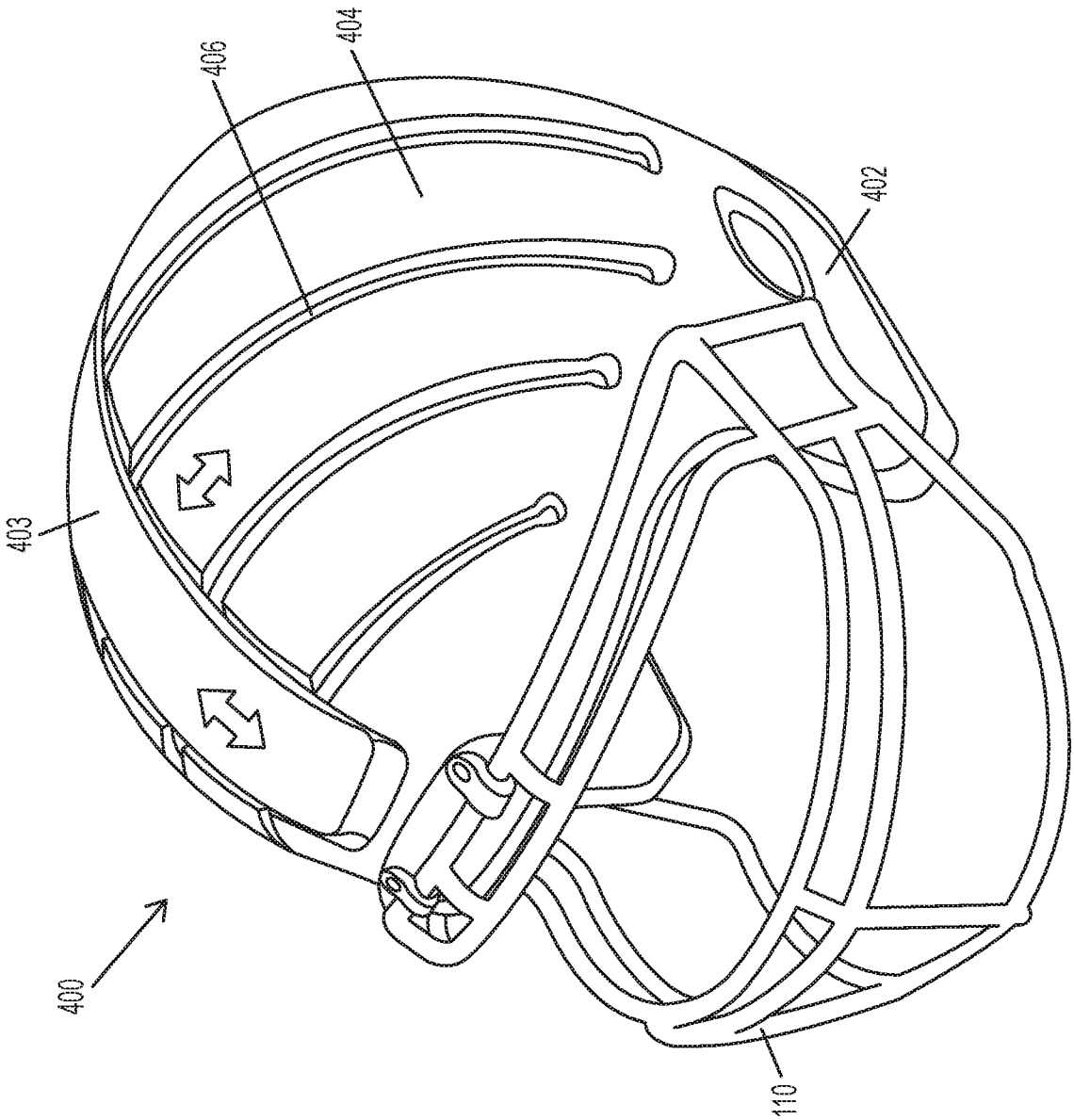

Fig. 29

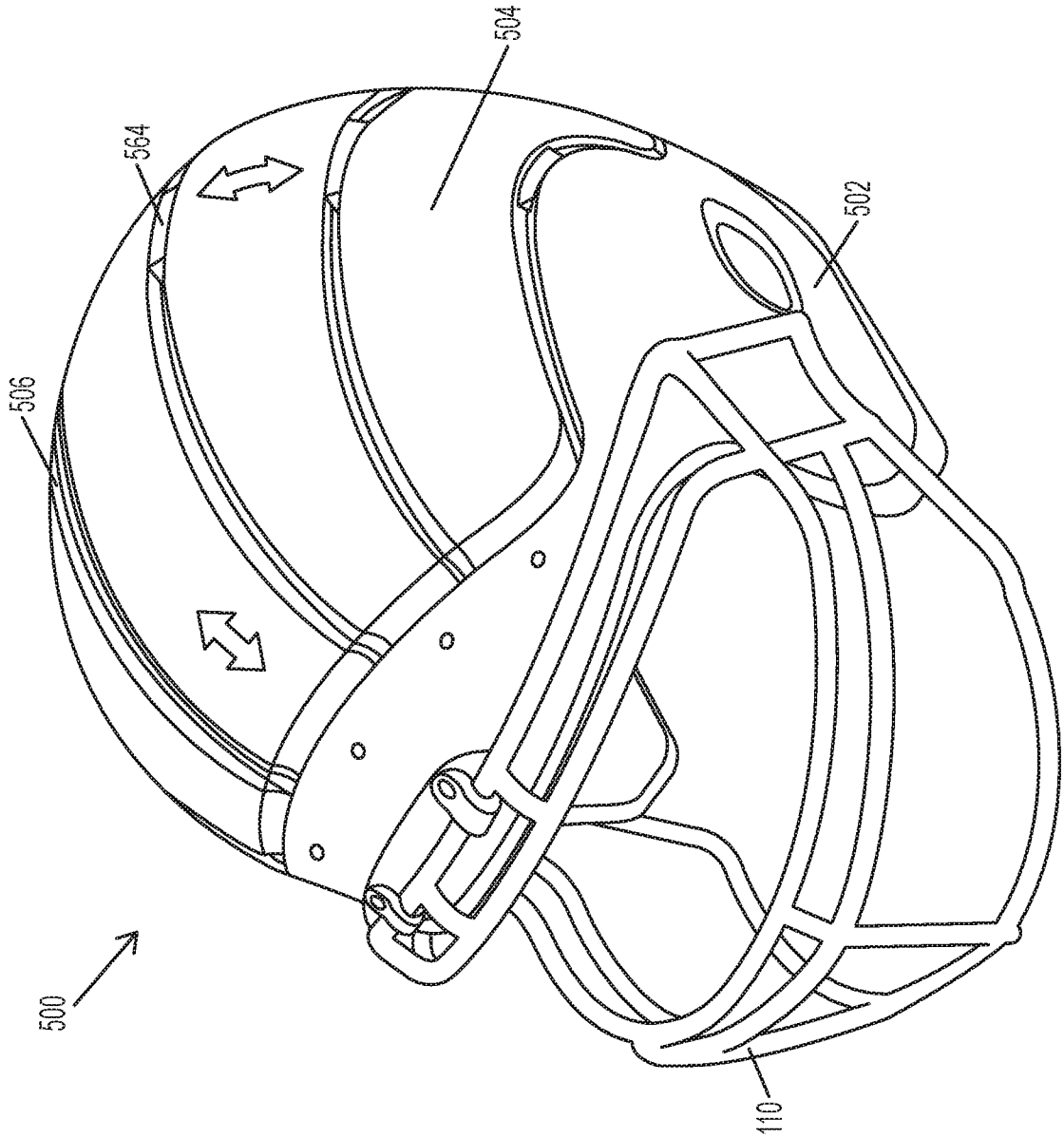

Fig. 30

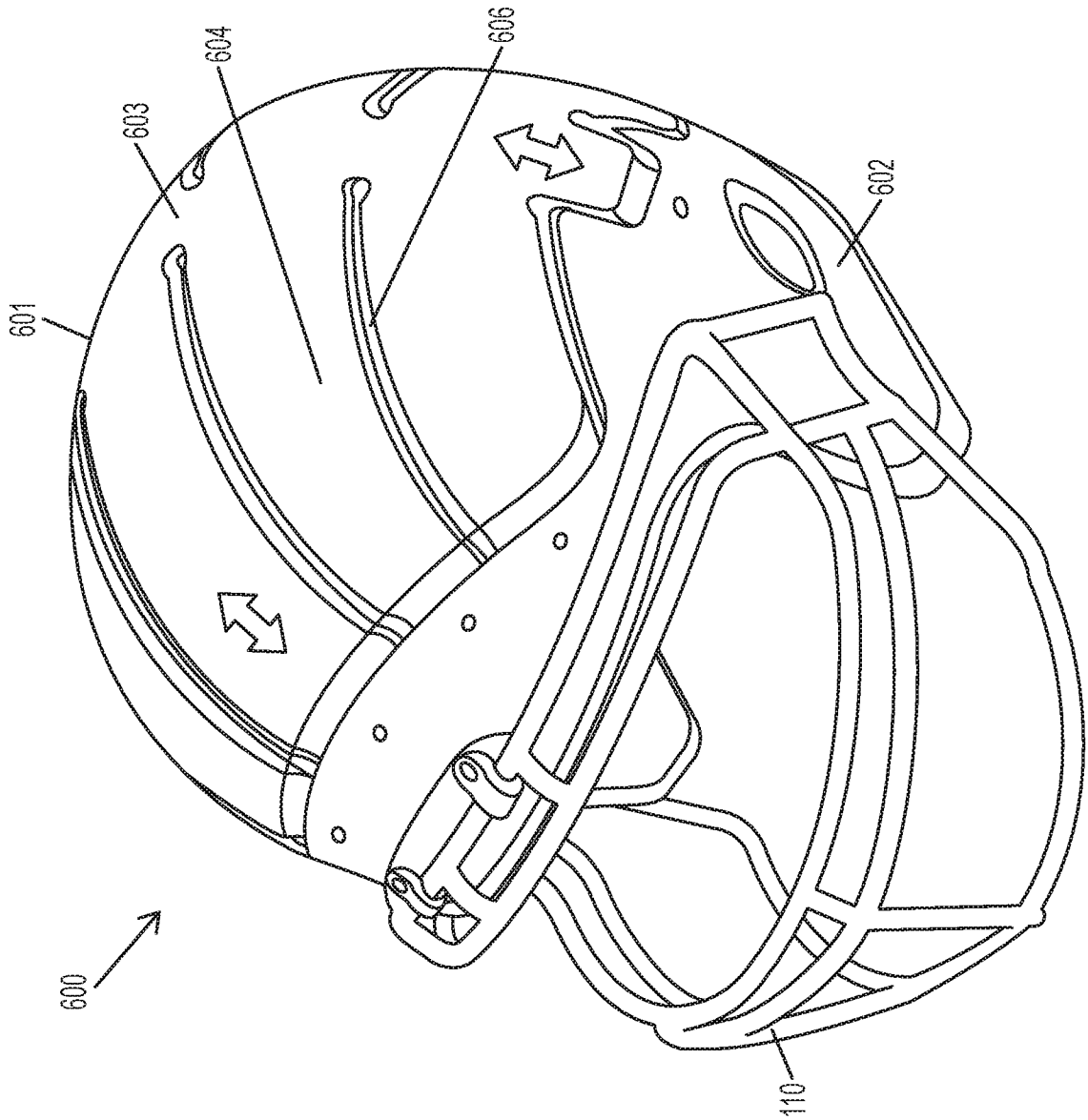

Fig. 31

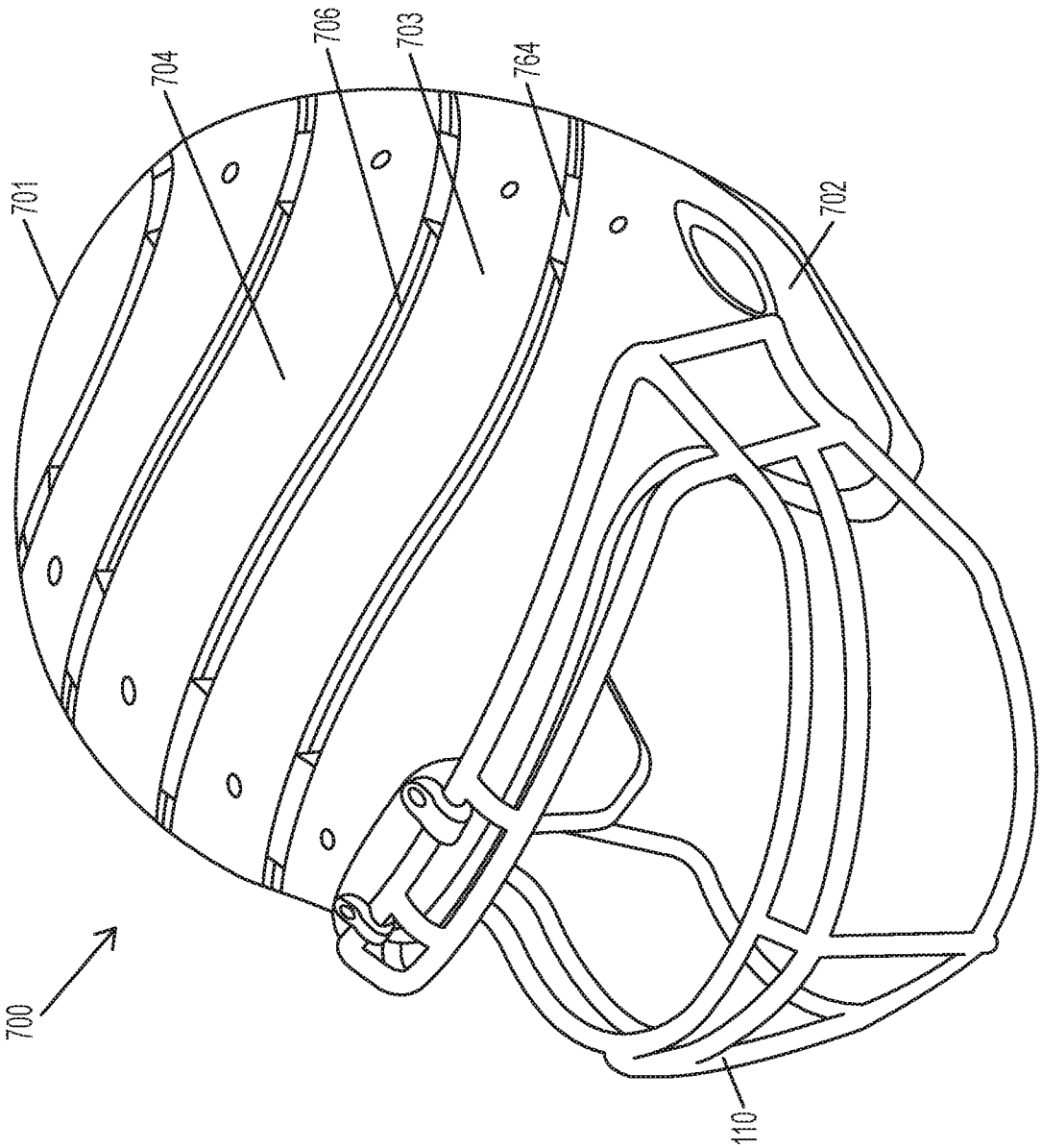

Fig. 32

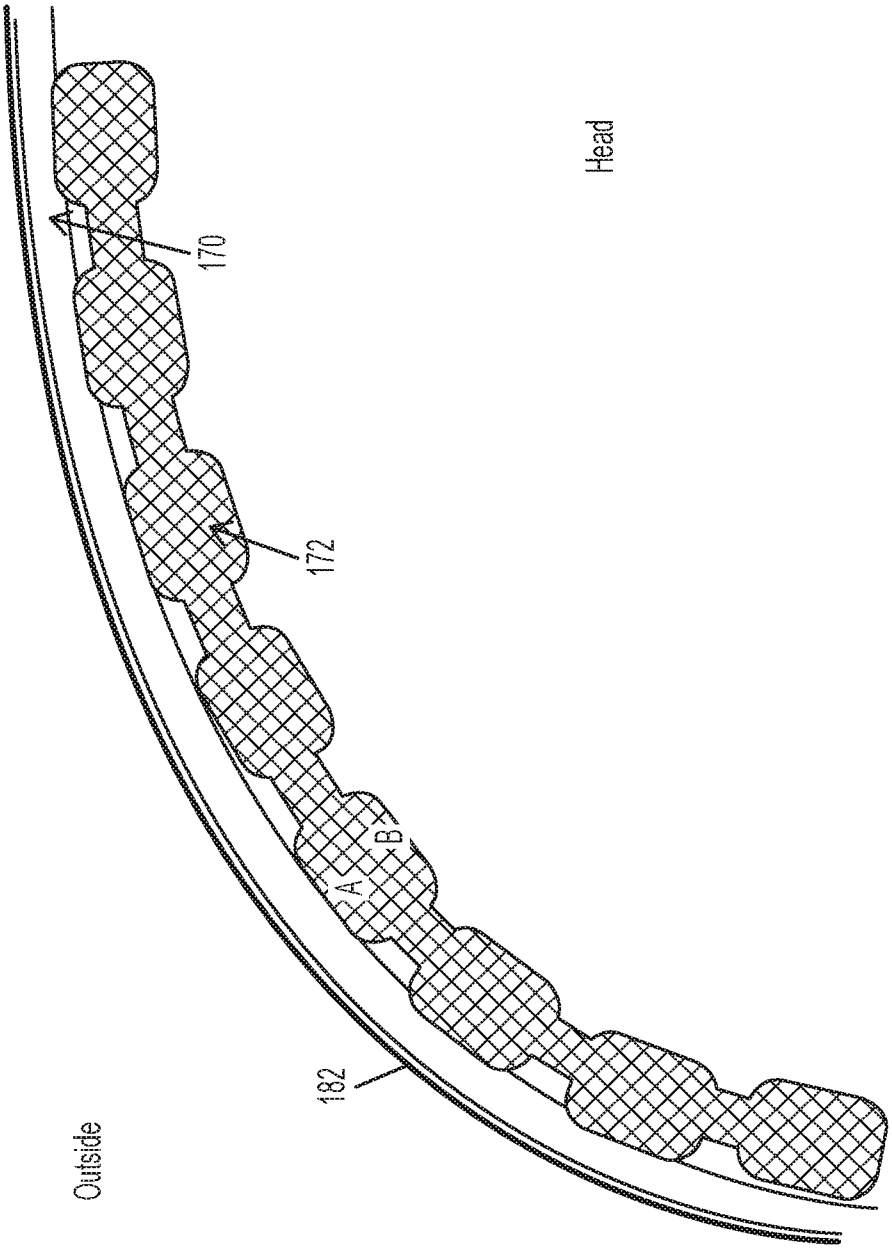

Fig. 33

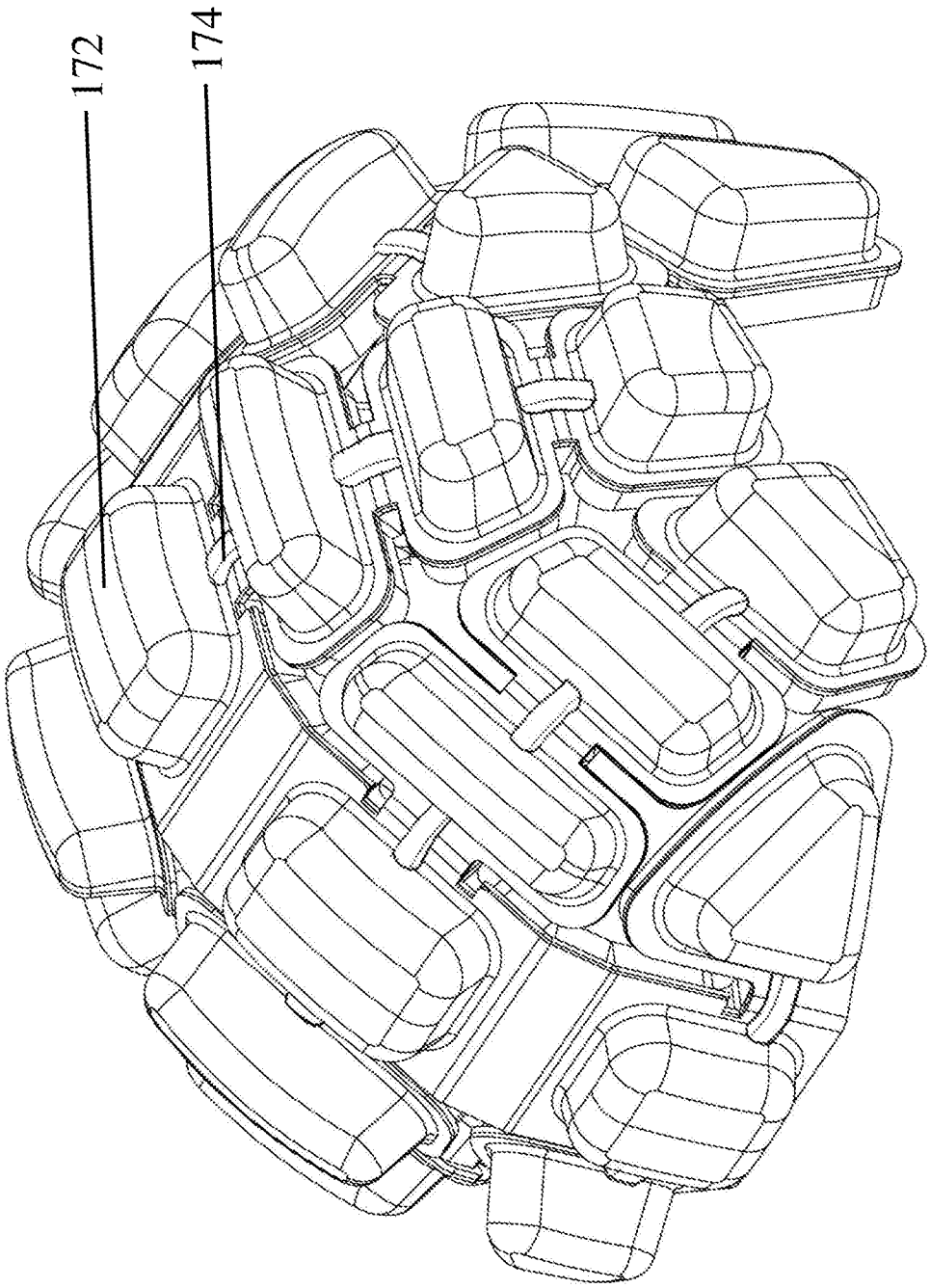

Fig. 34

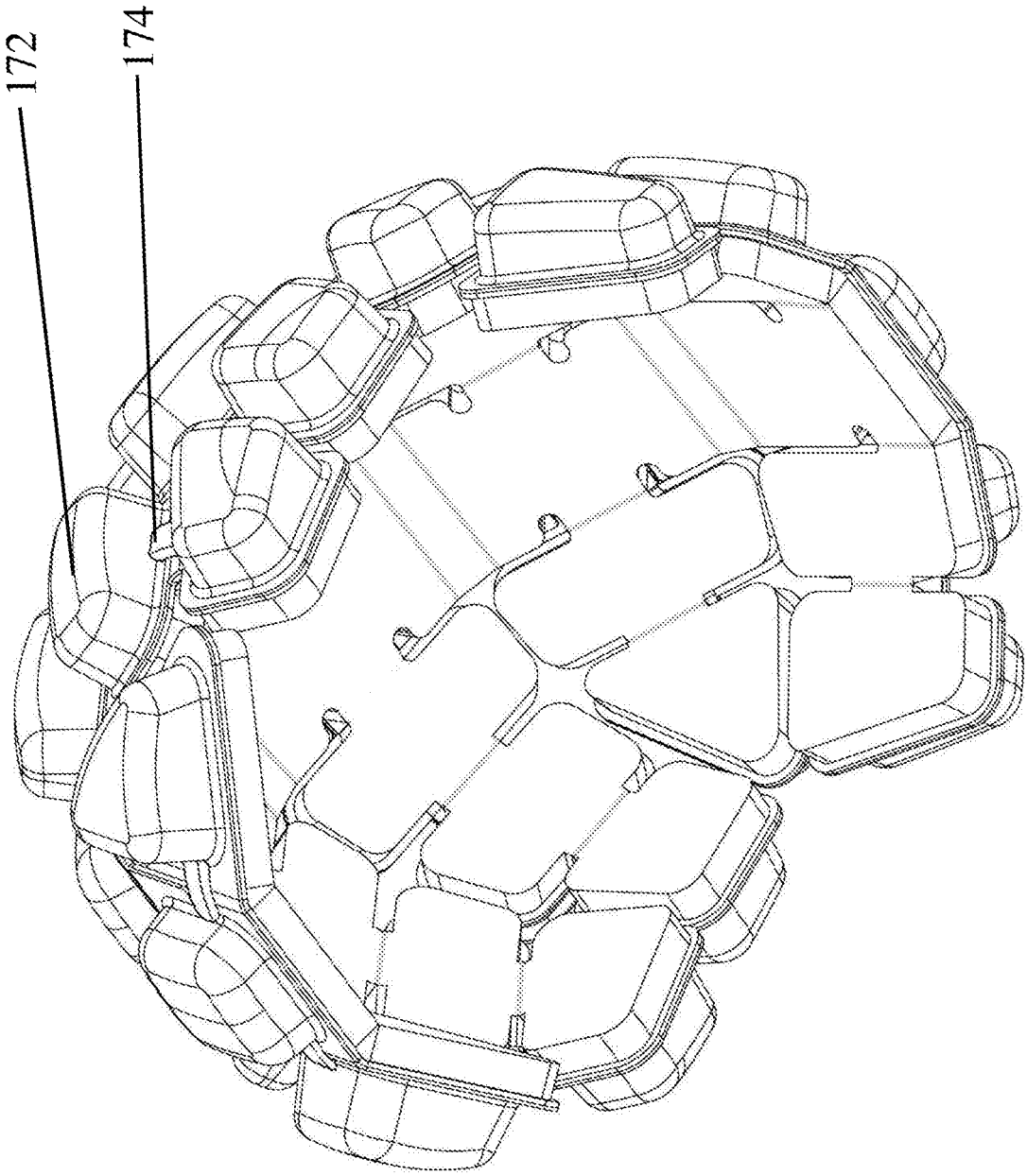

Fig. 35

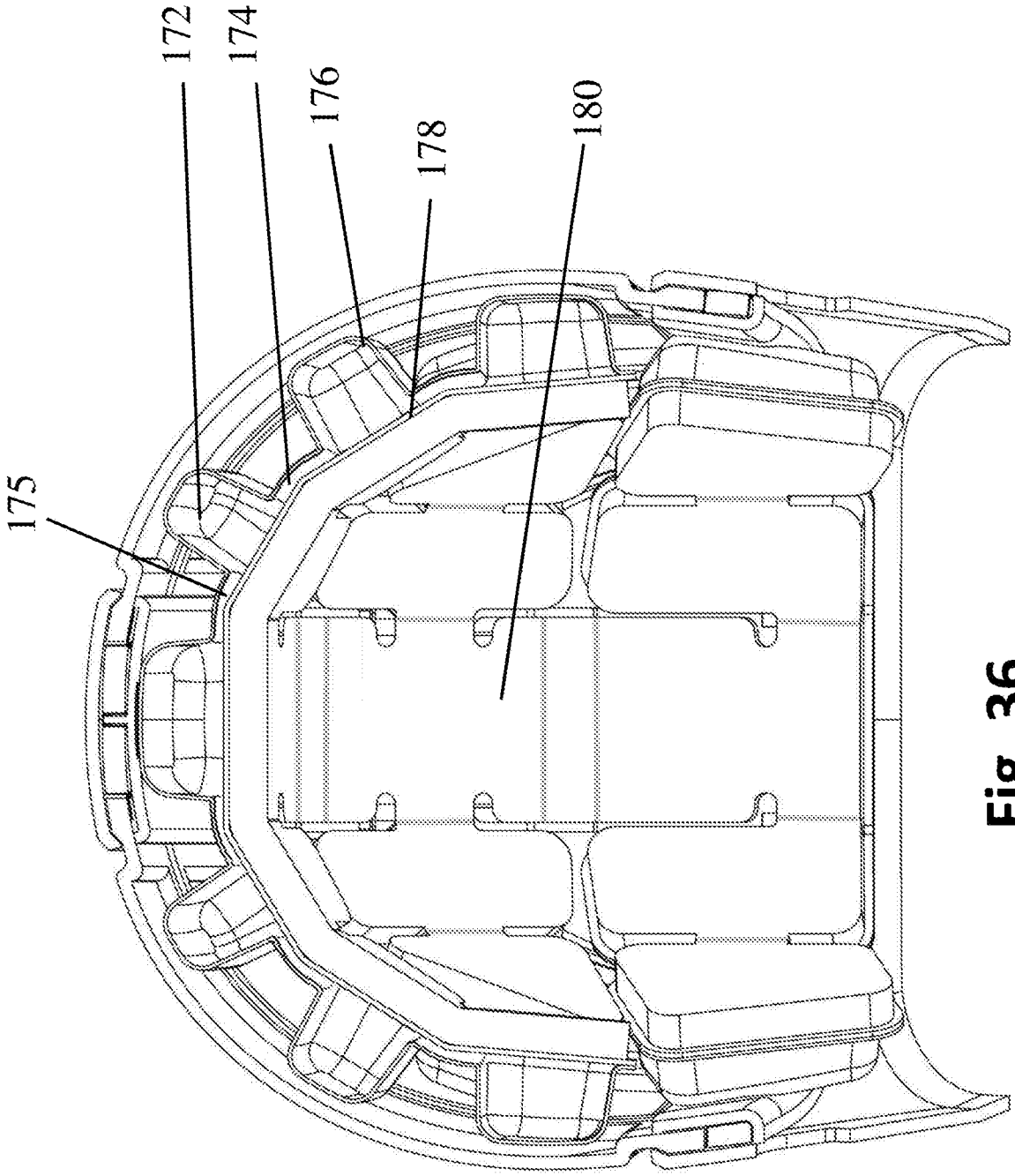

Fig. 36

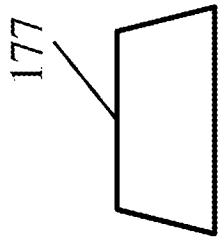

Fig. 39

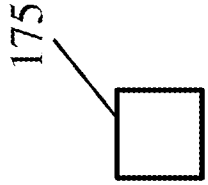

Fig. 38

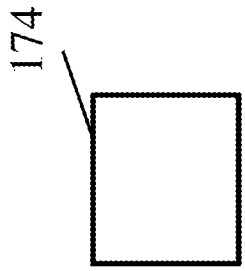

Fig. 37

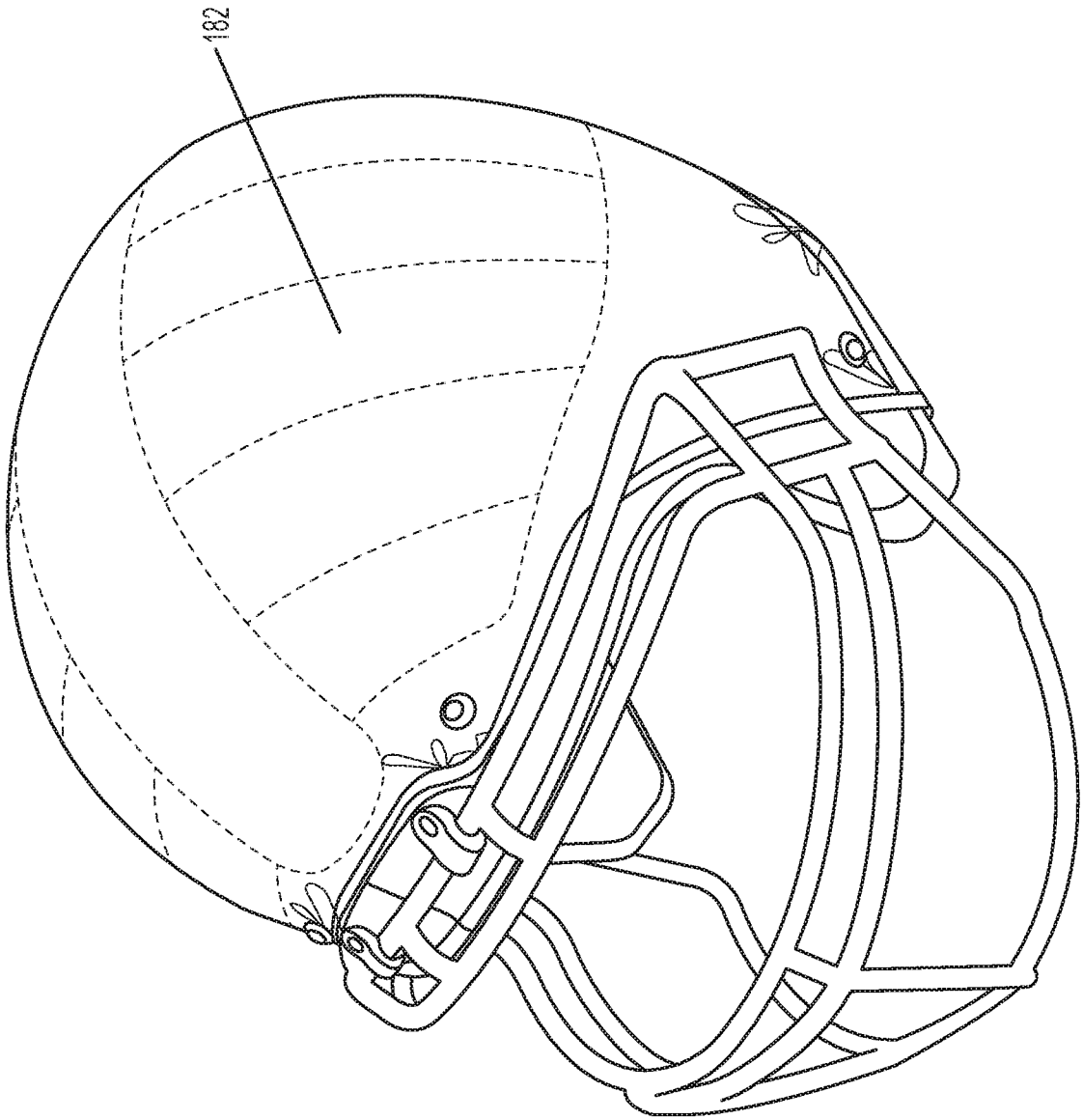

Fig. 40

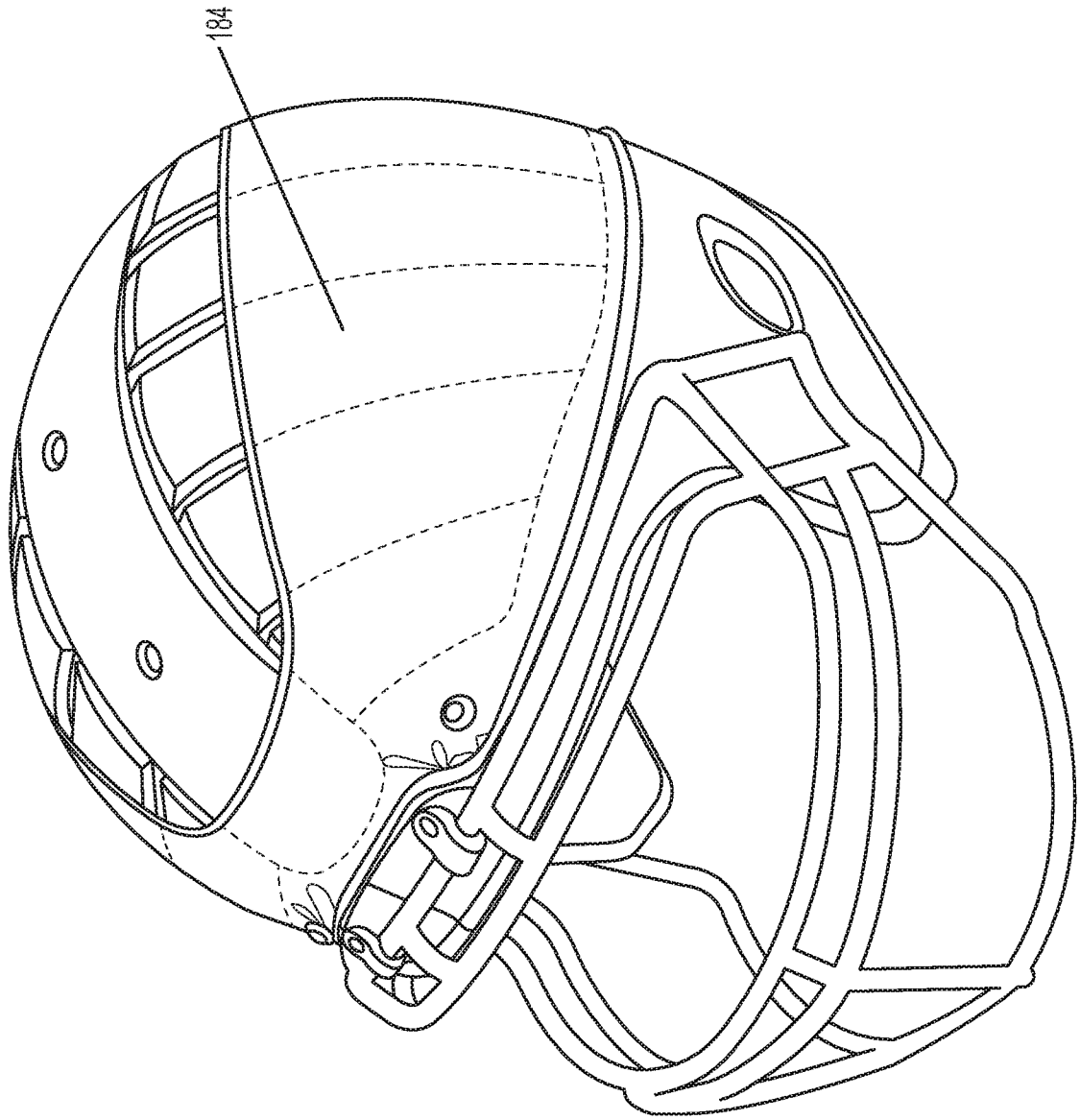

Fig. 41

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US17/60220

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

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

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

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

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

-***-Continued Within the Next Supplemental Box-***-

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

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

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

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

Remark on Protest

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

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

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US17/60220

A. CLASSIFICATION OF SUBJECT MATTER
IPC - A42B 3/04, 3/06; F41H 1/04 (2017.01)
CPC - A42B 3/04, 3/06, 3/064; F41H 1/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/0310856 A1 (GUADAGNIN P et al.) October 23, 2014; figures 1, 6, 9; paragraphs [0023], [0033], [0035]	1-3, 10, 11, 15-19, 23, 26, 27
---		---
Y		4-9, 20-22, 24, 25, 28, 31, 39
X	US 2012/0047635 A1 (FINIEL R et al.) March 1, 2012; figures 6, 11; paragraphs [0016], [0025]	1, 10, 12-14
---		---
Y		29-44
Y	US 2014/0298572 A1 (MAZZ ENTERPRISES LLC) October 9, 2014; figures 1, 8A; paragraphs [0017], [0109]	4, 5, 20, 21, 24, 25
Y	US 2013/0061374 A1 (CLEVA RE) March 14, 2013; figure 1; paragraph [0051], [0052]	6, 22, 28
Y	US 3,107,356 A (PESTRONK SM et al.) October 22, 1963; figure 6; column 3, lines 10-15, 40-45	7, 9, 38, 42, 43
Y	US 2012/0131730 A1 (SHOHAM G et al.) May 31, 2012; figure 1; paragraphs [0047], [0050]	8
Y	US 1,698,769 A (MULLINS RT) January 15, 1929; figure 1; page 1, lines 75-100; page 2, lines 5-20	29-44
A	US 4,665,569 A (SANTINI JJGR) May 19, 1987; entire document	1-44

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 February 2018 (21.02.2018)	06 MAR 2018
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US17/60220

-***-Continued from Box No. III Observations where unity of invention is lacking-***-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-15 are directed toward: a helmet comprising: the upper frame member limiting movement of the plates; and a resilient, compressible material positioned within the upper frame member.

Group II: Claims 16-22 are directed toward: a helmet comprising: each of the plurality of plates being connected to the first and second rigid frame members.

Group III: Claims 23-28 are directed toward: a helmet comprising: where each plate has a first end region and is movably connected at the first end region to the first frame member.

Group IV: Claims 29-44 are directed toward: a helmet comprising: a first semi-rigid or rigid plate positioned on a left side of the helmet.

The inventions listed as Groups I-IV do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I include: the upper frame member limiting movement of the plates; and a resilient, compressible material positioned within the upper frame member, which are not present in Groups II-IV.

The special technical features of Group II include: each of the plurality of plates being connected to the first and second rigid frame members, and each of the plurality of plates having a home position; wherein the plates are movable relative to at least one of the first and second rigid frame members and out of their home positions, which are not present in Groups I and III-IV.

The special technical features of Group III include: where each plate has a first end region and is movably connected at the first end region to the first frame member; and a resilient, compressible material such that an impact to an external surface of one of the plates compresses the resilient, compressible material positioned between the first frame member and the first end region of the plate, which are not present in Groups I-II and IV.

The special technical features of Group IV include: a first semi-rigid or rigid plate positioned on a left side of the helmet and extending from the lower frame member toward the upper frame member, the first plate having an upper end; a second semi-rigid or rigid plate positioned on a right side of the helmet and extending from the lower frame member toward the upper frame member, the second plate having an upper end; and the helmet is configured such that the upper end of the first plate moves toward and/or away from the upper end of the second plate when the helmet is impacted, which are not present in Groups I-III.

The common technical features of Groups I-IV are: a helmet comprising: an upper frame member; a lower frame member; a plurality of plates that are semi-rigid or rigid, the plates being movable relative to one another; wherein the lower frame member limits movement of the plates; and a resilient, compressible material positioned between the plates and the upper frame member.

These common technical features are disclosed by US 4,665,569 A (SANTINI). Santini discloses a helmet comprising: an upper frame member (10; figures 4, 5a); a lower frame member (9); a plurality of plates (11) that are semi-rigid or rigid (forming part of the helmet 2, i.e. rigid or semi rigid; column 3, lines 50-68), the plates being movable relative to one another (clearance between parts 10 and 11 permit limited relative displacement; column 3, lines 60-65); wherein the lower frame (10) member limits movement of the plates (clearance between parts 10 and 11 permit limited relative displacement; column 3, lines 60-65); and a resilient, compressible material (23) positioned between the plates and the upper frame member (flexible acoustic seals 23 are positioned within sutures 6-8 between parts 10 and 11; column 3, lines 25-40; column 4, lines 25-50).

Since the common technical features are previously disclosed by the Santini reference, the common features are not special and so Groups I-IV lack unity.