



US 20170188649A1

(19) **United States**(12) **Patent Application Publication****Allen et al.**(10) **Pub. No.: US 2017/0188649 A1**(43) **Pub. Date:****Jul. 6, 2017**(54) **HELMET WITH BOUNDARY NUB AND ELASTOMER RETAINERS***A42B 3/12* (2006.01)*A63B 71/10* (2006.01)*A42B 3/28* (2006.01)(71) Applicant: **Bell Sports, Inc.**, Scotts Valley, CA (US)(52) **U.S. Cl.**CPC *A42B 3/064* (2013.01); *A63B 71/10*(2013.01); *A42B 3/283* (2013.01); *A42B 3/127*(2013.01); *A42B 3/003* (2013.01)(72) Inventors: **Scott R. Allen**, Scotts Valley, CA (US);
James R. Penny, Santa Cruz, CA (US);
Alexander J. Szela, Santa Cruz, CA (US);
Julio Valencia, Santa Cruz, CA (US);
Christopher T. Pietrzak, Ben Lomond, CA (US)

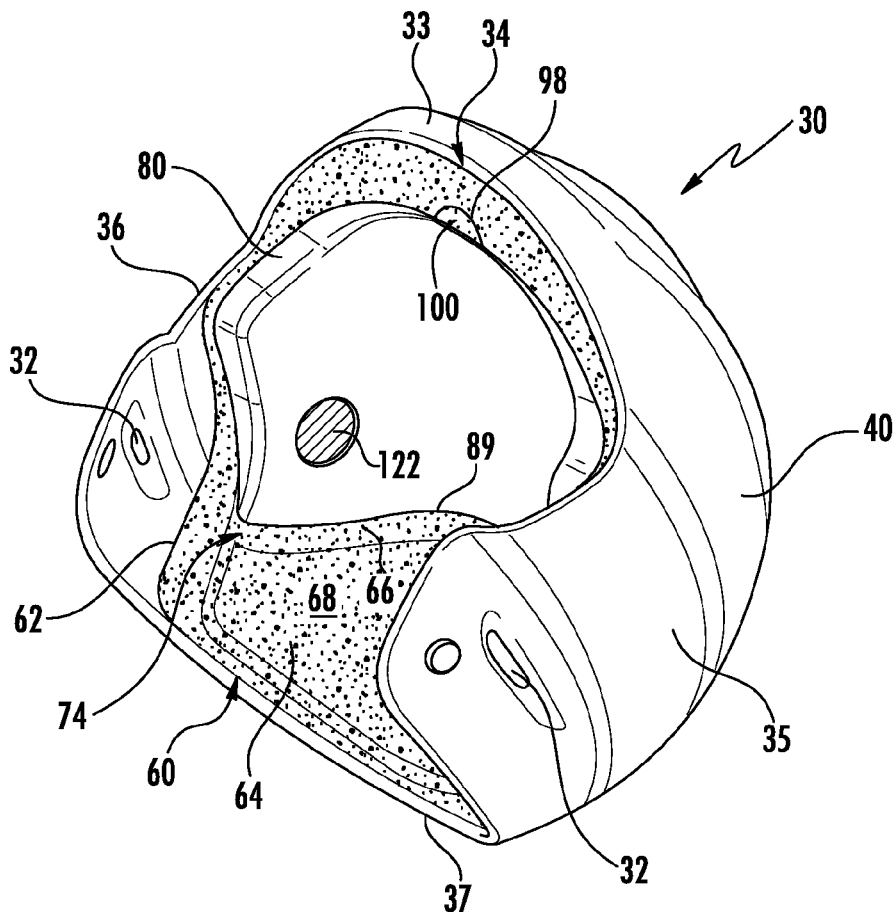
(57)

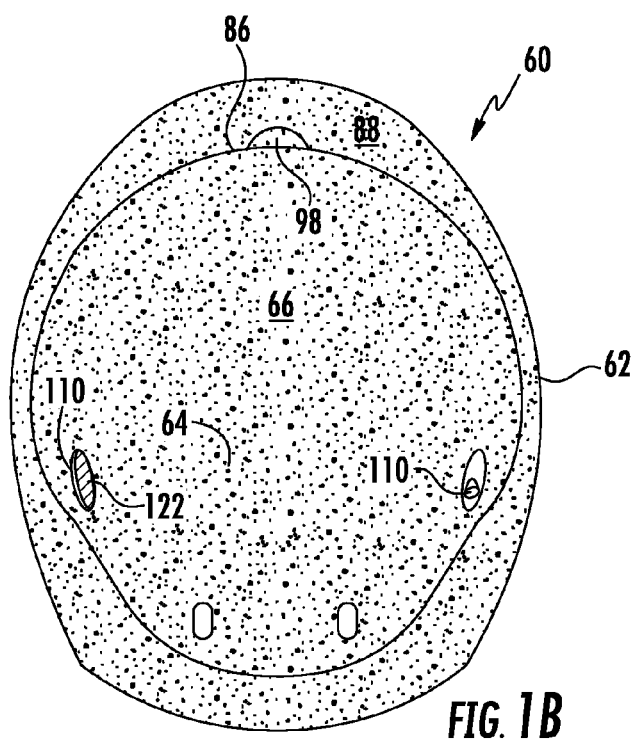
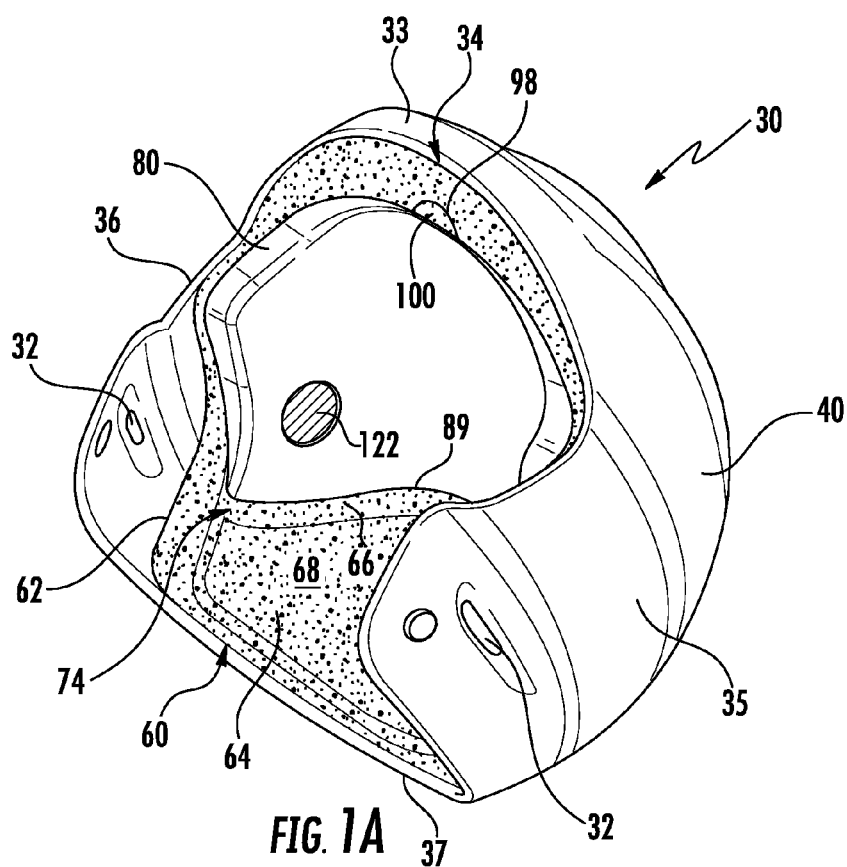
ABSTRACT

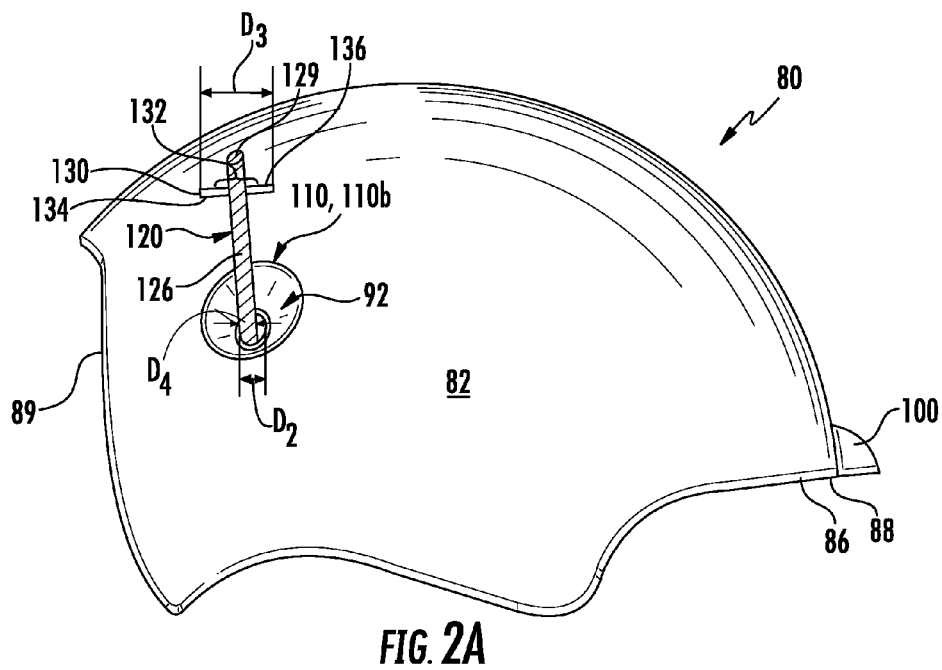
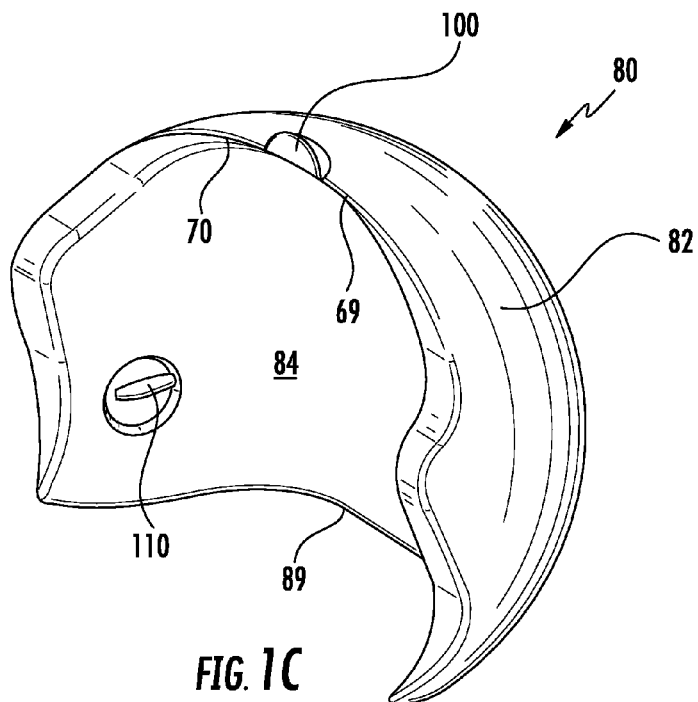
A protective helmet for rotational energy management may include an outer protective shell including an outer surface and an inner surface, a portion of which may be spherically shaped. An inner protective shell may be disposed within the outer protective shell and include a spherically shaped outer surface oriented towards the inner surface of the outer protective shell. A surface area of the outer surface of the inner protective shell may be less than a surface area of the inner surface of the outer protective shell. A first elastomer member may extend through a first channel through the outer protective shell and the inner protective shell. A boundary nub may include a spherical shape and be integrally formed with the inner protective shell at a front lower edge of the inner protective shell.

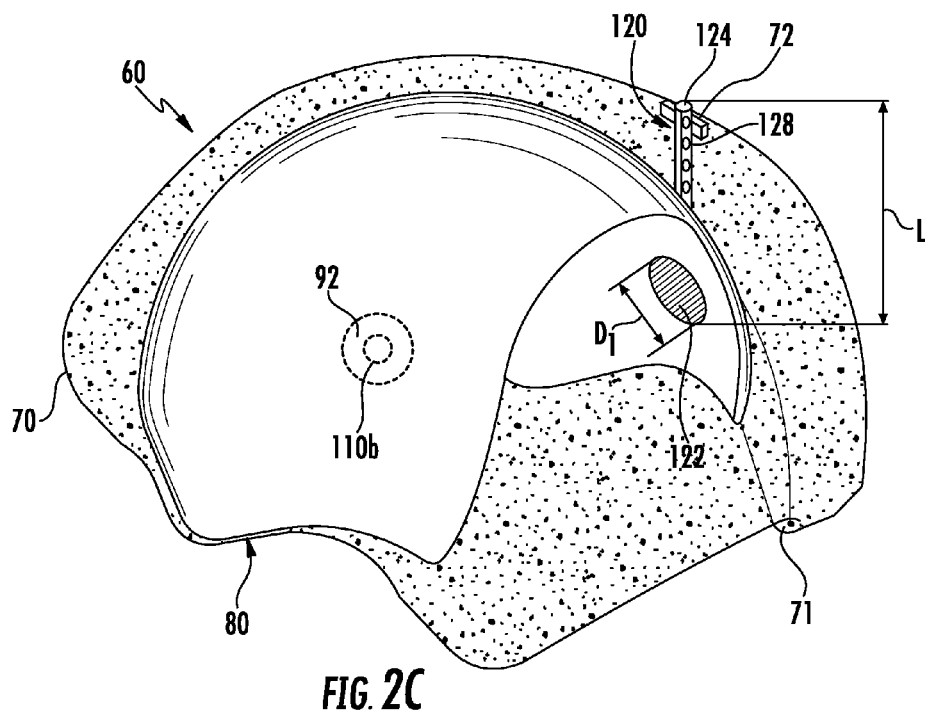
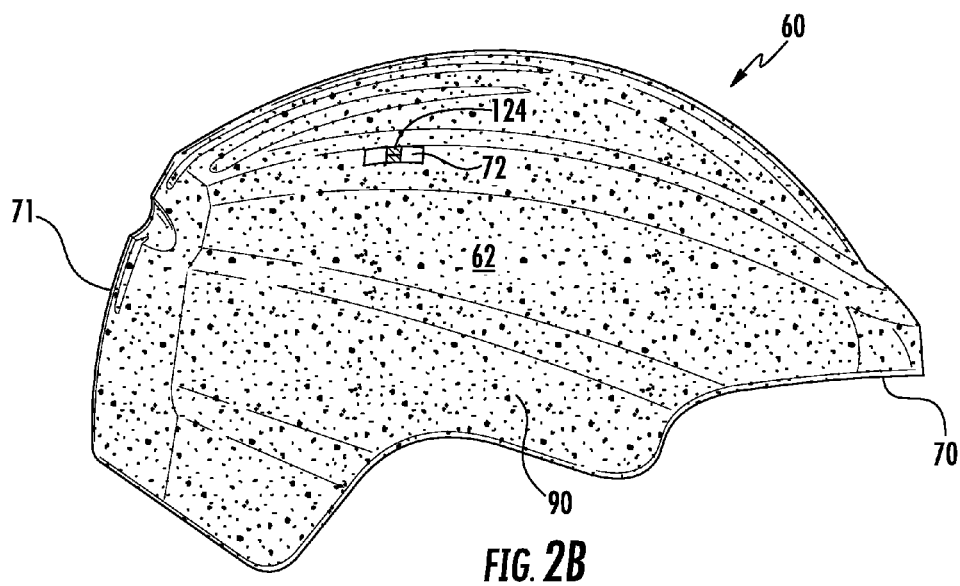
(21) Appl. No.: **15/395,639**(22) Filed: **Dec. 30, 2016****Related U.S. Application Data**

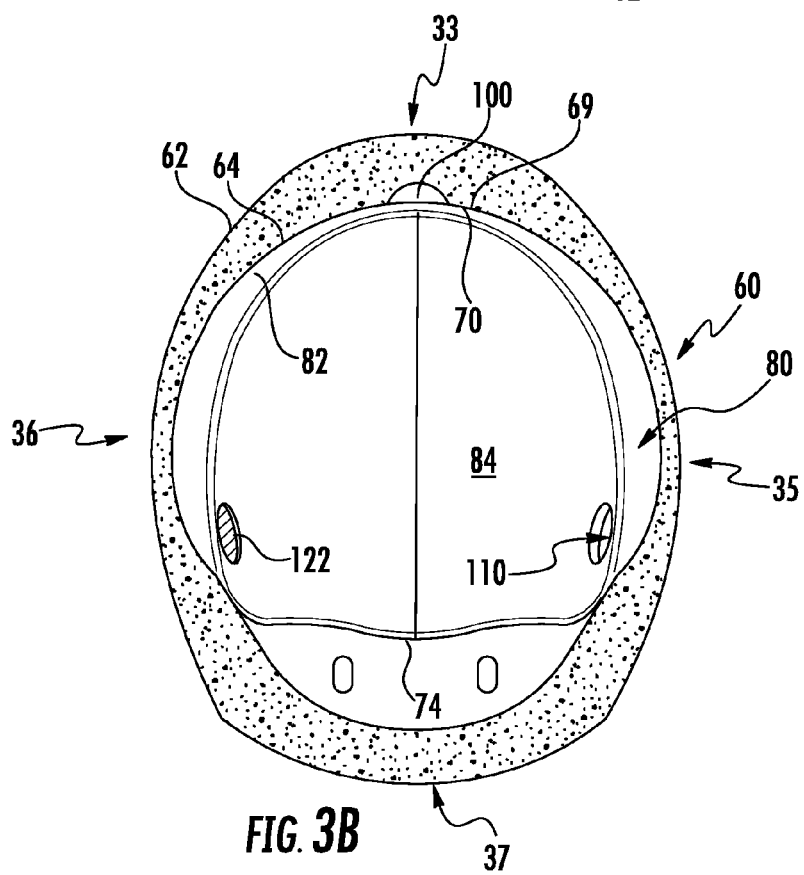
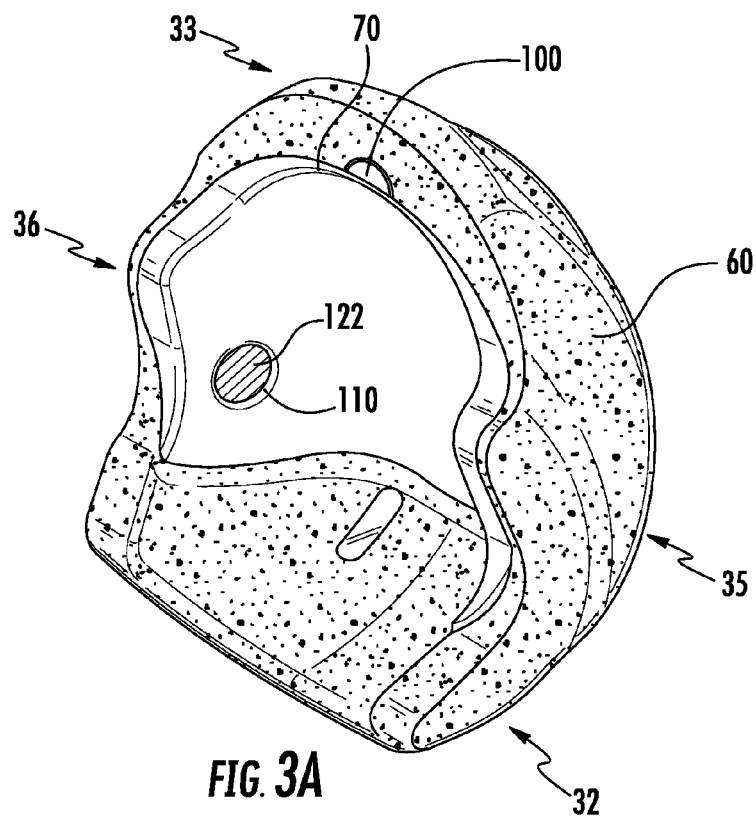
(60) Provisional application No. 62/274,491, filed on Jan. 4, 2016.

Publication Classification(51) **Int. Cl.***A42B 3/06* (2006.01)*A42B 3/00* (2006.01)









HELMET WITH BOUNDARY NUB AND ELASTOMER RETAINERS

RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. provisional patent application 62/274,491, filed Jan. 4, 2016 titled "Helmet with Boundary Nub and Elastomer Retainers," the entirety of the disclosure of which is incorporated herein by this reference.

TECHNICAL FIELD

[0002] This disclosure relates to a protective helmet comprising multiple layers.

BACKGROUND

[0003] Protective headgear and helmets have been used in a wide variety of applications and across a number of industries including sports, athletics, construction, mining, military defense, and others, to prevent damage to a user's head and brain. Damage and injury to a user can be prevented or reduced by helmets that prevent hard objects or sharp objects from directly contacting the user's head. Damage and injury to a user can also be prevented or reduced by helmets that absorb, distribute, or otherwise manage energy of an impact.

[0004] A number of helmets have been designed to address both linear impacts and rotational impact forces, such as those disclosed in U.S. Pat. No. 6,658,671 titled "Protective Helmet," U.S. Pat. No. 8,316,512 titled "Apparatus at a Protective Helmet," U.S. Pat. No. 8,578,520 titled "Helmet," and U.S. Pat. No. 8,615,817 titled "Protective Headgear and Protective Armour and a Method of Modifying Protective Headgear and Protective Armour." These helmets describe various approaches to addressing rotational impact forces within a protective helmet, including the use of multiple layers of materials. In some instances, helmets comprising multiple layers of materials have included lubricants or extra low-friction layers or liners disposed between an outer shell and an energy management material to provide relative movement, slipping, or rotation, between the layers.

SUMMARY

[0005] A need exists for an improved helmet for rotational energy management. Accordingly, in an aspect, a helmet can comprise an outer protective shell comprising an outer surface and an inner surface opposite the outer surface, a portion of the inner surface being spherically shaped. An inner protective shell can be disposed within the outer protective shell and further comprise a spherically shaped outer surface oriented towards the inner surface of the outer protective shell and an inner surface opposite the outer surface. A surface area of the outer surface of the inner protective shell can be less than a surface area of the inner surface of the outer protective shell. A first channel can extend through the outer protective shell and the inner protective shell. A first elastomer member can extend through the first channel and comprise a first end positioned at the inner surface of the inner protective shell. A second end opposite the first end can be positioned at the outer surface of the outer protective shell. A connecting portion can extend between the first end and the second end. A boundary nub can comprise a spherical shape and can be

integrally formed with the inner protective shell at a front lower edge of the inner protective shell.

[0006] The helmet can further comprise an occipital portion of the inner surface of the outer protective shell that is not spherical in shape, but comprises a convex curve that is not covered by the inner protective shell. The boundary nub can be formed of the same material as the inner protective shell. The first end of the first elastomer member can be enlarged to comprise a maximum cross-sectional width D_1 that is greater than a maximum cross-sectional width D_2 of the first channel. The second end of the first elastomer member can further comprise an opening disposed completely through the second end of the first elastomer member. A pin can be disposed through the opening, the pin comprising a distance D_3 greater than a distance D_4 of a maximum cross-sectional width of the connecting portion of the first elastomer member. The pin can comprise a center portion disposed between two end portions, the center portion of the pin contacting the first elastomer member and the two end portions of the pin contacting the outer protective shell. The second end of the first elastomer member and the pin can be positioned within a recess in the outer protective shell. The first channel and the first elastomer member can be disposed at a left rear portion of the helmet, and a second channel and a second elastomer member can be disposed at a right rear portion of the helmet. A protective outer cover can be disposed over the outer protective shell.

[0007] In another aspect, a protective helmet for rotational energy management can comprise an outer protective shell comprising an outer surface and an inner surface opposite the outer surface. An inner protective shell can be disposed within the outer protective shell with an outer surface oriented towards the inner surface of the outer protective shell and an inner surface opposite the outer surface. A first channel can extend through the outer protective shell and the inner protective shell. A first elastomer member can extend through the first channel and comprise a first end, a second end opposite the first end, and a connecting portion extending between the first end and the second end. A boundary nub can comprise a spherical shape.

[0008] The helmet can further comprise the boundary nub being disposed along a lower edge of the helmet at an interface between the outer protective shell and the inner protective shell. The boundary nub can be integrally formed with the outer protective shell or the inner protective shell. A portion of the inner surface of the outer protective shell can be spherically shaped. The outer surface of the inner protective shell can be spherically shaped and comprise a surface area less than a surface area of the inner surface of the outer protective shell. An occipital portion of the inner surface of the outer protective shell can be non-spherical (not be spherical) in shape, but can comprise a convex curve that is not covered by the inner protective shell. The second end of the first elastomer member can further comprise an opening disposed completely through the first end or second end of the first elastomer member, and a pin disposed through the opening. The pin can comprise a distance D_3 greater than a distance D_4 of a maximum cross-sectional width of the connecting portion of the first elastomer member. The pin can comprise a center portion disposed between two end portions, the center portion of the pin contacting the first elastomer member and the two end portions of the pin contacting the outer protective shell. The first channel and the first elastomer member can be disposed at a left rear

portion of the helmet, and a second channel and a second elastomer member can be disposed at a right rear portion of the helmet.

[0009] In another aspect, the protective helmet for rotational energy management can further comprise an outer protective shell comprising an outer surface and an inner surface opposite the outer surface, a portion of the inner surface being spherically shaped. An inner protective shell can be disposed within the outer protective shell and can further comprise a spherically shaped outer surface oriented towards the inner surface of the outer protective shell and an inner surface opposite the outer surface. A surface area of the outer surface of the inner protective shell can be less than a surface area of the inner surface of the outer protective shell. A first channel can extend through the outer protective shell and the inner protective shell. A first elastomer member can extend through the first channel and comprise a first end, a second end opposite the first end, and a connecting portion extending between the first end and the second end. The protective helmet can also comprise a boundary nub.

[0010] The helmet can further comprise an occipital portion of the inner surface of the outer protective shell. The occipital portion can be uncovered (not covered) by the inner protective shell and comprise a convex curve to follow an occipital curve of helmet wearer. The boundary nub can comprise a spherical shape disposed at a lower edge of the protective shell along an interface between the outer protective shell and the inner protective shell. The boundary nub can be formed of the same material as the inner protective shell or the outer protective shell. The first end of the elastomer member can be enlarged to comprise a maximum cross-sectional width D_1 that is greater than a maximum cross-sectional width D_2 of the first channel. The second end of the first elastomer member can further comprise an opening disposed completely through the upper end of the first elastomer member. A pin can be disposed through the opening, the pin comprising a distance D_3 greater than a distance D_4 of a maximum cross-sectional width of the connecting portion of the first elastomer member, wherein the pin comprises a center portion disposed between two end portions, the center portion of the pin contacting the first elastomer member and the two end portions of the pin contacting the outer protective shell. The pin can be positioned within a recess in the outer protective shell. The first channel and the first elastomer member can be disposed at a left rear portion of the helmet, and a second channel and a second elastomer member can be disposed at a right rear portion of the helmet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIGS. 1A-1C show various views of an embodiment of a protective helmet comprising protective shells.

[0012] FIGS. 2A-2C show various views of the protective helmet comprising an elastomer member.

[0013] FIGS. 3A-3B show various views of protective shells coupled with elastomer members.

DETAILED DESCRIPTION

[0014] This disclosure, its aspects and implementations, are not limited to the specific helmet or material types, or other system component examples, or methods disclosed herein. Many additional components, manufacturing and assembly procedures known in the art consistent with helmet

manufacture are contemplated for use with particular implementations from this disclosure. Accordingly, for example, although particular protective helmets are disclosed, such protective helmets and implementing components may comprise any shape, size, style, type, model, version, measurement, concentration, material, quantity, and/or the like as is known in the art for such protective helmets and implementing components, consistent with the intended operation of a protective helmet.

[0015] The word “exemplary,” “example,” or various forms thereof are used herein to mean serving as an example, instance, or illustration. Any aspect or design described herein as “exemplary” or as an “example” is not necessarily to be construed as preferred or advantageous over other aspects or designs. Furthermore, examples are provided solely for purposes of clarity and understanding and are not meant to limit or restrict the disclosed subject matter or relevant portions of this disclosure in any manner. It is to be appreciated that a myriad of additional or alternate examples of varying scope could have been presented, but have been omitted for purposes of brevity.

[0016] While this disclosure includes a number of embodiments in many different forms, there is shown in the drawings and will herein be described in detail, particular embodiments with the understanding that the present disclosure is to be considered as an exemplification of the principles of the disclosed methods and systems, and is not intended to limit the broad aspect of the disclosed concepts to the embodiments illustrated.

[0017] This disclosure provides a device, apparatus, system, and method for providing a protective helmet that may include an outer shell and an inner energy-absorbing layer, such as foam. The protective helmet may be a bike helmet used for mountain biking or road cycling, and may also be used for a skier, skater, hockey player, snowboarder, or other snow or water athlete, a football player, baseball player, lacrosse player, polo player, climber, auto racer, motorcycle rider, motocross racer, sky diver or any other athlete in a sport. Other industries also use protective headwear, such that individuals employed in other industries and work such as construction workers, soldiers, fire fighters, pilots, or types of work and activities may also use or be in need of a safety helmet, where similar technologies and methods may also be applied. Each of the above listed sports, occupations, or activities may use a helmet that includes either single or multi-impact rated protective material base that is typically, though not always, covered on the outside by a decorative cover and includes comfort material on at least portions of the inside, usually in the form of comfort padding.

[0018] Although helmets have existed for a long time as a way to protect a wearer's head in the case of an impact, and impact absorbing materials and the ways in which those materials have been used to manage impact force have significantly improved over the years, the issue of rotational impact or indirect impact has been addressed more recently.

[0019] Crash impacts have two main types of force—linear and rotational. Both are related to the majority of brain injuries. Linear forces may occur when the wearer's head is moving in a straight line and comes to a sudden stop or is struck by an object moving in a straight line. Rotational forces may occur when a wearer's head is struck at an angle or rotates quickly and comes to a sudden stop (like when the wearer skids along a road during a crash or hits his head on an object at an oblique angle (i.e., an angle that is not

“straight on”)). This may cause the brain to twist within the wearer’s skull and become injured.

[0020] Conventional helmets have generally been formed to follow a contour of the inner surface of the helmet, typically an oblong shape that matches or closely matches the shape of a typical human head. Applicant has observed that to these conventional helmets, additional “slip” layers have been added within the helmet to follow the same contour and shape of the internal surface of the helmet and to manage energy in rotational impacts. When rotational forces impact the outer shell of the helmet, the slip layer facilitates shifting in relation to the innermost part of the helmet or the user’s head to reduce the rotational forces on the wearer’s head. Applicant has noted that even slight reductions in rotational forces may make a significant reduction in the severity of injuries.

[0021] FIG. 1A shows a non-limiting example of perspective view of a helmet or a protective helmet for rotational energy management 30. The helmet 30 may comprise vents or openings 32 that are formed in, and extend through, a portion or entirety of the helmet 30, including an outer cover 40, an outer protective shell or outer energy management layer 60, and an inner protective shell or inner energy management layer 80. As such, the vents 32 may be comprised of a plurality of vents or vent segments, including vents or openings formed in the outer cover 40, the outer protective shell 60, and the inner protective shell 80. The vents 32 can allow for airflow and circulation of air from outside the helmet 30 into the helmet 30 and adjacent a head of a user to cool the user and provide ventilation.

[0022] The helmet 30 may also comprise straps or webbing that can be attached to the helmet 30 and may be used to couple or releasably attach the helmet 30 to the head of the user. An optional comfort liner or fit liner can also be disposed within, and coupled to, the helmet 30. The comfort liner may be disposed within the inner protective shell 80, as well as within the outer protective shell 60. The comfort liner may be made of textiles, plastic, foam, polyester, nylon, or other suitable materials. The comfort liner 46 may be formed of one or more pads of material that can be joined together, or formed as discrete components, that are coupled to the helmet 30. The comfort liner can be releasably or permanently attached to the helmet 30, such as by being attached to the inner protective shell 80, using an adhesive, permanent adhesive, PSA, foam-core adhesive, tape, two-sided tape, mounting foam adhesive, fastener, clip, cleat, cutout, tab, snap, rivet, hog ring, or hook and loop fasteners, or other interlocking surfaces, features, or portions. As such, the comfort liner can provide a cushion and improved fit for the wearer of the in-molded helmet.

[0023] The helmet 30 may also comprise an outer cover or shell 40 that may be placed or disposed over the outer protective shell 60 and the inner protective shell 80. The outer cover 40 may be formed of a more durable material than the protective shells 60, 80 and may, without limitation, be formed of a plastic, resin, fiber, or other suitable material including polycarbonate (PC), polyethylene terephthalate (PET), acrylonitrile butadiene styrene (ABS), polyethylene (PE), polyvinyl chloride (PVC), vinyl nitrile (VN), fiberglass, carbon fiber, or other similar material, including dense and durable materials. The outer cover 40 may be stamped, in-molded, injection molded, vacuum formed, or formed by another suitable process. The outer cover 40 may provide a shell into which the protective shells 60, 80 is disposed. The

outer cover 40 may also provide a smooth aerodynamic finish, a decorative finish, or both, for improved performance, improved aesthetics, or both. As a non-limiting example, the outer cover 40 may comprise PC shell that is in-molded in the form of a vacuum formed sheet, or is attached to the outer protective shell 60 with an adhesive. The outer cover 40 may also be permanently or releasably coupled to the outer protective shell 60, using any suitable chemical or mechanical fastener or attachment device or substance including without limitation, an adhesive, permanent adhesive, pressure sensitive adhesive (PSA), foam-core adhesive, tape, two-sided tape, mounting foam adhesive, fastener, clip, cleat, cutout, tab, snap, rivet, hog ring, or hook and loop fasteners.

[0024] While the outer cover 40 is, for convenience, referred to as an “outer” cover, in some instances additional layers or covers can be placed over the outer cover 40. In any event, the outer cover 40 may provide some protection from direct linear forces and friction impacts that frequently occur in accidents or road accidents whether the helmet 30 can be generally classified as an in-molded helmet or a hard shell helmet. As known in the art, in-molded helmets may comprise a thin outer shell (e.g. outer cover 40), an energy-absorbing layer or impact liner (e.g. protective shells 60, 80), and a comfort liner or fit liner (e.g. disposed within or adjacent the protective shells 60, 80 as discussed above). Hard-shell helmets may comprise a hard outer shell (e.g. outer cover 40), an impact liner (e.g. protective shells 60, 80), and a comfort liner (e.g. disposed within or adjacent the protective shells 60, 80 as discussed above). The hard outer shell may be formed by injection molding and may include Acrylonitrile-Butadiene-Styrene (ABS) plastics or other similar or suitable material. The outer shell for hard-shell helmets is typically made hard enough to resist impacts and punctures, and to meet the related safety testing standards, while being flexible enough to deform slightly during impacts to absorb energy through deformation, thereby contributing to energy management. Hard-shell helmets may be used as skate bucket helmets, motorcycle helmets, snow and water sports helmets, football helmets, batting helmets, catcher’s helmets, hockey helmets, and may be used for BMX riding and racing. Thus, the various aspects and implementations presented in the disclosure may be part of a soft shell helmet, hard shell helmet, or an in molded helmet, such as for cycling or powersports.

[0025] The helmet 30 may further comprise at least two layers of impact energy absorbing materials or protective shells, including the outer protective shell 60 and the inner protective shell 80. The outer protective shell 60 and the inner protective shell 80 may be made of one or more layers of the same or similar materials, including an impact energy absorbing material such as, without limitation, expanded polystyrene (EPS), expanded polypropylene (EPP), expanded polyurethane (EPU), expanded polyolefin (EPO), foam, or any other suitable synthetic or natural material that absorbs impact energy through deformation, whether through elastic or inelastic deformation, such as by bending, flexing, crushing, or cracking. For convenience, the present disclosure shows the helmet 30 comprising two protective shells 60, 80, but also encompasses helmets 30 that comprise more than two protective shells, such as three, four, or any suitable number of protective shells.

[0026] FIG. 1B shows the outer protective shell 60 without the outer cover 30 and the inner protective shell 80. The

outer protective shell 60 may comprise an outer surface 62 and an inner surface 64 opposite the outer surface 62, a portion 66 of the inner surface 64 being spherically shaped. The outer protective shell 60 may partially surround the wearer's head and the inner surface 64 may be smoothly textured to slide against an outer surface 82 of the inner protective shell 80, which is shown, for example, in FIG. 1C.

[0027] A rounded boundary nub receiving recess 98 may be formed in the outer protective shell 60 along an inner front edge 86 of the outer protective shell 80. The boundary nub receiving recess 98 may extend from the inner surface 64 of the outer protective shell to front lip 88 that may extend between, and be perpendicular or substantially perpendicular to, the outer surface 82 and the inner surface 84. As used herein the term substantially perpendicular means within 1°, 3°, 5°, 10°, or 20° of perpendicular. The boundary nub receiving recess may comprise a quarter-spherical or apse shape.

[0028] FIG. 1C shows, for clarity, the inner protective shell 80 without the outer cover 30 and without the outer protective shell 60. The inner protective shell 80 may comprise an outer surface 82 and an inner surface 84 opposite the outer surface 82. As shown in FIG. 1A, when the helmet 30 is in use, or being worn by its user, the inner protective shell 80 may be disposed within the outer protective shell 60 and oriented towards the inner surface 64 of the outer protective shell 60. The outer surface 82 of the inner protective shell 80 may be spherically shaped, like the portion 66 of the outer protective shell 60 that may be coupled to, and is configured or adapted to receive, the inner protective shell 80. A surface area, including an entire surface area, of the outer surface 62 of the inner protective shell 60 may be less than a surface area, including an entire surface area, of the inner surface 84 of the outer protective shell 80. Thus, as shown in FIG. 1A, the outer protective shell 60 may comprise an occipital portion 68 that is exposed with respect to, and not covered by, the inner protective shell 80. The occipital portion 68 of the outer protective shell 60 may comprise a convex curve that is not spherical in shape, but more generally follows the occipital curve of the user's head. As such, the inner protective shell 80 may be a partial shell of protective material that partially surrounds the wearer's head and covers a smaller portion of the user's head than does the outer protective shell 60.

[0029] FIG. 1A also shows a sliding area, rotation zone, or transition area 74 may be formed as a part of, or be disposed on, the inner surface 64 of the outer protective shell 60 between a back or rear edge 89 of the inner protective shell 80 and the non-spherical occipital portion 68 of the outer protective shell. The sliding area 74 may be adjacent, defined by, and share a rear edge or rear boundary with the occipital portion 68. Similarly, the sliding area 74 may be adjacent, defined by, and share a front edge or front boundary with the back edge 89 of the inner protective shell when the inner protective shell 80 is at a standard, normal, or at rest position within the outer protective shell 60.

[0030] The sliding area 74 may be a part of the spherically shaped portion 66 of the inner surface 64 of the outer shell 60 may comprise a spherical shape that allows for relative movement or sliding of the outer protective shell 60 and the inner protective shell 80 until the inner protective shell comes to an end of the sliding area 74 and contacts or arrives at the occipital portion 68 of the outer shell where the non-spherical curvature of the outer shell 80 increases

friction and reduces, limits, or stops further movement of the inner shell 80 into or across the occipital portion 68 of the outer protective shell 60. Thus, the spherically shaped portion 66, the sliding area 74, and an entirety of the inner surface 64 of the outer shell 60 may comprise a suitably smooth textured surface to facilitated desired sliding or relative movement between the inner surface 64 of the outer protective shell 60 and the outer surface 82 of the inner shell 80.

[0031] Thus, the sliding or relative movement of the outer protective shell 60 with respect to the inner protective shell 80 may be limited, controlled, or guided by a number of features or factors, including: (i) the spherical shape and contours of the mating surfaces 64 and 82, (ii) the surface texture of the mating surfaces 64, 82, (iii) the elastomer members 120, and (iv) the boundary nub 100 and its interaction with the boundary nub receiving recess 98.

[0032] With respect to (i) the spherical shape and contours of the mating surfaces 64 and 82, and (ii) the surface texture of the mating surfaces 64, 82, the outer surface 82 of the inner protective shell 80 and the inner surface 64 outer protective shell 60 may be directly coupled together at a spherical plane that matches, extends parallel with, or is disposed between, the spherically shaped portion 66 of the inner surface 64 of the outer shell 60 and the spherically shaped inner surface 84 of the outer surface 82 of the inner protective shell 80 to provide a desired amount of slippage or relative rotational movement. One or both of the spherical interface surfaces 64, 82 may be made smooth to increase the speed of slippage at a particular force, or may be made rough, textured, or both to decrease the speed of slippage at a particular force depending upon the needs of a particular helmet, a particular helmet purpose, or a particular helmet embodiment.

[0033] Although the term "spherical" surface is used in this disclosure, it will be clear to one of ordinary skill in the art that the surfaces referenced, including surfaces 64, 82 are not full, complete spheres and that a portion of a spherical surface may be used to the extent the portion is needed. Thus, where "spherical surface" is used herein, the term may mean that the surface has a substantially consistent radius of curvature throughout the surface and in some embodiments to wherever the surface and layer extends, but at least for a majority of the extent of the surface. A substantially consistent radius of curvature means that the radius of curvature is between 70%-100% of a constant radius of curvature throughout the spherical surface, or within 30% of a radius of curvature of a majority of the spherical surface. In particular embodiments, the spherical surface may be a completely consistent radius of curvature, or within 5% of a constant radius of curvature. In other particular embodiments, the spherical surface may have portions similar in shape to a typical headform and other portions that have a substantially consistent radius of curvature throughout the portions of the spherical surface. The spherical surfaces, where used, may also be discontinuous and include gaps between sections of a spherical surface within a common spherical plane, or may be on different spherical planes.

[0034] Furthermore, an additional slip layer, slip plane, or low friction interface may be disposed between outer shell 60 and the inner shell 80, and comprise a spherical shape. The slip layer can be made of any suitable material known in the art to reduce friction or to allow movement between adjacent surfaces, such as shells 60, 80, and may include a

plastic, metal, or any other suitable material known in the art, similar or identical to those materials listed herein for other components or portions of the helmet 60. In a particular embodiment, a rigid or semi-rigid slip layer that maintains its own shape when not exposed to external forces can be used, such as, without limitation, an aluminum surface, a vacuum formed poly carbonate surface, a carbon fiber surface or any other surface that allows movement between the adjacent surfaces, such as surfaces 64, 82, may be formed as a slip layer or spherical surface body and interposed between the spherical interface surfaces 64, 82 so that the three parts work together to provide impact energy management for the helmet 30 and the user wearing the helmet 30. Just as with the spherical interface surfaces 64, 82 themselves, one or both of an inner or outer surface of the slip layer interposed between the spherical interface surfaces 64, 82 may be textured with a smooth or rough texture depending on the particular needs of the helmet embodiment or purpose.

[0035] For clarity, while the slip layer may be used to facilitate rotational movement and energy management, the slip layer is not itself, per se, a protective shell or impact energy absorbing material as this term is used herein relative to the outer protective shell 60 and the inner protective shell 80. Instead, the slip layer is a thin layer that does not itself absorb any measurably significant amount of impact energy through deformation, but rather merely assists to divert the impact energy through slippage.

[0036] In some embodiments, the slip layer or an interface between the outer protective shell 60 and the inner protective shell 80 may include an in-mold helmet design in which one or both of an inner surface 64 of the outer protective shell 60 and an outer surface 82 of the inner protective shell 80 include an in-molded shell, such as a shell comprising polycarbonate or other suitable material. By in-molding one or more of the interface surfaces 64, 82, relative movement between the outer protective shell 60 and the inner protective shell 80 may also be facilitated.

[0037] As indicated above, the sliding or relative movement of the outer protective shell 60 with respect to the inner protective shell 80, can also be limited, controlled, or guided by the boundary nub 100 and its interaction with the boundary nub receiving recess 98. The outer protective shell 60 may comprise the boundary nub receiving recess 98 formed as a recess, indent, hollow, or opening in the outer shell 60, and more particularly at the front lip 88 or lower edge of the outer protective shell 60. The recess 98 may comprise a spherical shape, hemispherical shape, or apse shape with the bottom of the recess 98 being defined by the lip 88 of the outer shell 80.

[0038] Similarly, the inner protective shell 80 may comprise a boundary nub 100 formed as a projection extending away from the outer surface 82 of the shell 80 disposed at an inner front edge 69 or lower edge of the outer protective shell 60. The boundary nub 100 may comprise a spherical shape, hemispherical shape, or apse shape with the bottom of the nub 100 being defined by the front lip 70 of the outer shell 80. The boundary nub 100 may be integrally formed with the inner protective shell 80, and the boundary nub 100 may also be formed of a same material as the inner protective shell 80.

[0039] The nub 100 may be mateably sized to rotatably couple with the recess 98 so that together the recess 98 and the nub 100 may limit, direct, or control relative rotation,

sliding, or movement between the inner protective shell 80 and the outer protective shell 60. However, the relative positioning of the recess 98 and the nub 100 may also be reversed so that the nub 100 is formed in the outer protective shell 60 and the recess 98 is formed in the inner protective shell 80. For example, the recess 98 may be formed as an inward-projecting recess on the outer surface 82 of the inner protective shell 80, and a corresponding, mating nub 100 may be formed on the inner surface 64 of the outer protective shell 60. In some embodiments, the form of the boundary nub and receiving recess may be altered or repositioned from the front edges 69, 86 to be located elsewhere on the helmet 30, including. Inclusion of the boundary nub 98 at or near a front lower edge 34 of the helmet 30, including at or near the front lip 70 and the front lip 88, the protective shells 60, 80 can maximize the relative potential rotation possibilities for the outer protective shell 60 and the inner protective shell 80. For example, such positioning may allow for side to side rotation between the left side 35 and the right side 36 of the helmet 30 with relative movement or sliding occurring, and being facilitated by, the spherical or domed shape of the recess 98 and the nub 100. Similarly, relative movement or sliding may occur backwards or with the outer shell 40 moving to the rear of the inner shell 80, the movement being facilitated by, the spherical or domed shape of the recess 98 and the nub 100. On the other hand, relative movement or sliding in a frontwards direction, or with the outer shell 40 moving to the front of the inner shell 80, may be prevented by the recess 98 contacting and being resisted by the nub 100.

[0040] In some instances, recess 98 and nub 100 may also comprise a slip layer, slip plane, or material such as a polycarbonate shell or of their own, as described above with respect to the protective shells 60, 80. In any event, the protective helmet 30 of the present disclosure may absorb impact energy by relative rotation of the outer protective shell 60 with respect to the inner protective shell 80. By arranging the inner and outer protective shells as described and shown above, the protective shells may freely pivot or rotate, in desired directions, with respect to each other in response to a point load or force being applied to the helmet 30. Additionally, the inner protective shell 80 may stay fixed with respect to the wearer's head while the outer protective shell 60 may freely pivot or rotate with respect to the wearer's head and with respect to the inner protective shell 80 in response to a point load or force being applied to the helmet 30. For example, the inner surface 84 of the inner protective shell 80 may be custom fit with the wearer's head to limit rotation between the inner custom fitted surface 84 of the inner protective shell 80 and the wearer's head. The increased stability and fit of a custom fitted inner surface 84 of the helmet 30 may reduce rotation and energy management through rotation between the inner surface 84 of the helmet 30, or an inner surface of comfort padding or a fit system, and the wearer's head. Instead, rotation and absorption of impact energy through distribution of rotational energy may occur through relative movement between the inner protective shell 80 and outer protective shell 60, which may be retained together by the elastomer members 120 shown and discussed in greater detail with respect to FIGS. 2A-2C.

[0041] FIG. 2A shows a side profile view of the inner protective shell 80, with the front lip 88 disposed on the right of the figure and the back 89 of the shell 80 disposed at the

left of the figure, the right side 90 of the inner protective shell 80 being shown. A channel or elastomer member receiving aperture 110 may be formed in and extend through the outer protective shell 60 and the inner protective shell 80. More specifically, the channel 110 may comprise a first portion or channel 110a that is formed in, or extends through, the outer protective shell 60 and a second portion or channel 110b that is formed in or extends through the inner protective shell 80. The channel 110b may intersect with, or open into, a recess, crater, or bowl 92 that is formed in the inner protective shell 80 and extends from the outer surface 82 of the inner shell 80 partially but not completely through the inner protective shell 80. The recess 92, like the channel 110b, may be configured or adapted to receiving an elastomer member or elastomer retainer 120 as it extends through the inner protective shell 80. The recess 92 may provide or allow for increased unconstrained movement of the elastomer member 120 without the elastomer member 120 contacting the shell 80, as would otherwise occur without the recess 92 or with just the channel 110b.

[0042] As shown in the figures, at least one, but in most cases at least two, channels 110 may extend through the protective shells 60, 80, and receive corresponding at least one elastomer members 120. More specifically, FIG. 2A shows a second channel 110b, and a corresponding elastomer member 120 disposed at a right rear portion of the helmet 30 in the inner protective shell 80. A corresponding or mirroring first channel 110a and first elastomer member 120 may be disposed at a left rear portion of the helmet, as shown in the various view of the figures. In other instances a single channel 110, different positions of the channels 110, and more than two channels 110 may also be used or present.

[0043] FIG. 2A also shows an elastomer member 120 disposed within, and extending through, the channel 110. The elastomer member 120 may comprise a first end 122 positioned at the inner surface 84 of the inner protective shell 80, a second end 124 opposite the first end 122 positioned at the outer surface 62 of the outer protective shell 60, or in a recess, opening, or crater 72 in the outer protective shell 60 that intersects with the channel 110a. The elastomer member 120 may further comprise a connecting portion 126 that extends between the first end 122 and the second end 124. The elastomer member 120 may be formed of rubber, silicon, or other stretchable or elastically deformable material that is biased to return back to its original shape after being stretched. The elastomer member(s) 120 may pass through channel(s) 110 that are formed in, and extend through, both the outer protective shell 60 and the inner protective shell 80.

[0044] The first end 122 of the elastomer member 120 may be enlarged to comprise a maximum cross-sectional width D_1 that is greater than a maximum cross-sectional width D_2 of the first channel 110. The second end 124 of the elastomer member 120 may further comprise one or more openings 128 disposed completely through the second or upper end 124 of the elastomer member 120. A pin, retention pin, or stop member 130 may be formed of metal, plastic, or other suitably strong material, and may be disposed through one of a plurality of the openings 128 through the elastomer member 120, the openings 128 being disposed along a length L of the elastomer member 120. The plurality of openings 128 may optionally provide different positions for the pin 130, thereby accommodating different helmet configurations and amounts of tension under which the elasto-

mer members 120 are placed, when coupling together the outer protective shell 60 and the inner protective shell 80, thereby influencing an amount of force needed to achieve a set amount of relative movement between the outer protective shell 60 and the inner protective shell 80. The pin 130 may comprise a distance D_3 , perpendicular to the length L, that is greater than a distance D_4 of a maximum cross-sectional width of the connecting portion 126 of the elastomer member 120. The pin 130 may comprise a center portion 132 disposed between two end portions, 134, 136, the center portion 132 of the pin 130 contacting the first elastomer member 120 and the two end portions 134, 136 of the pin 130 contacting the outer protective shell 60.

[0045] More specifically, the pin 130 and the second end 124 of the elastomer member 120 may be disposed or positioned within a recess 72 in the outer protective shell, so that the pin is offset, or below, the outer surface 62 of the outer protective shell 60. The recess 72 may be circular, oval, rectangular, square, or of any other organic, geometric, or other suitable shape, and may be sized to receive the pin 130. The two end portions 134, 136 of the pin 130 may contact the outer protective shell 60 within the recess 72. The distance D_4 of the connecting portion 126 of elastomer member 120 may be less than distance D_2 of the channel 110, through which the elastomer member 120 passes so that the elastomer member 120 may move, stretch, and elongate to facilitate the relative movement of protective shells 60, 80 during collisions and rotational energy management. The recess 92 may in the inner protective shell 80 may be larger than the recess 72 in the outer shell 60, as shown in FIGS. 2A and 2B, to accommodate the desired movement of the elastomer member 120.

[0046] FIG. 2B shows the front lip 70 of the outer protective shell 60 at the right of the figure, and the rear portion 71 of the outer shell 60 disposed at the left side of the figure. The outer end 124 of the elastomer member 120 extends slightly above the outer surface 62 of the outer protective shell 60, the elastomer member 120 continuing down through the openings 72, 110 in the outer shell 60 and through the inner protective shell 80. FIG. 2C shows a view of the outer protective shell 60, but reversed from that shown in FIG. 2B with the front lip 70 of the outer shell shown at the left of the figure and the rear portion 71 of the outer protective shell 60 shown at the right of the figure.

[0047] In FIG. 2C, the outer shell 60 is provided for context, and the inner shell 80 is shown placed within the outer shell 60, but with the patterning or texture of the outer shell 60 being omitted from covering or being disposed over the inner shell 80. By not including the shading of the outer shell 60 over the inner shell 80, as the inner shell 80 is disposed within the outer shell 60, the detail of the inner shell 80 can be more clearly seen. Similarly, the features 90 and 110b of the outer shell 60 shown in dashed lines to indicate the are included on the outer surface of the outer shell between the viewer and the inner shell 80. Thus, as can be seen, FIG. 2C differs from FIG. 2A in that the outer shell 60 is shown in FIG. 2C as a transparent layer that shows the elastomer member 120 extending through the helmet 30, from the inner surface 84 of the inner protective shell 6 to the outer surface 62 of the outer shell 60, or the recess 72 in the outer shell 60.

[0048] As shown in FIG. 2C, the elastomer member 120 may comprise an enlarged first end 122 at the inner surface 84 of the inner shell 80 and the openings 128 in the second

end 124 opposite the first end 122. In other instances, the relative positioning of the first end 122 and the second end 124 may be reversed so that the openings 128 are disposed at the inner surface 84 of the inner shell and the enlarged or flared first end 122 may be positioned at the outer surface 62 of the outer shell 60.

[0049] FIGS. 3A and 3B show various views of the outer protective shell 60 coupled to the inner protective shell 80 without the outer cover 40. The outer protective shell 60 and the inner protective shell 80 are coupled together with the boundary nub 100 nested within the boundary nub receiving recess 98, and with an elastomer member 120 disposed in the channel 110 on the right side of the helmet 36. The channel 110 on the left side 35 of the helmet 30 is shown by contrast, and for purposes of illustration, without an elastomer member 120, although before use an additional elastomer member 120 could be included within the channel 110. The inner end 122 of the elastomer member 120 is enlarged to retain the elastomer member 120 on the inner surface 84 of the inner protective shell 80, without being pulled through the channel 110 when subjected to tension. The outer end 124 of the elastomer member 120 extends through the outer shell 60 prior to placement of the pin 130 through one of the openings 128 in the elastomer member 120 so that together the enlarged end 122 and the pin 130 extending through the apertures 128, movably couples the inner protective shell 80 to the outer protective shell 60. If the inner protective shell 80 is held in place, such as on a wearer's head, and the outer protective shell 60 experiences an angular force, the outer protective shell 60 will rotatably move in relation to the inner protective shell 80, thus reducing the rotational impact forces on the wearer's head and neck.

[0050] As shown in FIGS. 3A and 3B, when the inner protective shell 80 is placed or positioned within the outer protective shell 60, the rounded boundary nub 100 may extend from the outer surface 82 of the inner protective shell 80 and fits within the rounded boundary nub receiving recess 98 formed in the outer protective shell 60 and extending from the inner surface 64 of the outer protective shell 60. The outer surface 82 of the inner protective shell 80 and the inner surface 62 of the outer protective shell 60 may also mate and create an interface plane between the two protective shells 60, 80. The inclusion of the single rounded boundary nub 100 at the front lower edge of the helmet 34 and two opposing elastomer members 120 positioned on either side 35, 36 near the back 37 of the helmet 30 may provide the balance needed to retain the inner protective shell 80 in its proper position within the outer protective shell 60 for proper operation both during testing and ultimately during normal use by a wearer.

[0051] In particular embodiments, the interface plane between the two protective shells 60, 80 may be a completely spherical interface plane so that where the two surfaces 64, 82 meet (including corresponding surfaces of a slip plane if present) may be spherical except for a discontinuity where the boundary nub 100 meets the receiving recess 98. The inventors discovered that during certain impact tests for helmets using inner and outer protective shells formed of impact or energy absorbing materials, and where the mating surfaces were spherical and the inner and outer protective shells were joined by an elastic member, that the inner and outer protective shells did not consistently remain in place to enable the impact testing because the weight of the inner or outer protective shells caused them to

rotate with respect to each other during the testing. Additionally, using tighter elastic or elastomer members in such cases, while reducing problems with positioning, created an additional problem of undesirably restricting the relative rotational movement between the outer and inner protective shells.

[0052] By placing the boundary nub 100 at the front 33 of the helmet 30, the outer protective shell 60 and the inner protective shell 80 do not move undesirably during testing because the boundary nub 100, together with the elastomer members 120 tightened to a desirable tension for facilitating rotation during impacts or crashes, sufficiently maintain the relative position of components of the helmet 30, such as protective shells 60, 80, for testing of the helmet 30 and during ordinary use of the helmet 30. By providing the boundary nub 100 and the corresponding receiving recess 98 with mating rounded surfaces, the outer protective shell 60 and inner protective shell 80 are able to rotate and move laterally (left and right) relative to each other. By placing the boundary nub 100 at the front edge 86 of the inner protective shell 80, the outer protective shell 80 is able to rotate and move backward relative to the inner protective shell 60. Thus, the boundary nub 100 in some instance will only restricts relative movement of the outer protective shell 60 toward the front 33 of the helmet 30 with respect to the inner protective shell 80, which also restricts the undesired movement occurring during testing without compromising safety performance. In embodiments where the boundary nub 100 is formed of the same impact energy management materials as the inner protective shell 80, such as EPS, EPP, EPU, EPO, or other foam, when an impact with sufficient rotational force strikes or is passed to the outer protective shell 60 and causes the outer protective shell 60 to rotate forward in relation to the inner protective shell 80 with sufficient force, the boundary nub 100 is structured or designed to break off, or shear away, rather than transfer the rotational force to the wearer's head.

[0053] In other words, the structural strength and connection between the boundary nub 100 and the inner protective shell 80 will be maintained during minor impacts that result, such as from putting on the helmet, dropping the helmet, or from small bumps or impacts to the helmet 30 that pose no danger to the user and are routine. However, when the impacts and forces to the helmet 30 are larger, and pose a risk or potential risk to the user of the helmet 30, the nub 100 breaks off or breaks away from the inner protective shell 80, due to the shear force produced by energy from a rotational impact causing the outer protective shell 60 to press against the boundary nub 100. In particular embodiments, an additional groove, notch, or control joint may be formed at a junction or interface between the boundary nub 100 and the inner protective shell 80 to control or direct where the breaking, shearing, or failure of the connection between the nub 100 and the inner protective shell 80 occurs. As such, a location of the shearing between the nub 100 and the shell 80 may be more precisely controlled and a more specific or precise breaking force established for the shearing off of the nub 100.

[0054] The boundary nub 100 may comprise any size or diameter that would allow the boundary nub 100 to shear away from the inner protective shell at a predetermined rotational force. The size or diameter of the boundary nub 100 may vary based on the impact energy management material used, the helmet geometry, and other relevant

factors. Although the particular embodiments illustrated in the FIGs. show the boundary nub 100 formed at the front, center, lower edge 86 of the inner protective shell 80, a rear boundary nub 100 may also be formed at the center of the back lower edge 89 of the inner protective shell 80 with a corresponding mating receiving recess 98 being formed or disposed in the outer protective shell 60. In some instances more than one nub 100 and corresponding recess 98 may be used, such as both front and rear nubs 100. When front and rear nubs 100 are used and positioned so that the boundary nubs 100, and the corresponding receiving recesses 98, are matched along a same axis of curvature or axis of rotation, the front and rear boundary nubs 100 may still allow for the lateral (left to right) relative rotation of the outer protective shell 60 and the inner protective shell 80 without breaking or shearing off of the front or rear boundary nubs 100. When excess rotational force is exerted beyond the lateral relative rotational motion of the outer protective shell 60 and the inner shell 80 in relation to the axis of rotation, one or both of the front and rear boundary nubs 100 may break off from protective shell, such as shell 80, as a result the shear force caused by the rotational movement and contact between the outer protective shell 60 and the inner protective shell 80. As such, a desirable amount of relative movement between the outer protective shell 60 and the inner protective shell 80 during a crash or impact may be facilitated while the helmet 30 is absorbing or attenuating impact energy.

[0055] Where the above examples, embodiments and implementations reference examples, it should be understood by those of ordinary skill in the art that other helmet and manufacturing devices and examples could be inter-mixed or substituted with those provided. In places where the description above refers to particular embodiments of helmets and customization methods, it should be readily apparent that a number of modifications may be made without departing from the spirit thereof and that these embodiments and implementations may be applied to other to helmet customization technologies as well. Accordingly, the disclosed subject matter is intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the disclosure and the knowledge of one of ordinary skill in the art.

What is claimed is:

1. A protective helmet for rotational energy management, comprising:

an outer protective shell comprising an outer surface and an inner surface opposite the outer surface, a portion of the inner surface being spherically shaped;

an inner protective shell disposed within the outer protective shell and further comprising a spherically shaped outer surface oriented towards the inner surface of the outer protective shell and an inner surface opposite the outer surface, wherein a surface area of the outer surface of the inner protective shell is less than a surface area of the inner surface of the outer protective shell;

a first channel extending through the outer protective shell and the inner protective shell;

a first elastomer member extending through the first channel and comprising a first end positioned at the inner surface of the inner protective shell, a second end opposite the first end positioned at the outer surface of the outer protective shell,—and a connecting portion extending between the first end and the second end; and

a boundary nub comprising a spherical shape and integrally formed with the inner protective shell at a front lower edge of the inner protective shell.

2. The protective helmet of claim 1, wherein an occipital portion of the inner surface of the outer protective shell is not spherical in shape, but comprises a convex curve that is not covered by the inner protective shell.

3. The protective helmet of claim 1, wherein the boundary nub is formed of the same material as the inner protective shell.

4. The protective helmet of claim 1, wherein:

the first end of the first elastomer member is enlarged to comprise a maximum cross-sectional width D_1 that is greater than a maximum cross-sectional width D_2 of the first channel;

the second end of the first elastomer member further comprises an opening disposed completely through the second end of the first elastomer member; and

a pin is disposed through the opening, the pin comprising a distance D_3 greater than a distance D_4 of a maximum cross-sectional width of the connecting portion of the first elastomer member, wherein the pin comprises a center portion disposed between two end portions, the center portion of the pin contacting the first elastomer member and the two end portions of the pin contacting the outer protective shell.

5. The protective helmet of claim 4, wherein the second end of the first elastomer member and the pin are positioned within a recess in the outer protective shell.

6. The protective helmet of claim 1, further comprising: the first channel and the first elastomer member disposed at a left rear portion of the helmet; and

a second channel and a second elastomer member disposed at a right rear portion of the helmet.

7. The protective helmet of claim 1, further comprising a protective outer cover disposed over the outer protective shell.

8. A protective helmet for rotational energy management, comprising:

an outer protective shell comprising an outer surface and an inner surface opposite the outer surface;

an inner protective shell disposed within the outer protective shell with an outer surface oriented towards the inner surface of the outer protective shell and an inner surface opposite the outer surface;

a first channel extending through the outer protective shell and the inner protective shell;

a first elastomer member extending through the first channel and comprising a first end, a second end opposite the first end, and a connecting portion extending between the first end and the second end; and

a boundary nub comprising a spherical shape.

9. The protective helmet of claim 8, wherein the boundary nub is disposed along a lower edge of the helmet at an interface between the outer protective shell and the inner protective shell.

10. The protective helmet of claim 9, wherein the boundary nub is integrally formed with the outer protective shell or the inner protective shell.

11. The protective helmet of claim 8, further comprising: a portion of the inner surface of the outer protective shell is spherically shaped; and

the outer surface of the inner protective shell is spherically shaped and comprises a surface area less than a surface area of the inner surface of the outer protective shell;

wherein an occipital portion of the inner surface of the outer protective shell is not spherical in shape, but comprises a convex curve that is not covered by the inner protective shell.

12. The protective helmet of claim **8**, wherein the second end of the first elastomer member further comprises:

an opening disposed completely through the first end or second end of the first elastomer member; and

a pin disposed through the opening, the pin comprising a distance D_3 greater than a distance D_4 of a maximum cross-sectional width of the connecting portion of the first elastomer member, wherein the pin comprises a center portion disposed between two end portions, the center portion of the pin contacting the first elastomer member and the two end portions of the pin contacting the outer protective shell.

13. The protective helmet of claim **8**, further comprising: the first channel and the first elastomer member disposed at a left rear portion of the helmet; and a second channel and a second elastomer member disposed at a right rear portion of the helmet.

14. A protective helmet for rotational energy management, comprising:

an outer protective shell comprising an outer surface and an inner surface opposite the outer surface, a portion of the inner surface being spherically shaped;

an inner protective shell disposed within the outer protective shell and further comprising a spherically shaped outer surface oriented towards the inner surface of the outer protective shell and an inner surface opposite the outer surface, wherein a surface area of the outer surface of the inner protective shell is less than a surface area of the inner surface of the outer protective shell;

a first channel extending through the outer protective shell and the inner protective shell;

a first elastomer member extending through the first channel and comprising a first end, a second end opposite the first end, and a connecting portion extending between the first end and the second end; and

a boundary nub.

15. The protective helmet of claim **14**, further comprising an occipital portion of the inner surface of the outer protective shell, wherein the occipital portion is not covered by the inner protective shell and comprises a convex curve to follow an occipital curve of helmet wearer.

16. The protective helmet of claim **14**, wherein the boundary nub comprises a spherical shape disposed at a lower edge of the protective shell along an interface between the outer protective shell and the inner protective shell.

17. The protective helmet of claim **16**, wherein the boundary nub is formed of the same material as the inner protective shell or the outer protective shell.

18. The protective helmet of claim **14**, wherein:

the first end of the elastomer member is enlarged to comprise a maximum cross-sectional width D_1 that is greater than a maximum cross-sectional width D_2 of the first channel;

the second end of the first elastomer member further comprises an opening disposed completely through the upper end of the first elastomer member; and

a pin is disposed through the opening, the pin comprising a distance D_3 greater than a distance D_4 of a maximum cross-sectional width of the connecting portion of the first elastomer member, wherein the pin comprises a center portion disposed between two end portions, the center portion of the pin contacting the first elastomer member and the two end portions of the pin contacting the outer protective shell.

19. The protective helmet of claim **18**, wherein the pin is positioned within a recess in the outer protective shell.

20. The protective helmet of claim **14**, further comprising: the first channel and the first elastomer member disposed at a left rear portion of the helmet; and

a second channel and a second elastomer member disposed at a right rear portion of the helmet.

* * * * *