US 20220232924A1

(19) United States
(12) Patent Application Publication
COOK et al.
(10) Pub. No.: US 2022/0232924 A1
(43) Pub. Date: Jul. 28, 2022

(54) **HELMET**

(71) Applicant: **HEXR LTD**, London (GB)

(72) Inventors: **James COOK**, London (GB); **Henry NEILSON**, London (GB)

(73) Assignee: **HEXR LTD**, London (GB)

(21) Appl. No.: **17/616,549**

(22) PCT Filed: **Jun. 5, 2020**

(86) PCT No.: **PCT/GB2020/051378**

§ 371 (c)(1),
(2) Date: **Dec. 3, 2021**

(30) **Foreign Application Priority Data**

Jun. 6, 2019 (GB) 1908090.2

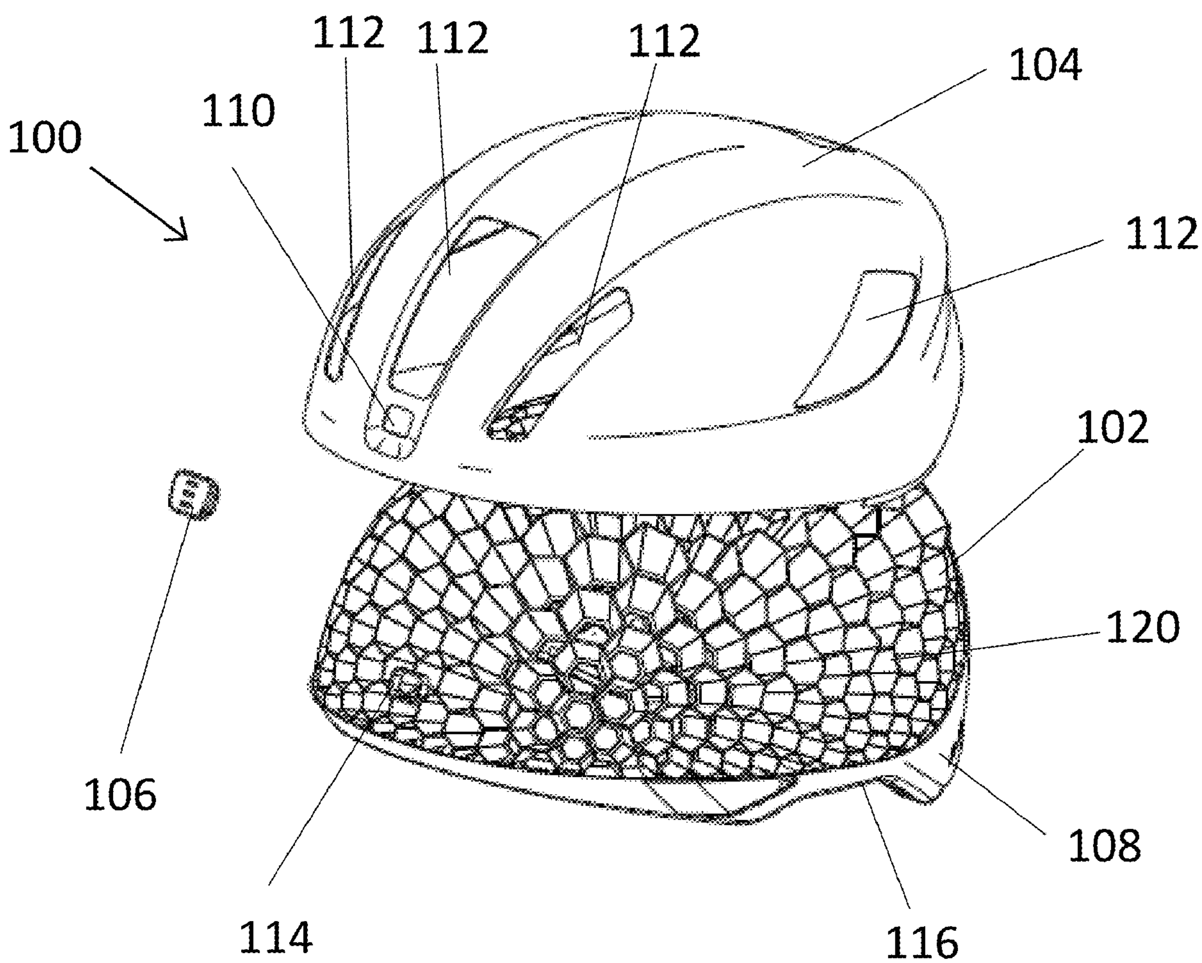
Publication Classification

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

(52) **U.S. Cl.**
CPC *A42B 3/064* (2013.01)

(57) **ABSTRACT**

A helmet (**100**) including an impact absorbing layer (**102**), an outer shell (**104**) and a connector (**106**, **114**). The outer shell is mounted on the outer surface of the impact absorbing layer. The connector connects the outer shell to the impact absorbing layer, to retain the outer shell on the impact absorbing layer. The connector is also arranged to allow the outer shell to separate from the impact absorbing layer when the helmet is subject to an impact.



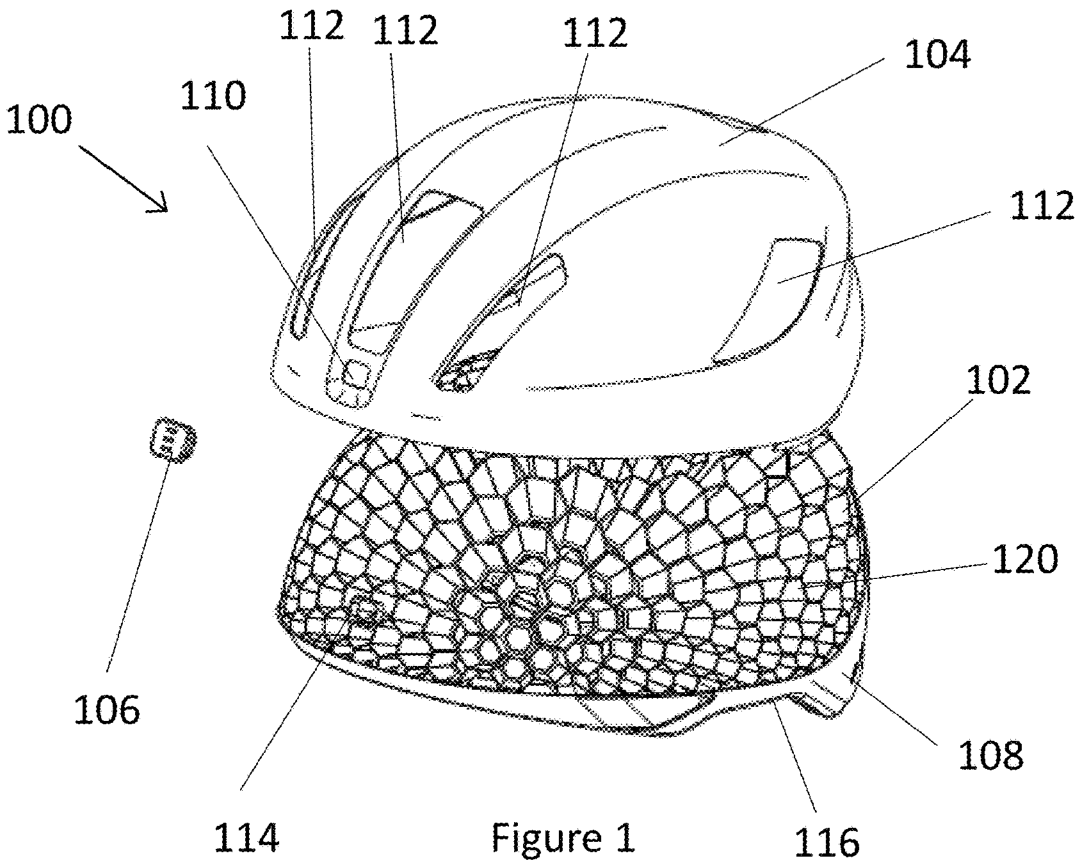


Figure 1

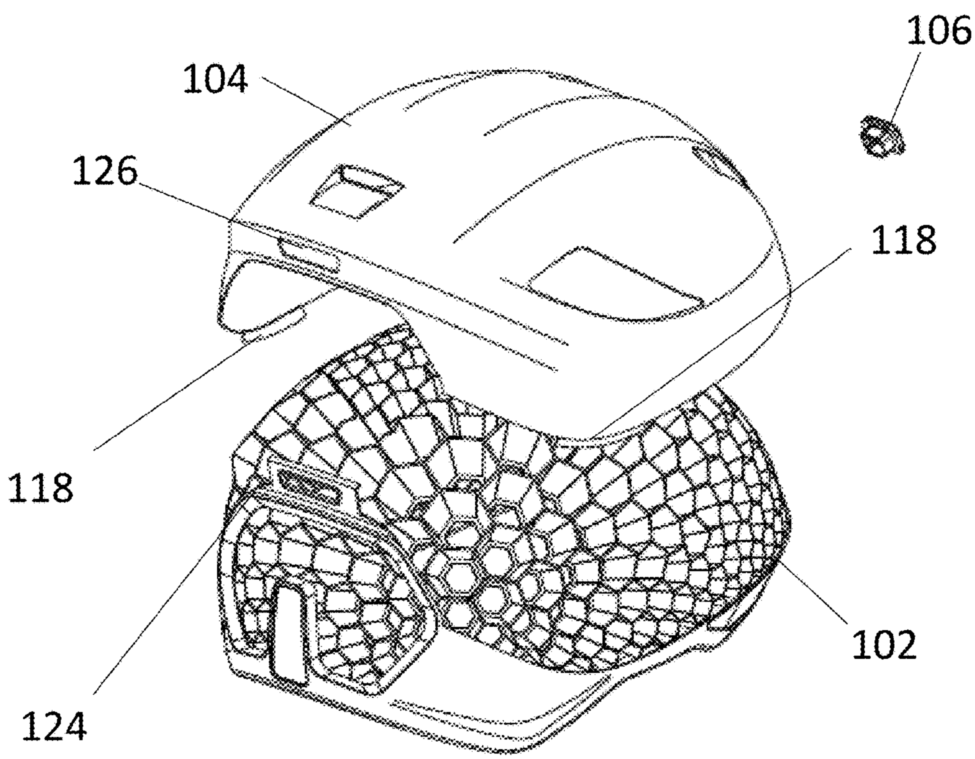


Figure 2

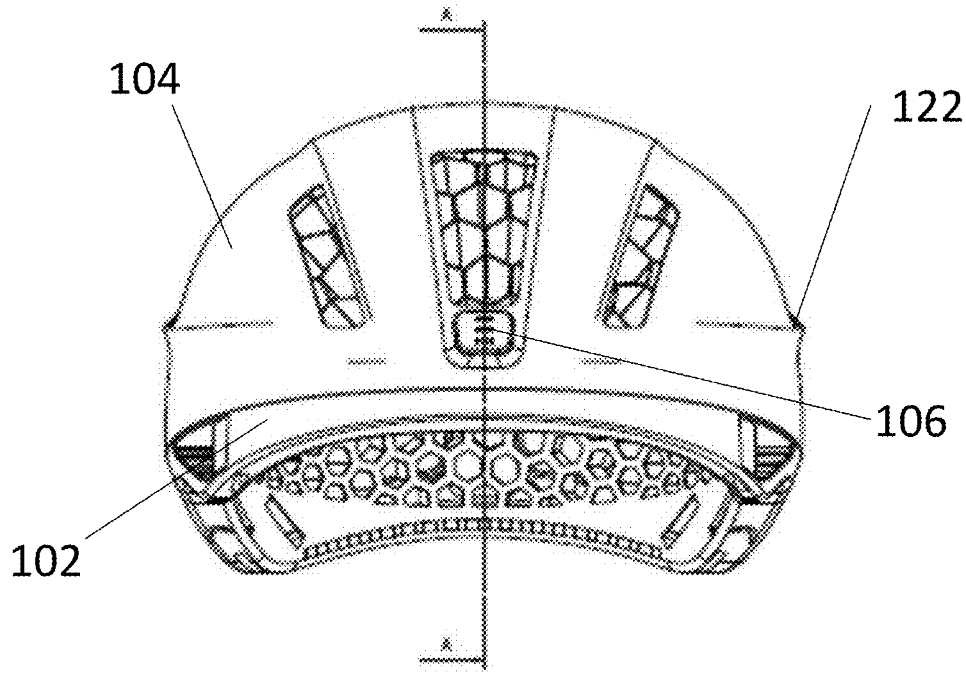


Figure 3

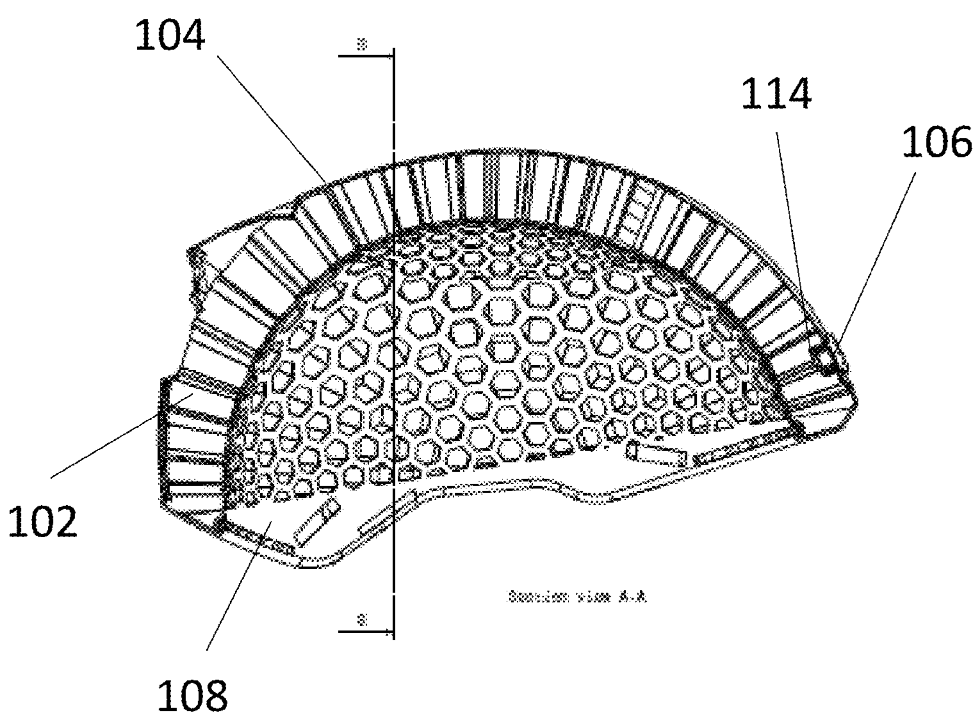


Figure 4

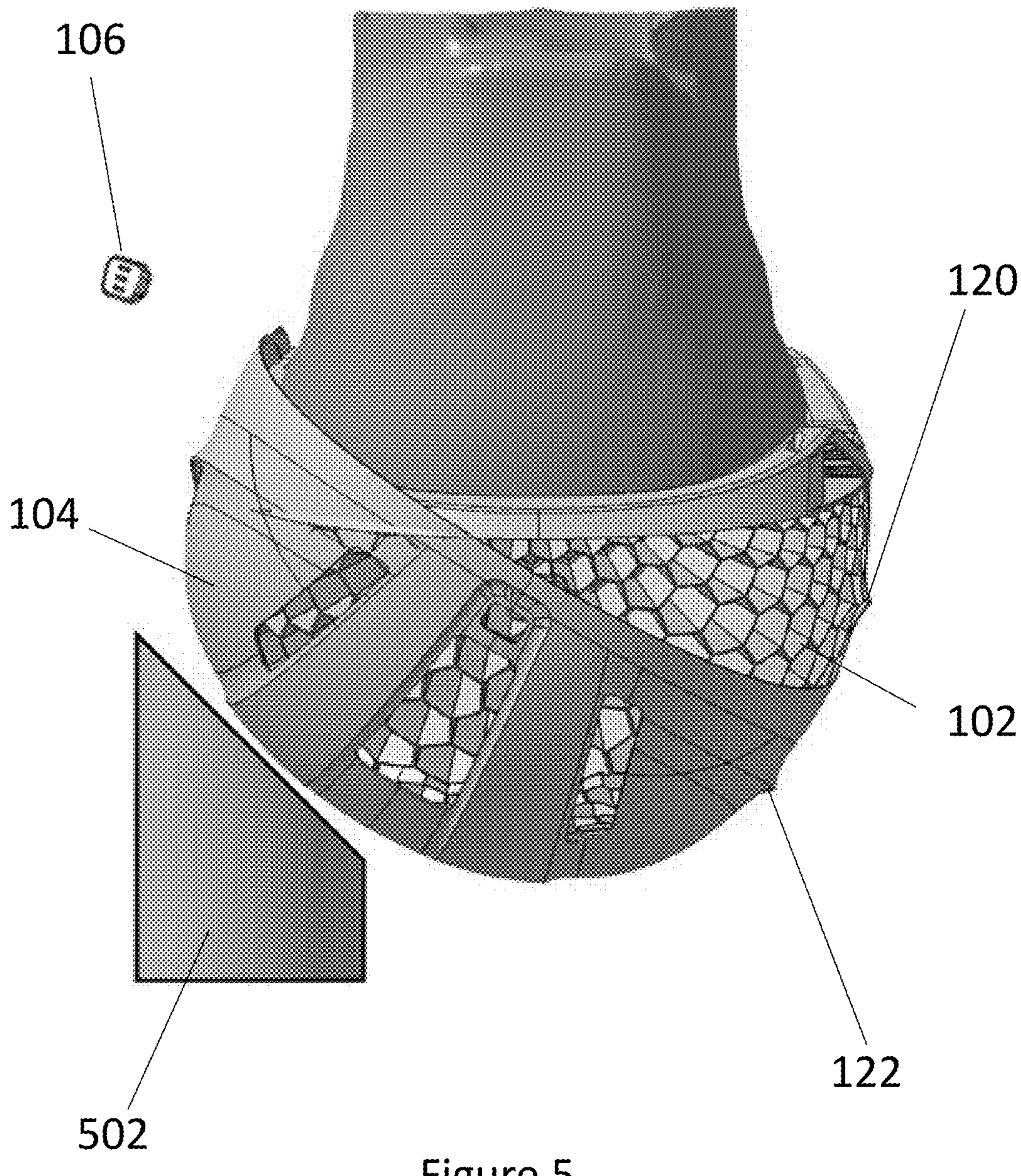


Figure 5

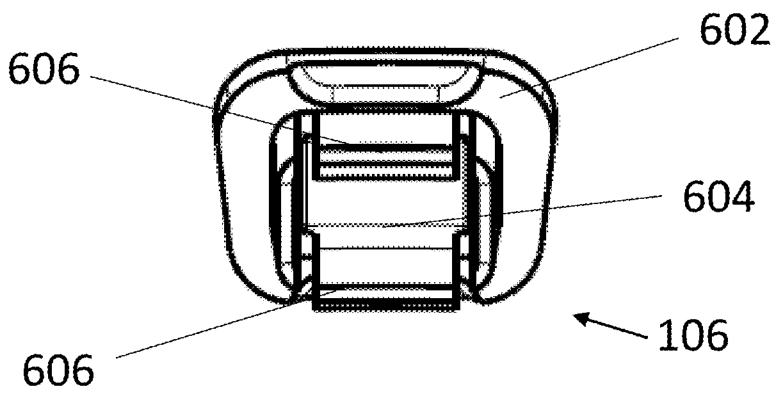


Figure 6A

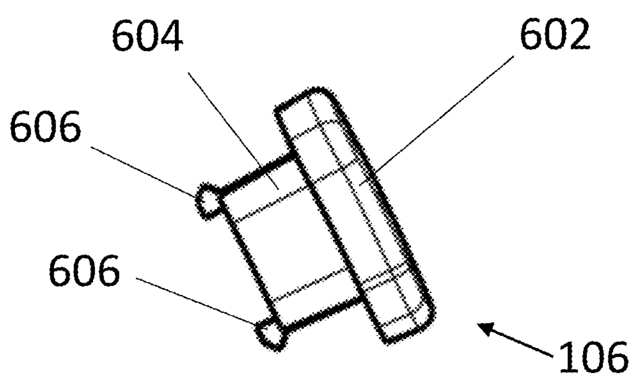


Figure 6B

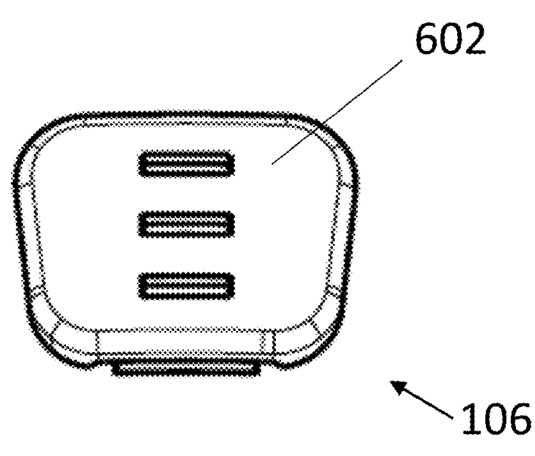


Figure 6C

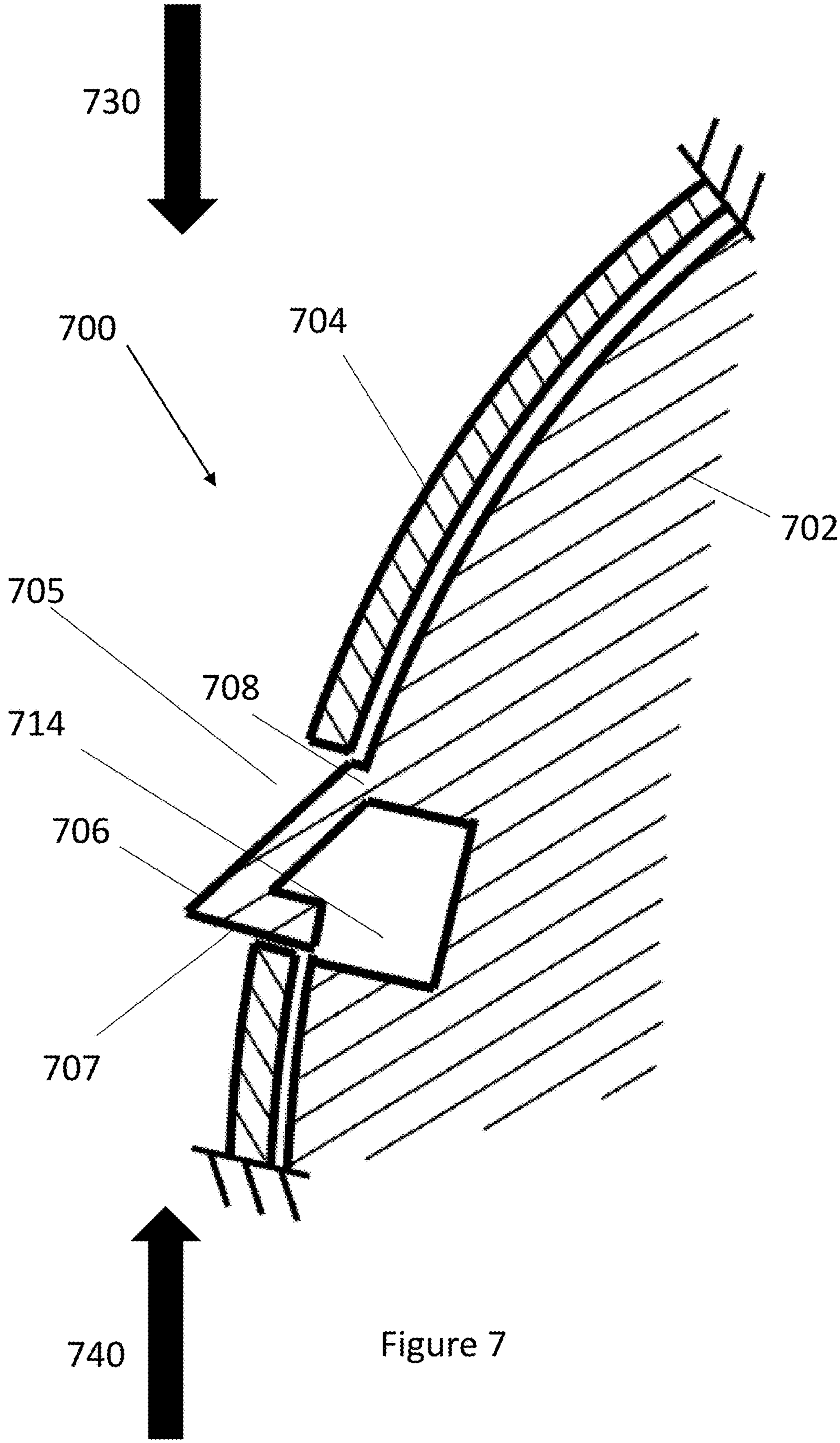


Figure 7

HELMET

[0001] This nonprovisional application is a National Stage of International Application No. PCT/GB2020/051378, which was filed on Jun. 5, 2020, and which claims priority to Great Britain Patent Application No. 1908090.2, which was filed in Great Britain on Jun. 6, 2019, and which are both herein incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] This invention relates to a helmet, in particular a helmet having a detachable outer shell.

Description of the Background Art

[0003] Head injuries, which can be incurred as a result of participation in sports such as cycling, horse riding or rock climbing, are a common cause of serious brain injuries. Impact protection is therefore important in preventing brain injuries as a result of impacts to the head. Head protection, in the form of helmets, is designed to reduce the forces experienced by a user's head during an impact. Typically, a helmet comprises at least one impact absorbing layer which is designed to absorb a portion of the forces to which the helmet is subjected during an impact.

[0004] However, a helmet often does not provide adequate protection during an oblique impact which subjects the helmet to significant tangential forces. Oblique impacts are common, as it is rare for an impact to occur directly along the normal to the outer surface of the helmet with no additional components in other directions. Tangential forces result in the rotational acceleration of the brain, which has been linked to bridging vein rupture. In turn, this may be responsible for subdural haematomas, and diffuse axonal injuries.

SUMMARY OF THE INVENTION

[0005] It is an aim of the present invention to provide an improved helmet.

[0006] When viewed from a first aspect the present invention provides a helmet comprising:

[0007] an impact absorbing layer;

[0008] an outer shell mounted on the outer surface of the impact absorbing layer; and

[0009] a connector which connects the outer shell to the impact absorbing layer to retain the outer shell on the impact absorbing layer;

[0010] wherein the connector is arranged to allow the outer shell to separate from the impact absorbing layer when the helmet is subject to an impact.

[0011] This invention relates to a helmet including an impact absorbing layer and an outer shell, which are connected together by a connector, e.g. to retain the outer shell on the impact absorbing layer during normal use. When the helmet is subject to an impact (and thus an external force acts on the helmet) the connector is arranged such that it allows the outer shell to separate from the impact absorbing layer (i.e. be moved to a different position from that in which the outer shell is mounted on the impact absorbing layer and the connector is connecting them). For example, the outer shell may be configured such that it is able to rotate about the impact absorbing layer when not connected to the impact absorbing layer by the connector.

[0012] The skilled person will appreciate that owing the way in which the outer shell is detachably connected to the impact absorbing layer via the connector, the outer shell is able to move, and for example rotate, about the outer surface of the impact absorbing layer when the outer shell has separated from the impact absorbing layer (owing to no longer being held in place by the connector). Therefore, when the helmet is subject to an impact that involves at least a tangential component (i.e. that is not solely along the normal direction to the outer surface of the helmet), at least a portion of the tangential forces produced by the impact may act to rotate the outer shell. This helps to reduce the rotation of the head of the user and thus the transfer of tangential forces from the impact. This is because the user's head (e.g. with the impact absorbing layer still attached thereto) may able to translate (e.g. slide or rotate) within the outer shell instead of being subject to the tangential forces itself.

[0013] When the tangential forces experienced by the head are reduced (thus reducing the rotational acceleration experienced by the head), the risk of injuries such as bridging vein rupture are decreased. Reducing the tangential forces experienced by a user's head further reduces the risk of neck injuries caused by over-rotation of the head with respect to the neck.

[0014] In at least preferred embodiments, the impact absorbing layer is designed to provide a user's head with a degree of protection against bulk forces exerted in an impact. Thus preferably, the impact absorbing layer is arranged to absorb at least a portion of the normal component of the forces exerted on the helmet during an impact.

[0015] The impact absorbing layer may be formed from any suitable and desired material, such as expanded polystyrene. In a preferred set of embodiments, the impact absorbing layer comprises a hollow cell structure, e.g. comprising a plurality of hexagonal cells (in cross section). Preferably, at least a plurality of the cells tessellate with each other. For example, the impact absorbing layer structure may comprise a micro-truss lattice or an out-of-plane honeycomb. The impact absorbing layer may further comprise a rim, e.g. around the edge (below) the hollow cell structure.

[0016] Typically, in conventional helmets comprising an outer shell, the outer shell may be provided predominately as an aesthetic feature used to improve the appearance of the helmet. Such outer shells are typically not connected as a separate, discrete part of the helmet (thus contrasting with the outer shell of the present invention). Instead conventional helmets may be manufactured in moulds, into which the material forming the impact absorbing layer is injected. In the present invention, the Applicant has appreciated that the outer shell may also help to reduce the rotation of the head of the user when the helmet is subject to an impact. Preferably the outer shell is formed from a rigid material, such as a thermoplastic, e.g. polycarbonate, or carbon fibre, or a composite material; however, it could be made from any suitable and desired material. Preferable materials for forming the outer shell have high strength to weight ratios.

[0017] In a preferred set of embodiments, the outer shell has a thickness that is significantly less than a thickness of the impact absorbing layer. The outer shell may thus comprise a membrane, e.g. at least partly covering the impact absorbing layer. Thus, while the outer shell is designed to detach from the impact absorbing layer when subject to an impact, the outer shell may itself not be designed to absorb the force of the impact. Preferably, the outer shell has a thickness (e.g. in the normal direction) of less than 6 mm, e.g. less than 4 mm, e.g. less than 2 mm, e.g. less than 0.5 mm Different outer shell thickness may be advantageous for different types of helmets, e.g. motorcyclist helmets may preferably have a thicker outer shell (e.g. 6 mm), whereas bicycle helmets may have a thinner outer shell (e.g. less than 4 mm).

[0018] Preferably the impact absorbing layer has a thickness (e.g. in the normal direction) of between 10 mm and 50 mm, e.g. between 20 mm and 30 mm. Different impact absorbing layer thickness may be appropriate for different types of helmets, e.g. motorcyclist helmets may preferably have a thicker impact absorbing layer (e.g. between 20 mm and 50 mm), whereas bicycle helmets may have a thinner impact absorbing layer (e.g. between 10 mm and 30 mm).

[0019] In a preferred set of embodiments, the outer shell covers at least 60% of the surface area of the outer surface of the impact absorbing layer, e.g. at least 70%, e.g. at least 80%. The outer shell preferably covers the impact absorbing layer at one or more, e.g. all, sites on the helmet which may experience an impact. The outer shell may comprise one or more vent apertures to allow airflow. The outer shell may not extend over the rim of the impact absorbing layer, when provided. Thus for example, the outer shell may only extend over the outer surface of the hollow cell structure. However, in other examples the shell extends at least partly over the rim.

[0020] In a set of embodiments, the outer shell has a smooth outer surface, e.g. in which the impact absorbing layer is formed from a plurality of cells. In a set of embodiments, the inner surface of the outer shell is smooth. Such embodiments may be advantageous as providing smooth surfaces enables the outer shell to rotate over the impact absorbing layer with a minimized resistance upon impact.

[0021] The connecter is designed to retain the outer shell on the impact absorbing layer (e.g. during normal use), and to allow the outer shell to separate from the impact absorbing layer during an impact. This may allow the outer shell to move, e.g. rotate, about the outer surface of the impact absorbing layer. This may be achieved in any suitable or desired way. For example, the connector may be arranged to retain the outer shell in position on the impact absorbing layer when weaker forces act on the helmet (e.g. as would be expected in normal use), and allow the outer shell to separate from the outer shell when larger forces act on the helmet, e.g. as the result of an impact. Preferably the connector extends in a radial direction, e.g. perpendicular, to the surface of the impact absorbing layer (e.g. parallel to the walls of the plurality of cells) and/or perpendicular to the surface of the outer shell.

[0022] In a set of embodiments, the connector is arranged to allow the outer shell to separate from the impact absorbing layer when the (e.g. outer shell of the) helmet is subject to an impact having a particular (e.g. predetermined) force (e.g. an oblique force). This helps to retain the outer shell on the impact absorbing layer during normal use and to separate from the impact absorbing layer when subject to an impact. The particular force required for the connector to allow the outer shell to separate from the impact absorbing layer may be chosen to have any suitable and desired value (e.g. such that the outer shell only separates from the impact absorbing layer as the result of a sufficiently large impact). In one embodiment the particular (e.g. predetermined) force is between 10 and 100 N, e.g. between 30 N and 70 N, e.g. approximately 50 N. The particular force may, for example be chosen such that it reflects the lowest range of forces acting on the helmet which may cause an injury.

[0023] The connector may be located at any suitable and desired position on the helmet. However, preferably the connector is located along an axis of symmetry of the helmet, e.g. along the mid plane of the helmet extending from the front to the rear of the helmet. In a set of embodiments, the connector is located at the front of the helmet. Positioning the connector at the front of the helmet may be particularly useful in aiding the detachment of the outer shell in an oblique impact, particularly for impacts that are offset from the central axis of symmetry and thus the front of the helmet.

[0024] The connector may have any suitable and desired form, e.g. such that it is arranged to allow the outer shell to separate from the impact absorbing layer when the helmet is subject to an impact (e.g. having a force greater than a particular value e.g. approximately 50 N). In a set of embodiments, the connector comprises a discrete component from the outer shell and the impact absorbing layer. Thus preferably at least a portion (e.g. the discrete component) of the connector is arranged to detach from the impact absorbing layer and/or the outer shell when the helmet is subject to an impact, e.g. such that the at least a portion (e.g. the discrete component) of the connector is no longer in contact with the rest of the helmet, thus allowing the outer shell to be separated from the impact absorbing layer.

[0025] In one set of embodiments the connector comprises a plug which extends between (and, e.g., is attached to both) the outer shell and the impact absorbing layer. Preferably, the outer shell comprises an aperture for receiving the plug. Thus, for example, the plug extends through the aperture and attaches to (e.g. a socket of) the impact absorbing layer. The plug therefore may be accessible from the outside of the outer shell. This may allow the plug to be easily removed to interchange the plug and/or the outer shell. Interchanging the plug or the outer shell is particular advantageous if either is damaged accidently or for aesthetic reasons.

[0026] Preferably the plug comprises an outer head having dimension(s) greater than the corresponding dimension(s) of the aperture. The outer head of the plug may therefore cover (e.g. encase) a portion of the outside of the outer shell. This may further aid easier removal of the plug to interchange the plug and/or the outer shell.

[0027] The plug may attach to the impact absorbing layer in any suitable and desired way. The plug may attach directly to the impact absorbing layer. For example, in embodiments in which the impact absorbing layer comprises a hollow cell structure (e.g. comprising a plurality of cells), the plug may attach directly into a cell of the hollow cell structure of the impact absorbing layer.

[0028] In a preferred set of embodiments, the connector comprises a socket (e.g. clip) for receiving the plug of the connector. Preferably the socket is formed on or attached to the outer surface of the impact absorbing layer. Thus, when the outer shell is mounted on and retained to impact absorbing layer, the plug is located in the socket. Preferably, when the helmet is subject to an impact, the plug is arranged to be removed from the socket, such that this allows the outer shell to separate from the impact absorbing layer.

[0029] In one set of embodiments, the connector is an integrally formed part of the helmet (e.g. of the outer shell and/or the impact absorbing layer). For example, the outer shell and the impact absorbing layer may comprise complementary (e.g. male and female) parts which (e.g. fit together to) form the connector. Thus, for example, the outer shell may comprise a female (or male) member and the impact absorbing layer may comprise a corresponding male (or female) member which connect together to attach the outer shell to the impact absorbing layer. As outlined above, for example, the male member may comprise a plug and the female member may comprise a complementary socket.

[0030] In a set of embodiments, the connector comprises a (e.g. hinged) projection (e.g. a projecting latch). Preferably the projection is integral to (comprises part of) the impact absorbing layer. Preferably, the projection is attached (e.g. integral) to the main body of the impact absorbing layer by a flexible (e.g. hinged) portion. Preferably the flexible portion is formed from the same material as (e.g. is integral to) the impact absorbing layer.

[0031] The flexible (e.g. hinged) portion may be formed by a portion of material (e.g. a "living hinge") that is thinner than the surrounding material (e.g. of the impact absorbing later and/or the projection). The flexible portion allows the projection to bend and/or deform (e.g. relative to the impact absorbing layer) when a force is applied, e.g. without fracturing and/or rupturing the projection or its attachment to the main body of the impact absorbing layer (via the flexible portion).

[0032] In a set of embodiments, the impact absorbing layer comprises a cavity arranged to receive the projection, e.g. when the projection bends or deforms (e.g. via the flexible portion) relative to the main body of the impact absorbing layer. This may happen, for example, when a force is applied to the projection (e.g. via the outer shell). Preferably the projection is arranged to bend and/or deform relative to the main body of the impact absorbing layer, to allow the outer shell to separate from the impact absorbing layer when the helmet is subject to an impact. Thus, preferably, in normal use of the helmet, the cavity is empty and the projection substantially does not protrude into the cavity.

[0033] Preferably, the outer shell comprises an aperture for receiving the projection (e.g. in the manner of a latch). The projection and the aperture are preferably arranged such that the projection extends through the aperture, e.g. when no force is applied to the projection. Preferably the projection and the aperture are arranged to retain the outer shell on the impact absorbing layer.

[0034] Preferably the projection and the aperture are arranged such that when a force is applied to the projection (e.g. as a result of a force being applied to the outer shell) the projection and the aperture move relative to (e.g. apart from) each other, allowing the outer shell to move relative to the impact absorbing layer. This may be owing to the projection being pushed into the cavity or the outer shell flexing away from the projection. Preferably this results in the projection no longer extending through the aperture in the outer shell.

[0035] This arrangement may help to retain the outer shell in a desired position on the impact absorbing structure during normal use, while allowing (e.g. translational) movement of the outer shell over the impact absorbing layer when the projection has been moved into the cavity in the impact absorbing layer (e.g. owing to a force being applied to the projection during an accident or by intentional means by a user, such as to remove the outer shell from the impact absorbing layer).

[0036] In any of the embodiments described herein, the components of the connector may attach to each other (and/or to the outer shell and/or impact absorbing layer) in any suitable or desired way, e.g. to provide them with an attachment requiring a particular separation force (e.g. the particular force required to separate the outer shell from the impact absorbing layer as outlined above).

[0037] For example, the plug and the (e.g. socket of the) impact absorbing layer may attach together via a push (e.g. friction) fit. The push fit may be determined (e.g. solely) by the dimensions of the plug (and, e.g., the socket). However, in one embodiment, the plug and/or socket comprise one or more grips, ridges or latches. The grips, ridges or latches may help to control (e.g. increase) the friction therebetween and thus the force required to be exerted for the connector to allow the outer shell to separate from the impact absorbing layer when the helmet is subject to an impact.

[0038] The connector may be formed from any suitable and desired material. Preferably the connector (e.g. the plug and/or socket) is formed from a rigid material such as plastic, e.g. a thermoplastic, e.g. thermoplastic polyurethane (TPU), or a polyamide (Nylon), e.g. laser sintered polyamide 11, or acrylonitrile butadiene styrene (ABS). The connector (e.g. the plug and/or socket) may be formed of multiple parts which may be fabricated from different materials, as appropriate. For example, as outlined above, at least part of the connector may be integrally formed with (and thus preferably formed from the same material from) the impact absorbing layer.

[0039] In some embodiments the connector is arranged to separate into distinct parts or break when the helmet is subjected to an impact, rather than to deform and absorb energy when subjected to an impact. Preferably the plug is weaker than the outer shell, such that the connector may detach before the shell fractures during an impact.

[0040] The connector may be arranged to allow the outer shell to separate from the impact absorbing layer as a result of an impact in any suitable and desired way. Furthermore, the outer shell and the impact absorbing layer may be arranged to separate from each other in any suitable and desired way. In a preferred embodiment, e.g. when the helmet is subject to an oblique impact (such that tangential and radial forces are exerted on the helmet), the outer shell is arranged to be displaced relative to (e.g. rotated about) the impact absorbing layer. Preferably the displacement of the outer shell causes the connector to disconnect (e.g. the plug to be detached), e.g. owing to shearing forces.

[0041] The outer shell may be displaced relative to the impact absorbing layer in any suitable and desired way. Preferably the outer shell is arranged to translate (e.g. slide or rotate) relative to the impact absorbing layer when the helmet is subject to an impact. Thus, preferably, apart from the connector (and, e.g. any further features (e.g. as outlined herein) that help to locate the outer shell relative to the impact absorbing layer), the outer shell is not fixed (e.g. glued, taped or attached permanently by connectors) to the impact absorbing layer. This enables the outer shell to be separated from the impact absorbing layer when the connector is no longer connecting the outer shell to the impact absorbing layer. Thus preferably no part which is integral to the (e.g. inner surface of the) outer shell (e.g. away from the perimeter of the outer shell) is attached to the impact absorbing layer.

[0042] When subject to an impact that causes the outer shell to separate from the impact absorbing layer, preferably the connector is arranged to allow the outer shell to separate from the impact absorbing layer within 5 ms of the impact. Preferably the outer shell and the impact absorbing layer are arranged to move, e.g. rotate, relative to each other for between 10 and 15 ms when subject to an impact, e.g. after the outer shell has separated from the impact absorbing layer.

[0043] While the helmet may comprise only one connector, in a set of embodiments the helmet comprises a plurality of connectors that connect the outer shell to the impact absorbing layer. The plurality of connectors may be identical or different. Preferably the plurality of connectors are (together) arranged (e.g. together) to allow the outer shell to separate from the impact absorbing layer when the helmet is subjected to a particular (e.g. predetermined) force. Preferably the plurality of connectors are located in respective different positions on the helmet. For example, the connectors may be located at particular angles about the base of the outer shell, e.g. evenly spaced from each other.

[0044] While the connector preferably provides the principal connection that connects the outer shell to the impact absorbing layer to retain the outer shell on the impact absorbing layer, the helmet may comprise one or more additional features which aid the (correct) positioning and retention of the outer shell on the impact absorbing layer. The (e.g. rim of the) impact absorbing layer may comprise at least one groove or projection formed therein. In some embodiments the outer shell may comprise at least one inwardly projecting ridge (e.g. clip).

[0045] Preferably the at least one ridge corresponds (e.g. in location) to and engages with the at least one groove (or projection) in the (e.g. rim of the) impact absorbing layer (e.g. in terms of location and dimensions), such that the ridge is located in the groove (or on the projection), when the outer shell is mounted on the impact absorbing layer. The at least one ridge may thus be located in the at least one groove (when the outer shell is mounted on the impact absorbing layer), such that there are additional attachment point(s) between the outer shell and the impact absorbing layer than just the connector. The interconnecting ridge(s) and groove (s) (or projection(s)) help to retain the outer shell in position during general use.

[0046] Preferably, the interconnecting ridge(s) and groove (s) (or projection(s)) provide a weaker connection between the outer shell and the impact absorbing layer than is provided by the connector. During an impact, when the connector disconnects the outer shell from the impact absorbing layer, the at least one ridge is forced out of position from its corresponding groove (or projection) such that the outer shell is able to separate from the impact absorbing layer.

[0047] Thus, in one embodiment, the ridge(s) and groove (s) (or projection(s)) are arranged (e.g. interconnected when the outer shell is mounted on the impact absorbing layer) such that a particular (e.g. predetermined) force is required to remove the ridge(s) from the corresponding complementary groove(s) (or projection(s)). Preferably, this particular (e.g. predetermined) force is less than the particular (e.g. predetermined) force required for the connector to allow the outer shell to separate from the impact absorbing layer when the helmet is subject to an impact. This helps to ensure that once the force of an impact is sufficient to disconnect the connector between the outer shell and the impact absorbing layer, to separate the outer shell from the impact absorbing layer, the ridge(s) and groove(s) (or projection(s)) will preferably also detach (or have already detached) from each other and will preferably not act to provide any further resistance in retaining the outer shell on the impact absorbing layer.

[0048] In some embodiments the (e.g. rim of the) impact absorbing layer comprises at least one ridge and the outer shell comprises at least one groove (or projection), i.e. the positioning of the ridge and the groove on the impact absorbing layer and the outer shell are the opposite way around compared to the arrangement described above. The features of the ridge(s) and groove(s) (or projection(s)) outlined herein may apply equally to this embodiment.

[0049] The one or more grooves (or projections) and ridges may be located in any suitable and desired positions around the (e.g. rim of the) impact absorbing layer and the outer shell. In a set of embodiments, the groove(s) (or projection(s)) are equally spaced about the (e.g. rim of the) impact absorbing layer. The one or more ridges are preferably correspondingly located towards (e.g. at) the bottom edge (e.g. a rim) of the outer shell. For example, complementary grooves (or projections) and ridges may be located at the sides and rear of the helmet. Providing a plurality of interconnecting grooves (or projections) and ridges allows the shell to be held more securely in position on the impact absorbing layer, when the outer shell is mounted on the impact absorbing layer during normal use.

[0050] In one embodiment, e.g. in addition to the ridge(s) and groove(s) (or projection(s)) outlined above, in order to help retain the outer shell in position on the impact absorbing layer during normal use, the impact absorbing layer may comprise at least one protrusion on its outer surface. When the impact absorbing layer comprises a plurality of protrusions, preferably the protrusions are evenly spaced around the outer surface of the impact absorbing layer. In this embodiment, preferably the outer shell comprises at least one recess corresponding (and complementary) to the at least one protrusion of the impact absorbing layer. Thus, when the outer shell is located on the outer surface of the impact absorbing layer, the at least one protrusion on the impact absorbing layer interconnects with the at least one corresponding recess.

[0051] Preferably, the complementary protrusion(s) and recess(es) are provided (only) to help locate the outer shell in its correct position on the impact absorbing layer. Thus preferably, the complementary protrusion(s) and recess(es) provide a (e.g. significantly) weaker connection between the outer shell and the impact absorbing layer than is provided by the connector (and, e.g., by the complementary groove(s) (or projection(s)) and ridge(s)). During an impact, when the connector disconnects the outer shell from the impact absorbing layer, the protrusion(s) and recess(es) move apart from each other such that the outer shell is able to separate from the impact absorbing layer.

[0052] Thus, in one embodiment, the complementary protrusion(s) and recess(es) are arranged such that a particular (e.g. predetermined) force is required to displace the protrusion(s) from the complementary recess(es). Preferably, this particular (e.g. predetermined) force is (e.g. significantly) less than the particular (e.g. predetermined) force required for the connector to allow the outer shell to separate from the impact absorbing layer when the helmet is subject to an impact. This helps to ensure that once the force of an impact is sufficient to disconnect the connector between the outer shell and the impact absorbing layer, to separate the outer shell from the impact absorbing layer, the complementary protrusion(s) and recess(es) will preferably also be displaced (or have already been displaced) from each other and will preferably not act to provide any further resistance in retaining the outer shell on the impact absorbing layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0053] An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

[0054] FIG. **1** shows a front exploded view of a helmet according to an embodiment of the present invention;

[0055] FIG. **2** shows a rear exploded view of the helmet shown in FIG. **1**;

[0056] FIG. **3** shows a front view of the helmet shown in FIGS. **1** and **2**;

[0057] FIG. **4** shows a cross-section view of the helmet shown in FIGS. **1**, **2** and **3**;

[0058] FIG. **5** shows a front view of the helmet shown in FIGS. **1** to **4** during an oblique impact;

[0059] FIGS. **6**A, **6**B and **6**C show a selection of views of a plug for use in the helmet; and

[0060] FIG. **7** shows a cross-section view of a portion of a helmet according to another embodiment of the present invention.

DETAILED DESCRIPTION

[0061] A helmet acts to protect a user's head from injury by absorbing energy from an impact. Oblique impacts, which are a common type of impact, may subject a helmet to significant tangential forces. Such forces have the potential to cause rotational acceleration of the user's brain, which may cause serious brain injuries. Embodiments of the present invention aim to provide an improved helmet that seeks to mitigate the effect of such oblique impacts.

[0062] FIGS. **1** to **5** show different views of a helmet **100** according to an embodiment of the present invention. Both FIGS. **1** and **2** show an exploded view of the helmet to demonstrate the different components of the helmet **100** clearly. FIG. **1** shows a view directed towards the front of the helmet **100**. FIG. **2** shows a view directed towards the back of the helmet **100**. The helmet **100** has the following principal components: an impact absorbing layer **102**, an outer shell **104** and a plug **106**.

[0063] The impact absorbing layer **102** is predominately formed of an out-of-plane honeycomb structure. The impact absorbing layer **102** further comprises a rim **108** around the base of the helmet **100**. The rim **108** is formed from a solid (e.g. non-hollow) material such as expanded polystyrenes in contrast to the out-of-plane honeycomb structure **102** which formed of hollow cells, the tessellating cells having a hexagonal cross section.

[0064] The rim **108** of the impact absorbing layer **102** further includes a set of grooves **116**, into which ridges **118** on the lower edge of the outer shell **104** (as can be seen in FIG. **2**) fit. These interlocking grooves **116** and ridges **118** help to retain the outer shell **104** in position on the impact absorbing layer **102** during normal use. FIG. **2** also shows an additional protrusion **124** on the impact absorbing layer **102** mounted on the rear of the helmet. The protrusion **124** interconnects with a corresponding recess **126** on the outer shell **104**, and further helps to retain the outer shell **104** in position on the impact absorbing layer **102** during normal use.

[0065] As can be seen from FIG. **1**, a socket **114** is attached to the outer surface of the impact absorbing layer **102** into which the plug **106** fits. The plug **106** and the socket **114** fit together via a push (e.g. friction) fit. Together, the plug **106** and the socket **114** form a connector that connects the impact absorbing layer **102** and outer shell **104** together to retain the outer shell **104** on the impact absorbing layer **102** during normal use.

[0066] The outer shell **104** includes an aperture **110** at the front of the helmet through which the plug **106** can be inserted when the outer shell **104** is positioned on the impact absorbing layer **102**. To fit together the plug **106**, the outer shell **104** and the impact absorbing layer **102**, the outer shell **104** is first positioned on the impact absorbing layer **102**. This involves interlocking the side grooves **116** and corresponding complementary ridges **118**, as well as the rear protrusion **124** and the interconnecting recess **126**.

[0067] When the outer shell **104** is correctly positioned on the impact absorbing layer **102**, the aperture **110** in the outer shell **104** is aligned with the socket **114**. The plug **106** can then be inserted through the aperture **110** and into the socket **114**. A front view of the helmet **100**, with the plug **106** inserted and holding the outer shell **104** in position, is shown in FIG. **3**. FIG. **4**, which shows a cross section view of the helmet **100** in a plane along the central axis of symmetry of the helmet **100**, shows the plug **106** in position extending through the outer shell **104** and into the socket **114** on the impact absorbing layer **102**.

[0068] FIG. **3** also shows recesses **122** in either side of the inner surface of the outer shell **104**. In FIG. **5**, the corresponding protrusions **120** on the outer surface of the impact absorbing layer **102** are seen, as well as the recesses **122** in the outer shell **104**. When the outer shell **104** is positioned correctly on the impact absorbing layer **102**, the protrusions **120** fit into the recesses **122**, acting to help locate and retain the outer shell **104** on the impact absorbing layer **102**.

[0069] FIG. **5** demonstrates the reaction of the helmet **100** shown in FIGS. **1** to **4** in an oblique impact. In FIG. **5** the helmet **100**, which is attached to the head of a user who is falling downwards, has been subject to a collision with the obstacle **502**. The edge of the obstacle **502** which the helmet **100** contacts during the collision is slanted, and contacts the helmet **100** at a position which is offset from the centre of the helmet **100**, which results in the force exerted on the helmet from the impact having a significant tangential component.

[0070] In the impact shown in FIG. **5**, the force exerted upon the helmet **100** during the impact is larger than the particular force which is required to detach the plug **106** from the socket **114**, so to allow the outer shell to separate from the impact absorbing layer **102**. Therefore, upon impact with the obstacle **502**, the plug **106** is ejected from the helmet **100**; specifically ejected from the socket **114** on the impact absorbing layer **102**. As seen in FIG. **5**, the plug **106** completely separates from the helmet **100**. However, there may be other embodiments not shown in which the plug **106** remains in contact with at least part of the helmet

100 whilst still allowing the outer shell 104 to separate from the impact absorbing layer 102.

[0071] Upon impact with the obstacle 502, the interconnecting recesses 122 and protrusions 120, the interconnecting grooves 116 and ridges 118, and the interconnecting protrusion 124 and recess 126 also become disconnected from each other. There are therefore no remaining features which connect the outer shell 104 to the impact absorbing layer 102. The outer shell 104 is then able to rotate on the impact absorbing layer 102. This rotation is caused by the tangential component of the force exerted on the helmet 100 upon impact with the obstacle 502. The outer shell 104 rotating independently of the impact absorbing layer 102 (and ultimately the head of the user) reduces the rotation of head of the user, which may reduce the injuries sustained from the impact.

[0072] The Applicant has found that helmets according to embodiments of the present invention may reduce the rotational acceleration and velocity experienced the head of a user, compared to conventional foam helmets, by approximately 25% (in rotational acceleration) and approximately 45% (in rotational velocity).

[0073] FIGS. 6A, 6B and 6C show various views of the plug 106. As can be seen in these Figures, the plug 106 comprises an outer head 602. The outer head 602 has an area greater than that of the aperture 110 into which the plug fits. After insertion of the plug 106 through the aperture 110 and into socket 114, the outer head 602 sits outside of the outer shell 104 as seen in FIG. 3.

[0074] The plug 106 further comprises a neck 604, which is connected to the outer head 602. In examples in which the plug 106 and the socket 114 fit together via a push (e.g. friction) fit, the neck 602 may be made from a deformable plastic such that the neck 602 of the plug 106 can be inserted into the socket 114. The neck 604 has ridges 606 which act to hold the plug 106 in position in the socket 114. The socket may comprises corresponding grooves which mate with the ridges 606 of the plug 106 when the plug 106 is inserted into the socket.

[0075] FIG. 7 shows a cross-sectional view of a portion of a helmet 700 according to another embodiment of the present invention. The helmet 700 has the following principal components: an impact absorbing layer 702, an outer shell 704 and a latch 706. The latch 706 may be positioned in a similar location as the plug shown in previous figures.

[0076] The latch 706 is integral to (e.g. formed from the same material as) the impact absorbing layer 702. The latch 706 includes a flexible portion 708 that attaches the latch 706 to the main body of the impact absorbing layer 702. The flexible portion acts as a living hinge to allow the position of the latch 706 to change relative to the main body of the impact absorbing layer 702 and the outer shell 704. The latch 706 also includes a block tip 707.

[0077] The impact absorbing layer 702 additionally includes a cavity 714. When a force is applied to the latch 706, the flexible portion 708 bends, which may move the latch 706 into the cavity 714.

[0078] The outer shell 704 includes an aperture 705. During normal use (e.g. not during an accident), the latch 706 extends through the aperture 705. The block tip 707 of the latch 706 helps to keep the outer shell 704 in position on the impact absorbing layer 702 during normal use, by interacting with the edges of the aperture 705 to prevent translational movement of the outer shell 704 with respect to the impact absorbing layer 702.

[0079] Upon impact with an obstacle (e.g. similar to that seen in FIG. 5), the force of the impact acts on the flexible portion 708 of the latch 706, causing the flexible portion 708 to bend. The direction in which the flexible portion 708 is bent may depend on the direction of the tangential forces acting on the helmet upon impact.

[0080] In an impact in which the tangential forces act in the direction shown by arrow 730, i.e. the impact force acts downwards, as the outer shell 704 rotates downwards it moves over the latch 706 and the latch 706 is pushed into the cavity 714. This allows the outer shell 704 to detach from and move over the impact absorbing layer 702, helping to reduce the tangential forces transferred to the head of the user.

[0081] In an impact in which the tangential forces act in the direction shown by arrow 740, i.e. the impact force acts upwards, as the outer shell 704 rotates, the edge of aperture 705 of the outer shell 704 engages against the block tip 707 of the latch 706. The force exerted on the latch 706 either moves the latch 706 into the cavity 714, or rotates the latch 706 away from the cavity 714 and back on itself. Either of these movements of the latch 706 allows the outer shell 704 to detach from and/or move obstruction free over the impact absorbing layer 702, helping to reduce the tangential forces transferred to the head of the user.

[0082] In an impact in which the tangential forces act in another direction to that shown by arrows 730, 740, both of the abovementioned mechanisms may occur (e.g. at least in part) in order to enable the separation of the outer shell 704 and the impact absorbing layer 702.

[0083] In general, the latch 706 shown in FIG. 7, is able to maintain its functionality after an impact. For example, in an impact in which the latch 706 is merely compressing into the cavity 714 such that the outer shell 704 can move freely on the impact absorbing structure 702, after the impact the original (or a new) outer shell 704 may be repositioned on the impact absorbing structure 702.

[0084] The latch 706 may also be manually compressed into the cavity 714 by a user, e.g. to allow for easy intentional removal the outer shell 704. This may allow the outer shell 704 to be interchangeable, for example for aesthetic purposes.

[0085] Thus it will be appreciated by those skilled in the art that a helmet according to embodiments of the present invention, in which two independent layers (the outer shell and impact absorbing layer) connected by a connector, which allows the layers to separate when the helmet is subject to an impact, helps to reduce the tangential forces that may be transferred from an oblique impact to the head of the user. This may provide significant benefits over known helmets, e.g. in helping to reduce brain injuries. It will further be appreciated however that many variations of the specific arrangements described herein are possible within the scope of the invention. For example, a different type of connector (as opposed to a plug and socket and arrangement) may be provided to connect the outer shell to the impact absorbing layer.

What is claimed is:

1. A helmet comprising:

an impact absorbing layer;

an outer shell mounted on the outer surface of the impact absorbing layer; and a connector which connects the outer shell to the impact absorbing layer to retain the outer shell on the impact absorbing layer;

wherein the connector is arranged to allow the outer shell to separate from the impact absorbing layer when the helmet is subject to an impact.

2. The helmet as claimed in claim **1**, wherein the impact absorbing layer comprises a hollow cell structure.

3. The helmet as claimed in claim **1**, wherein the outer shell is formed from a rigid material.

4. The helmet as claimed in claim **1**, wherein the outer shell has a thickness of less than 6 mm, less than 4 mm, e.g. less than 2 mm, e.g. less than 0.5 mm.

5. The helmet as claimed in claim **1**, wherein the connector is arranged to allow the outer shell to separate from the impact absorbing layer when the helmet is subject to an impact having a particular force.

6. The helmet as claimed in claim **1**, wherein the connector is located along an axis of symmetry of the helmet.

7. The helmet as claimed in claim **1**, wherein the connector is located at the front of the helmet.

8. The helmet as claimed in claim **1**, wherein the connector comprises a discrete component from the outer shell and the impact absorbing layer.

9. The helmet as claimed in claim **1**, wherein at least a portion of the connector is arranged to detach from the impact absorbing layer and/or the outer shell when the helmet is subject to an impact.

10. The helmet as claimed in claim **1**, wherein the connector comprises a plug which extends between the outer shell and the impact absorbing layer.

11. The helmet as claimed in claim **10**, wherein the outer shell comprises an aperture for receiving the plug.

12. The helmet as claimed in claim **10**, wherein the connector comprises a socket for receiving the plug of the connector.

13. The helmet as claimed in claim **12**, wherein the socket is formed on or attached to the outer surface of the impact absorbing layer.

14. The helmet as claimed in claim **12**, wherein the plug and the socket attach together via a push fit.

15. The helmet as claimed in claim **10**, wherein the plug comprises an outer head having dimension(s) greater than the corresponding dimension(s) of the aperture.

16. The helmet as claimed in claim **1**, wherein the connector comprises a projection and that is integral to the impact absorbing layer, wherein the protection is attached to the main body of the impact absorbing layer by a flexible portion.

17. (canceled)

18. The helmet as claimed in claim **16**, wherein the impact absorbing layer comprises a cavity arranged to receive the projection.

19. The helmet as claimed in claim **16**, wherein the outer shell comprises an aperture for receiving the projection.

20. The helmet as claimed in claim **1**, wherein the impact absorbing layer comprises at least one groove formed therein, wherein the outer shell comprises at least one inwardly projecting ridge, and wherein the at least one ridge is arranged to engage with the at least one groove when the outer shell is mounted on the impact absorbing layer, and wherein the at least one ridge and the at least one groove are arranged such that a particular force is required to remove the at least one ridge from the at least one groove.

21. (canceled)

22. The helmet as claimed in claim **1**, wherein the connector extends in a radial direction to the impact absorbing layer.

* * * * *