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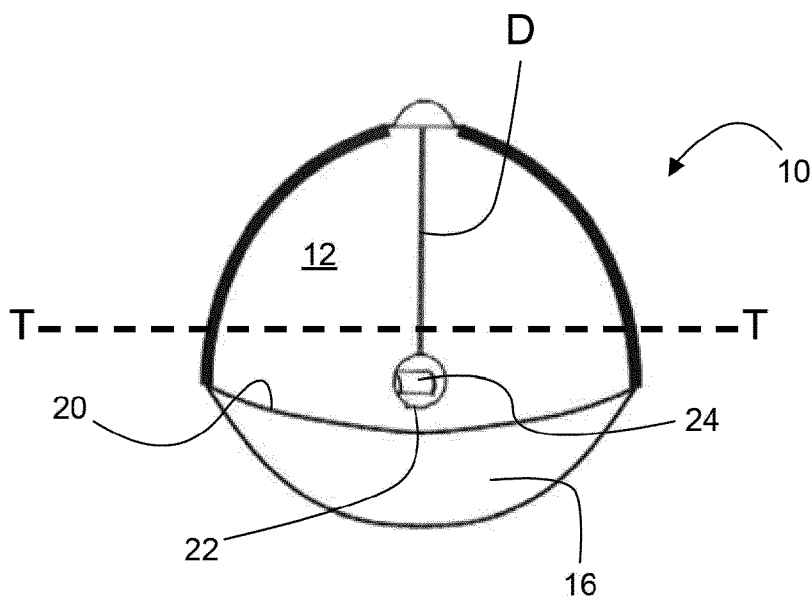


Figure 2

(57) Abstract: The present invention relates to a helmet (10). The helmet (10) comprises a shell (12) for receiving an impact; a detector coupled to the shell (12) to detect the impact; and an indicator arranged to provide an indication that the helmet (10) is damaged when the impact detected by the detector is greater than or equal to 35 G and less than 50 G.

HELMET

TECHNICAL FIELD

- 5 The invention relates to a helmet for protecting a user's head during a collision.

BACKGROUND

10 A human head is often subject to abnormal forces during various activities. These forces can be either prolonged such as when riding a roller-coaster or even more extreme cases such as a pilot flying a military fighter jet. In addition, the head may experience instantaneous forces during an impact. Examples of such impacts are numerous and include impacts experienced in a vocational setting and impacts experienced in leisure settings, for instance whilst playing various sports.

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In a sports setting, such as motorsport, impacts to the head can occur in the event of crashes into barriers or other vehicles. In all forms of horseback riding, from the recreational activity to racing and show-jumping, head impacts can occur in the event of a rider falling or being thrown from a horse resulting in their head hitting the ground. In cricket, a head impact may be experienced by a batsman facing deliveries of a ball (typically formed of cork and leather) at speeds of up to 90 miles per hour. In gridiron football, head impacts may result from 'hits' when tackling members of the opposition or when being tackled. In a vocational setting, builders and other labourers may experience head impacts from falling objects or where a restricted working space results in an increased likelihood of the head coming into contact with obstacles or structures.

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In order to protect a head from such impacts, a person may choose to don a helmet.

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After receiving a sufficiently severe impact, the integrity of a helmet may be compromised such that it is no longer capable of providing its intended protective function, or at least not to the required level. In these cases, it is best practice to replace the helmet to protect against subsequent impacts. However, using the

physiological effect on the wearer as an indication is not a reliable method for determining when a helmet should be replaced since effects such as a concussion are multivariable and in some cases a human head may tolerate a more severe impact without such adverse effects, though the helmet would likely still require replacement.

In addition, a doffed helmet may experience an 'off-head' impact, for instance by being dropped or colliding with a solid object during transit. These 'off-head' impacts may in some cases be severe enough that the protective function of the helmet is compromised.

In addition to using the physiological effects on the wearer as a guide to helmet replacement, one way to monitor the integrity of the helmet is to look for visual damage to the helmet such as scratches, cracks, dents, or holes. However, not all collisions would cause such visual damage since the damage to the helmet may not extend to the surface of the outer shell. In these cases, it is difficult for a diligent wearer to monitor whether their helmet has been damaged such that it is no longer safe for further use. In addition, less diligent wearers, or those who cannot necessarily afford to replace their helmet, would likely ignore such visual damage, especially if the visual damage looks only relatively minor. Conversely, visual damage to a helmet may not necessarily be due to an impact and so the helmet may still be safe for further use. Accordingly, using visual damage indications as a way in which to assess the necessity for helmet replacement is again not reliable.

It is an object of the present invention to address disadvantages associated with the prior art.

SUMMARY OF THE INVENTION

Aspects and embodiments of the invention provide a helmet as claimed in the appended claims.

According to an aspect of the present invention there is provided a helmet comprising; a shell for receiving an impact; a detector coupled to the shell to detect the impact; and an indicator arranged to provide an indication that the helmet is damaged when the impact detected by the detector is greater than or
5 equal to 35 G and less than 50 G.

By 'G' we mean a measure of G-force, that is, a measure of acceleration relative to free fall. Thus, '35 G' means an acceleration of 35 times the acceleration of standard gravity. As discussed below, it is not necessary for the detector to detect
10 an impact of greater than or equal to 35 G and less than 50 G exclusively, however, the detector should be able to provide an indication of damage by detecting impacts of greater than or equal to 35 G and less than 50 G. In this way, the detector is able to indicate that the helmet may have suffered damage otherwise unaccompanied by visual damage.

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The present invention is advantageous in that, in the event of an impact of greater than or equal to 35 G but less than 50 G, a user of the helmet is made aware that its structural integrity has been compromised and may no longer be safe for further use even when there are no visible signs of damage to the shell. This
20 means not only that the user involved in such an impact will be dissuaded from using the helmet again, but that people unaware that the helmet has experienced such an impact will be dissuaded from purchasing and/or making further use of it. Such impacts need not occur only when the helmet is in use i.e. when it is being worn by a user, but could include, for example, the helmet being dropped to the
25 ground from a sufficient height. Such impacts typically occur during transit to events where helmets are worn or to retail outlets where the helmets are sold.

For impacts experienced by the detector below about 35 G, there is a lesser likelihood that the structure of the helmet will be compromised such that it is no
30 longer safe for further use. It would be inconvenient for the user if impacts that did not render the helmet unsafe for further use nonetheless still caused the indicator to indicate that the helmet has experienced an impact. For example, the helmet bumping against a wall when being carried or impacts experienced during postage may be less likely to be above about 35 G and would not compromise the integrity

of the helmet. This is the case for shells formed of any of the various materials commonly used in the different industries in which helmets are used.

Helmets may be made from different materials, all of which distribute impact energy differently and can thus tolerate differing levels of impact. Regardless as to the material used for a helmet, impact forces at or above about 50 G will almost certainly result in the helmet being damaged such that it may no longer be safe for further use. Therefore, there is little value in indicating impacts of 50 G or greater and so calibrating the indicator to provide an indication of impacts below 50 G allows for otherwise 'invisible' damage to be detected. It should be appreciated however that the detector need not necessarily indicate impacts greater than or equal to 35 G and less than 50 G exclusively, provided that any impact within that range is positively indicated. For instance, it is not necessary for the indicator not to detect impacts of 50 G or greater, or only detect impacts of less than 50 G, since damage to the helmet would likely occur from impacts at 50 G or greater. Rather, indicating impacts at or above 50 G is unnecessary since impacts at this level would almost certainly be accompanied by visual damage, useable for quality control purposes to discard, or at least investigate, the damaged helmet.

In an embodiment, the indicator is arranged to provide the indication when the impact detected by the detector is greater than or equal to 40 G and less than 50 G. Shells may be made from different materials depending on their use. For instance, shells made from a carbon fiber material may require a range of detection with a reduced lower bound, namely 35 G. Shells made from another material, such as fire glass, may be able to tolerate higher impacts and so a range having a lower bound of above 40 G would be more appropriate to minimise the number of 'false positive' detections of impacts which do not cause any detrimental damage.

In an embodiment, the indicator is arranged to provide the indication when the impact detected by the detector is greater than or equal to 45 G and less than 50 G. Further material may also be employed for the shell. For instance, a plastics material may be able to tolerate higher impacts before damage occurs. For this

reason, a yet higher lower bound may be employed for the indication range, such as above 45 G, to reduce the number of 'false positive' detections.

5 In an embodiment, the indicator is arranged to provide the indication when the impact detected by the detector is greater than or equal to 40 G and less than or equal to 45 G. Alternative, it may be desirable to reduce the upper bound from less than 50 G to less than 45 G. This may be particularly desirable for shell materials which would more likely than not show visible signs of damage for impacts of 45 G or more and so indicating impacts of 45 G to 50 G would be
10 redundant.

In an embodiment, the indicator is arranged to provide the indication when the impact detected by the detector is greater than or equal to 35 G and less than or equal to 45 G. This range is an extension of the above where the upper bound
15 has been reduced from less than 50 G to less than 45 G but for materials which require a reduced lower bound due to exhibiting lower impact resistance.

In an embodiment, the indicator is arranged to provide the indication when the impact detected by the detector is greater than or equal to 35 G and less than or equal to 40 G. In this case, the upper bound has been lowered further to below 40 G for materials which are less likely to become damaged internally without any visible signs of damage on the exterior of the material.
20

All of the aforementioned numerical values are quoted to the nearest integer such that the term 'less than 50 G' may be expressed as less than or equal to 49 G since there is little additional benefit to measuring to a higher degree of accuracy or resolution.
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The detector may be positioned on a dorsal line of the helmet. Dorsal line is a term of art defined as an extension of the spinal column which is along the Sagittal plane of the person. Evidence suggests that most impacts are experienced at a top part of a helmet. Accordingly, mounting the detector on the dorsal line will provide adequate transmission of impact forces to the detector in the event of an impact. Even those impacts which are experienced from a side of the helmet will
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benefit from the detector being located on or near the dorsal line since a detector positioned off to one side would likely determine that an impact on the same side is more severe than an impact of equal magnitude on the opposite side. Accordingly, mounting the detectors to one side of the helmet would require an
5 increased number of detectors to compensate for such a disparity in the magnitude of detected side impacts than positioning the detector on the dorsal line. In the event that an impact is experienced, the head is more likely to move substantially forwards and/or backwards (i.e. a nodding action) rather than side to side. As such, points along the dorsal line of the helmet may experience the
10 greatest acceleration upon impact. Positioning the detector along the dorsal line of the helmet will therefore result in the magnitude of a received impact being detected with greater accuracy.

Alternatively, or in addition, the detector may be positioned below a test line of the
15 helmet. The 'test line' is a term of art and is a theoretical boundary line outlined in various testing standards, which testing standards are helmet specific and even country specific. Known standards include the Snell M2005 and M2010 Standards, the DOT Standard, the Pas 15 Standard and the ECE R22-05 Standard. The actual position of the test line can vary between testing standards.
20 Hence it is more accurate to define the line as a 'test line' rather than by dimensional and geometric positions to accommodate all types of helmet. During testing, the test line acts as a boundary, above which the structure of the helmet is tested, for instance by hitting various parts of the shell with a striking tool such as a hammer in order to ensure they are safe for use. Positioning the detector below
25 the test line is advantageous because it is desirable to test the helmet in its purest form; that is, to avoid unnecessarily subjecting any other components contained within, or attached to, the helmet during the impact testing.

In some embodiments, the detector is positioned in the vicinity of a rim of the
30 shell. Some helmets within the scope of the present invention may only have to be tested to a standard which does not include a test line. For instance, a builder's safety hat or construction helmet would not be tested according to a test line. Positioning the detector in the vicinity of the rim will ensure that the detector is

unlikely to have any effect on the outcome of any impact testing to which the helmet is subjected.

The indicator may be a visual indicator, which allows a user to determine easily
5 whether the helmet has been damaged.

In some embodiments, the detector is a mechanical detector. The functionality of a mechanical detector will not degrade over time and so the user can remain confident that the detector is fully functional over the lifespan of the helmet. Other
10 types of detector, for example an electrical detector, may need electrical power from a battery, for instance, whose power degrades over time. A mechanical detector may also be less likely to fail when the helmet is used in wet or other extreme conditions.

15 In some embodiments, the detector is integrally formed with the indicator in the form of a capsule comprising first and second compartments separated by a diaphragm, the capsule comprising a fluid stored in the first compartment before the impact, in use, and wherein the diaphragm is arranged to fail to allow fluid into the second compartment to provide the indication.

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Accordingly, the detector and the indicator can be provided as a single component since they are integrally formed as the capsule. The diaphragm in combination with the fluidic compartments is a simple construction and allows for passive detection of an impact great enough to warrant replacement of the helmet.

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The capsule may be elongate. An elongate capsule allows for the material usage to be optimized. For instance, uniformly three dimensionally shaped capsules, such as a sphere or a cube are possible though in order to make visible the first and second compartments for impact detection, the cube or the sphere would
30 have to be made proportionally larger in all dimensions to accommodate such scaling. In contrast, an elongate structure would allow for a length increase with minimal impact on the other dimensions of the capsule.

The capsule may be mounted tangentially relative to the shell. This ensures that upon impact an edge of the capsule is less likely to penetrate through the helmet, possibly to the head. This is particularly true of an elongate capsule. An additional benefit exists in that tangentially mounting an elongate capsule allows for a larger point of contact between the shell and the capsule to increase transmission of impact forces to the capsule, which would not be the case for instance for a radially mounted elongate capsule.

The capsule may be integrated within the helmet by a resilient clip. This means that the capsule may be fitted easily to the helmet, and locked into place during the manufacturing process. The resilient clip and shell may advantageously be formed as a substantially monolithic structure, for instance by injection molding. In this way, the snap fit connector is provided easily and at relatively low cost and in addition is less likely to break away or become loose relative to the shell, as would be the case for a connector mounted to the shell by a fastener.

The snap fit connector may comprise a resilient bias in order to maintain contact between the shell and the capsule. The resilient bias minimizes any play between the capsule and the shell which would have a detrimental impact on the fidelity of impacts detected by the detector. In particular, the values of G-force detected by the capsule should be an accurately transmit to the impact that is experienced by the shell and so ensure that the indicator transitions between configurations upon an appropriate impact.

In some embodiments the detector includes a magnet and the indicator includes a magnetic element. In these embodiments the magnetic element is arranged to be held by the magnet before the impact, in use, and allowed to depart from the magnet to provide the indication. When the helmet experiences an impact of sufficient force, the force of attraction caused by the magnet's magnetic field may be overcome such that the magnetic element moves away from the magnet. The position of the magnetic element relative to the magnet allows for easy determination as to whether the helmet is to be considered damaged or not. The use of magnets means that the detector is resilient to degradation over time and to extreme conditions.

The magnetic element may be substantially planar in section and oriented substantially tangentially to the shell. For example, a substantially spherical or cuboidal element would be more likely to penetrate through the helmet, possibly to the head, as it departs from the magnet in the event of an impact of sufficient severity. A sectionally planar element that is oriented tangentially to the shell may be scaled so that the cross-sectional area is large enough such that it does not penetrate through the helmet structure upon impact, but that its depth is small enough so as not to adversely affect the design (in terms of aesthetics and/or safety) of the helmet.

In some embodiments the helmet includes a central socket for securing the magnetic element before the impact, in use, and a plurality of circumferentially arranged sockets. In these embodiments each circumferential socket is arranged to secure the magnetic element in line with a direction of displacement, to provide the indication. This advantageously means that a user is informed not only when the helmet is damaged, but is provided with some information as to the likely location of the impact and possibly the particular region of the helmet that is most likely damaged.

The detector and the indicator may be provided internal to the shell. In this way it would be more difficult to remove. The helmet may include a liner connected to the shell by a permanent connector, and wherein the detector and the indicator are positioned intermediate the shell and the liner. Such positioning of the detector and indicator ensures a degree of tamper proofing of the helmet, since access to the detector and indicator is restricted unless the connection is destroyed.

The shell may include a window for viewing the indicator, in-use. This means that the configuration of the helmet may be determined simply by visual inspection, without needing to, for example, disassemble the helmet.

In some embodiments the helmet includes a liner connected to the shell by a rupturable mechanism, forming the detector and arranged to rupture in response to an impact to displace the liner relative to the shell for providing the indication.

As above, the rupturable mechanism may be a seam, a clip arrangement, an adhesive or spray deposition. Such a rupturable mechanism makes clear when the helmet has been involved in an impact and is not easily reversible.

- 5 The visual indicator may include a mark intermediate the shell and the liner, the mark positioned to be hidden before an impact, in-use, and exposed as a result of the displacement of the liner relative to the shell to provide the indication. Again, this means that determining whether the helmet is damaged may be achieved simply by inspection.

10

Any of the helmets disclosed above may be sports helmets. Such sports may include, but are not limited to, motorsport, equestrian, cricket, cycling, skiing and gridiron football.

- 15 A further alternative to the embodiments described above would be a detector that detects the variation in torque in the event of an impact. In such a case, the helmet may include two or more torque detectors coupled to the shell.

BRIEF DESCRIPTION OF THE DRAWINGS

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One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

- Figure 1 shows a side section view of a helmet according to an embodiment of the present invention;

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Figure 2 shows a front view of the helmet from Figure 1;

- Figure 3 shows a capsule from the helmet of Figure 2 where, specifically, Figure 3a shows the capsule before an impact, in-use, and Figure 3b shows the capsule providing an indication of a potentially damaging impact;

30

Figure 4 shows a resilient clip for integrating the capsule from Figure 3 into the helmet from Figures 1 and 2 where, specifically, Figure 4a shows the resilient clip in a neutral position and Figure 4b shows the resilient clip in a deflected position;

5 Figure 5 shows a similar view to Figure 2 of a front view of the helmet;

Figures 6a and 6b show opposing side views of the helmet from Figure 2 according to a further embodiment of the present invention in which the helmet includes side mounted capsules;

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Figures 7 a, b and c, show back, front and side views, respectively, of a helmet according to an alternative embodiment of the present invention in the form of a closed face motorsport helmet;

15 Figures 8 shows a perspective view of a helmet according to an alternative embodiment of the present invention in the form of a road cycling helmet;

Figure 9 shows an alternative resilient clip to that shown in Figures 6a and 6b;

20 Figure 10 shows a helmet in the form of a riding hat according to an alternative embodiment of the present invention to that from Figure 2, where the capsule is replaced by a rupturable mechanism, which rupturable mechanism is intact in Figure 10a and ruptured in Figure 10b to make visible a visual indicator intermediate a shell and a liner; and

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Figure 11 shows an alternative embodiment of the present invention where the capsule is replaced by a magnetic arrangement, where Figure 11a shows the magnetic arrangement before an impact in the form of a side section view, Figure 11b shows the magnetic arrangement before an impact from in front, Figure 11c shows a similar view to Figure 11a of the magnetic arrangement providing an indication of damage after an impact and Figure 11d shows a similar view to Figure 11b of the magnetic arrangement providing an indication of damage after an impact.

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DETAILED DESCRIPTION

With reference to Figure 1, a helmet 10 in the form of a riding hat includes a shell 12, a liner 14, and a sun peak 16. Of course, the helmet 10 may include other
5 components such as padding or aesthetic liners between the liner 14 and the head of a wearer though those other components are not shown since they would likely obscure and overcomplicate the Figure.

The shell 12 is designed to prevent foreign objects piercing through the helmet to
10 a wearer's head in the event of an impact. In addition, the shell 12 serves to distribute an impact force which it receives in-use over a wider area of the head of a wearer. In order to serve this purpose, the shell 12 is made from a hard material. In particular, the shell 12 is made from a plastics material such as a thermoplastic polymer, for instance acrylonitrile butadiene styrene (ABS) plastic.

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The liner 14 serves to absorb the impact received by the shell 12. The liner 14 is made from closed cell extruded polystyrene foam. An appropriate foam for use as a liner 14 is Styrofoam (RTM). An outer surface of the liner 14 compliments an inner surface of the shell 12. At a front side of the helmet 10, above the sun peak
20 16, a channel 18 is formed within a front surface of the liner 14. The channel 18 may be cut into the liner 14 or may be directly moulded into the liner 14 when forming the liner 14.

The sun peak 16 extends forward and is connected to the shell 12 by an
25 adhesive. The sun peak 16 is situated at a rim 20 of the helmet.

With reference to Figure 2, the helmet 10 also includes a window 22 located in the vicinity of the rim 20 above the sun peak 16. The window 22 is made from a transparent or translucent material. The window 22 is secured to a hole cut into
30 the shell 12 by an adhesive or alternatively the window 22 may be welded to the shell 12 by any suitable form such as friction or electronic conduction welding.

Still with reference to Figure 2, the helmet 10 also includes a capsule 24. The capsule 24 is situated interior to the shell 12 and is integrated to the helmet 10

behind the window 22. The capsule 24 will be described in more detail below, though with specific reference still to Figure 2, only half of the capsule 24 is visible through the window 22. The reason for this will become evident below when describing a detecting and indicating function of the capsule 24.

5

The actual position of the capsule 24 is more particular than it appears at first sight. In particular, the capsule 24 is situated on a dorsal line D. The dorsal line D is a term of art and references a line extending along a Sagittal plane of a wearer of the helmet 10 and can be imagined as an extension of a spinal column of the
10 wearer. In addition, the capsule 24 is positioned below a test line T. The test line T is again a term of art and relates to a geometric line above which, the helmet is subject to various tests such as being struck with a hammer or the like to test the integrity of any peripheral objects, such as seams or even pins holding on helmet straps (not shown). The actual position of the test line is helmet type specific and
15 even changes according to the country within which the helmet will be used. For instance, PAS standards are used to test riding hats in the UK whereas Snell standards are used for motorsport helmets in the USA. It is therefore, more appropriate to define the location of the capsule 24 as being below the 'test line' T rather than define the location of the capsule 24 in terms of any specific geometric
20 or dimensional location on the helmet 10. Accordingly, the capsule 24 will not be tested by being struck with a hammer or the like during testing allowing the helmet to be tested in its purest form.

With reference to Figure 3a, the capsule 24 is an elongate cylinder and is made
25 from a transparent or translucent material. Typically, the capsule 24 will have a diameter of about 3-4 mm. A capsule of a length within the range of between about 14 mm and 18 mm, or more specifically about 16 mm would be sufficient to ensure the function of acting as a visual indicator (see below) whilst not expending too much on raw materials to provide the capsule. The capsule 24 includes an
30 indicator fluid 26 in the form of ink or dye within an outer cylindrical casing 28. The outer casing 28 is planar at one end and convex, or more particularly hemispherical or dome shaped, at the other. The casing 28 may be shatter-proof. Since the capsule 24 includes only mechanical parts, the capsule 24 can be thought of as a mechanical detector integrally formed with a visual indicator.

Still with reference to Figure 3a, interior to the capsule 24, a first compartment 30 is separated from a second compartment 32 by a diaphragm 34. The first and second compartments 30, 32 are equal in volume and shape. The diaphragm 34
5 is made from a material more brittle than the casing 28 and arranged to fail, specifically fracture, at or above a predetermined G-force, or threshold. The predetermined G-force in this embodiment is greater than 35G though this value is quoted for illustrative purposes and could change depending upon the structural makeup of the helmet 10 (Figure 1). It should be noted that the predefined G-force
10 is arranged to be the G-force experienced by the capsule (Figure 1) during an impact. Illustratively, an impact of 48 G is likely to damage the helmet 10, which will require replacement or at least an inspection and repair.

With reference to Figure 3b, the impact experienced by the shell 12 (Figure 1) transmits to the capsule 24 by virtue of the way in which the capsule 24 is
15 integrated within the helmet 10 (Figure 1) as will be described in further detail below. However, in summary, an impact of 48 G leads to the diaphragm 34 shattering and allowing the dye 26 flowing from the first compartment 30 to the second compartment 32. Accordingly, the capsule 24 can be thought of as serving
20 two purposes. Firstly, the capsule 24 is a detector for detecting the magnitude of impacts. Secondly, the capsule 24 is an indicator for indicating whether the helmet is intact, where the dye 26 is solely in the first compartment 30, or damaged, where the diaphragm 34 has fractured and the dye 26 is in both the first and second compartments 30, 32.

25

Returning to Figure 2, the second compartment (only shown in Figure 3) is the only compartment visible through the window 22. Accordingly, the capsule 24 acts as a visual indicator since it is possible to determine with the naked eye that the helmet 10 is damaged when any dye 26 (shown in Figure 3) is visible through the
30 window 22.

With reference to Figure 4a, the helmet includes a resilient clip 38. The resilient clip 38 is connected to the shell 12. The resilient clip 38 includes a root point 40 which connects the connector 38 to an interior surface of the shell 12. The

connector 38 also includes an arm 42, which is cantilevered from the shell 12 by the root point 40. The arm 42 is arcuate and has an interior surface complimenting the exterior surface of the casing 28 of the capsule 24 (shown in Figure 3). The arm 42 is resilient and biases towards a neutral position when not being subjected to an external force. A flange 44 is provided at the end of the arm 42 opposite the root point 40. The flange 44 is linear and in the neutral position of the connector 38, the flange 44 is parallel to the interior surface of the shell 12. A gap 46 of constant width is provided between the flange 44 and the interior surface of the shell 12. However, it is conceivable that the flange 44 is inclined so as to point away from the shell 12. Doing so would provide a gap 46 which reduces towards the root point 40.

With reference to Figure 4b, the resilient clip 38 is shown in a deflected position. In moving to the deflected position, the flange 44 is moved away from the shell 12, either by a user's finger or by pressing the capsule 24 (Figure 3) towards the root point 40. Once the capsule 24 (Figure 3) has passed the flange 44, the arm 42 biases due to its resilience and snaps back to the neutral position securing the capsule 24 in place against the interior surface of the shell 12. Since the capsule 24 (Figure 3) is elongate, the full length of the capsule is in contact with the shell so as to maximise the transmission of forces between the shell and the capsule. Beneficially, the capsule is tangentially mounted relative to the shell 12 so as not to penetrate through the liner 14 (Figure 1) when the shell 12 receives an impact.

The resilience of the arm 44 acts to bias the capsule 24 (Figure 3) towards, and against, the shell 12. In this way, any play between the shell 12 and the capsule 24 will be minimised and the capsule will not work free. In addition, or even alternatively to the connector 38, an adhesive may be applied to the shell 12 to secure the capsule in place.

The resilient clip 38 is formed together with the shell 12 by injection moulding so as to provide a substantially monolithic structure.

Returning to Figure 1, during fabrication, the shell 12 and the liner 14 are fitted together such that the capsule 24 (Figure 3) is received within the channel 18 of

the liner 14. Next, the liner 14 and the shell 12 are bonded together such that the two are permanently connected. In this way, it is only likely that the two could be disconnected by a force or other means sufficient to damage both parts irreversibly. Accordingly, there is an inherent degree of tamper proofing provided
5 by the construction of the helmet 10.

The permanent connection may be provided by any permanent connector 48. For instance, the permanent connector 48 may be an adhesive. The permanent connector 48 is shown around the rim 20 of the helmet 10 in Figure 2 though the
10 adhesive may be spread over substantially all of the helmet to completely secure the shell 12 to the liner 14 over the helmet's entirety.

With reference to Figures 1 to 4, the shell 12 receives an impact when either being donned for instance by a fall of a wearer or doffed for instance by dropping
15 the helmet 10 from a height on to a floor. The impact force is transmitted through the shell 12 to the capsule 24 (Figures 2 and 3).

Taking the situation whereby a donned helmet receives an impact, the force of the impact causes the shell 12 and consequently the liner 14 to deflect. In a short time
20 period, the shell 12 and liner 14 will likely deflect in a ripple like motion away from the impact point. This ripple like motion can be categorised as a G-force due to the rate of change of deflection. The actual G-force will depend on several variables including the material from which the shell 12 and liner 14 are made from and their respective mass. Whether the helmet 10 is donned or doffed will
25 also affect the G-force due to the mass of the head within the helmet 10.

As a result of the absorption properties of the shell 12 and liner 14, the force of the liner 14 against the skull is lower than the force of impact onto the shell 12. This reduced force will impact onto the skull in a similar way to that of the shell 12,
30 albeit over a larger area since the helmet will have spread the impact force. In particular, the skull will have a ripple effect emanating from the point of impact. However, the skull will not deflect as much as the liner 14, and in addition the mass of the head is higher than that of the liner 14, and thus the G-force will be much higher at the skull than at the shell 12, even though the force experienced

by the skull is lower than that experienced by the liner 14. However, even though the G-force experienced by the head is higher than that of the donned helmet 10, the G-force of the head will be much lower than it would be should the same force have impacted the head directly i.e. without a helmet.

5

If the impact is less than 48 G then the diaphragm 34 (Figure 3) will remain intact and no dye 26 will be visible through the window 22 (Figure 2). However, if the impact 12 is greater than or equal to 35 G, e.g. 48 G, then the diaphragm 34 will fail and allow the dye 26 to flow between into the second compartment 32 (Figure 10 3b), and thus be visible through the window 22 (Figure 2). A user seeing the presence of dye through the window 22 (Figure 2) will know that the helmet is now damaged and will replace the helmet 10.

Indicating the usability of the helmet 10 to a wearer in this way is more reliable 15 than relying on other indicators like visual damage to the helmet since some impact which would damage the helmet may not leave visual damage and in contrast, a visually damaged helmet 10 may not necessarily be damaged structurally and still be safe for use. In addition, donned impacts can be detected more reliably too. For instance, impacts while a user is wearing a helmet may or 20 may not cause physiological effects, such as a concussion. There is no need to use these physical effects as an indicator for helmet replacement since the indicator will advise categorically whether the impact was sufficient to replace the helmet or whether it is safe for further use. With this in mind, it is noted that the present invention is not to be used for assessing for such physiological effects as 25 a concussion, since the threshold for an impact does not indicate the corresponding impact experienced by the head. In any case, it is likely that the threshold corresponds to an impact experienced by the head that is much lower than that needed to cause concussive effects.

30 With this in mind, the actual transition threshold, above which the detector transitions from an intact state to a damaged state, is not necessarily limited to 35. This is because shells may be made from different materials exhibiting different impact absorption properties. However the upper limit of detection need not be any greater than 50 G, or moreover, should be less than 50 G. For most shells

strengthened in some way, an acceptable range of indication is considered to be greater than or equal to 45 G and less than 50 G. However, this lower bound of 45 G can be reduced to accommodate a lower grade helmet, which may fail in response to an impact of less than 45 G. In this way the indication range may be greater than or equal to 40 G and less than 50 G. However, it is not advisable to lower the transition threshold, or lower bound of the indication range, to 35 G or lower, since most helmets can survive an impact at this level and doing so would unnecessarily indicate that a helmet should be replaced when a low magnitude impact, of say 20 or 25 G. This is important since a helmet will experience a relatively high frequency of such lower magnitude impacts by being dropped whilst doffed. To this end, a lower bound of around 35 G is considered to be the lowest acceptable limit for helmets of all configurations and energy absorption grades.

Other 'indication ranges' are also important to consider depending on the material and construction of the helmet. For instance, an indication range of greater than or equal to 35 G and less than 45 G for materials having relatively low impact resistance and which would likely show visible signs of damage between 45 G and 49 G. In some cases, an indication range of greater than or equal to 35 G and less than or equal to 40 G. Or alternatively, an indication range of greater than or equal to 40 G and less than or equal to 45 G may be employed so as to cover those materials less likely to become damaged for impacts at 40G or below but reducing the upper bound to less than or equal to 45 G so as to reduce the risk of any 'false positive' indications.

It will be appreciated that the capsule need not stop indicating impacts at 50 G or above since those higher level impacts would result in damage to the helmet. However, indicating such higher level impacts (of 50 G or above) is redundant since those impacts will likely be accompanied by visual damage, which visual damage in itself indicates that the helmet is damaged. In this way, the indication range is said to indicate impacts at least within any of the aforementioned ranges. That said, alternative embodiments are conceivable, which may be configured to detect exclusively impacts within the range of greater than or equal to 35 G and less than 50 G. For instance, a detector in the form of an accelerometer and an indicator comprising a Light Emitting Diode (LED) and a controller arranged to

monitor the accelerometer's output and illuminate the LED only for impacts of greater than or equal to 35 G and less than 50 G but not, for example, for impacts of 50 G or greater.

- 5 In order to calibrate the capsule 24 (Figure 3) to transition between the intact and damaged states can be calibrated by altering the material and/or thickness of the diagram accordingly.

10 In other embodiments of the present invention, the capsule 24 may be located in different places to that shown in Figure 2. For instance, with reference to Figure 5, the capsule 24 may be located at a rear part of the helmet 10, again along the dorsal line D and below the test line T (not shown though equal to that of Figure 2). The rear mounted capsule 24 is mounted in the same way as the capsule of Figure 2. The helmet 10 may in fact have both a rear mounted capsule 24 (Figure 15 5) and a front mounted capsule 24 (Figure 2), or may only have a single capsule, either mounted at the rear or at the front of the helmet 10.

In a further embodiment of the present invention, the capsule 24 may be located off the dorsal line D, such as being side mounted as shown in Figure 6a and 6b. 20 Side mounted capsules 24 would be more accurate for impacts received at the side of the helmet 10. However, it would be advantageous in such a scenario to include capsules 24 at both right and left sides since a right hand capsule 24 would determine a right hand impact as being of a higher magnitude than a left hand impact of the same magnitude. Regardless, it is still the case that the side 25 mounted capsules 24 are situated below the test line for the reasons outlined above.

With reference to Figures 7 a to c, an alternative embodiment of the helmet may be in the form of a closed faced helmet 110 such as a motor sports helmet. Again, 30 the helmet 110 includes all of the features of the helmet 10 from Figures 1 to 6, save the sun peak 16 is replaced with a visor 116 for protecting the eyes of a wearer from impacts from foreign objects when travelling at high speeds. The visor 116 is connected to the shell 112 by a pivot 117. The pivot 117 is in the form of a pin. The helmet of Figure 7a has a capsule mounted at the rear. Helmet 110

in Figure 7b has a capsule mounted at the front and helmet 110 shown in Figure 7c has a capsule mounted at the side. The capsules are hidden behind a translucent window 122 to represent an intact configuration though it will be appreciated that the dye would be visible if the helmet was in a damaged configuration.

With reference to Figure 8, the helmet 210 is in the form of a road cycling helmet 210. The helmet 210 includes the shell 212 and the liner 214. The shell 212 is a thin shell and is provided more for aesthetic purposes than for preventing penetration from foreign bodies into the liner 214 though a degree of distribution of impact forces will be realised by the thin shell 212. Again, the shell 212 is connected to the liner 214 by a permanent connector 248, or more specifically, by an adhesive. The helmet 210 has cooling vents 215 cut into it to prevent over heating of the wearer.

With reference to Figure 9, the liner 214 includes the channel 218. However, this time, the capsule (not shown) is integrated to the helmet by a resilient clip 230 formed from the channel 218. The resilient clip 230 includes opposing resilient arms 242a, 242b. The resilient arms 242a, 242b are shown in a neutral position. When inserting the capsule, the resilient arms 242a, 242b are arranged to deflect to a deflected position, or downwards direction on Figure 9. After the capsule has passed the resilient arms 242a, 242b, they return to the neutral position. The resilient arms are tapered towards the channel 218 such that it is easier to insert than remove the capsule. The posterior side of the arms 242a, 242b, are horizontal to sit against the casing of the capsule and maintain its position fast relative to the liner 214. In this way, any play between the capsule and the liner 214 will be minimised. In addition, an adhesive can be applied to secure the capsule in place. Alternatively, or in addition to the arms 242a, 242b, the channel 218 may be sized to be an interference fit with the capsule to hold the capsule in place and in contact with the liner 214. The channel 218 is shown having a perpendicular bottom though it is conceivable to provide a concave bottom to compliment the shape of the casing. Of course, providing the resilient clip 230 within the liner 214 in this way is also possible in the other helmet embodiments.

With reference to Figures 10a and 10b, a further embodiment of a helmet 310 is provided again in the form of a riding hat. The riding hat 310 has the same construction as that from Figures 1 and 2 save the window 22, the resilient clip 30 and the capsule 24. Instead, the detector functionality is provided by a rupturable mechanism 360 in the form of a layer of glue extending around the rim 320. In addition, a gap is located between the shell 312 and the liner 314 at a top of the hat 310. The gap between the liner 314 and the shell 312 is greater than that shown in Figure 1. A mark 362 is applied to the interior surface of the shell 312. The mark 362 is a coloured mark, for instance a red stripe located in the vicinity of the rim 320.

In use, the rupturable mechanism 360 is arranged to fail in response to an impact within the indication range. In doing so, the liner 314 displaces relative to the shell 312 and moves upwards into the shell closing the space between the liner 314 and the shell 312. In this way, the mark 362 which was previously hidden by the liner 314 is now exposed and visible for indicating that the helmet 310 is in a damaged configuration.

With reference to Figures 11 a to d, a further embodiment of the present invention is also provided, whereby the capsule 24 (Figure 3) is replaced in the helmet of Figure 2 by a magnetic arrangement 70.

The magnetic arrangement 70 may be coupled to the shell 12 of the helmet 10 (Figure 2), so as to detect an impact experienced by the shell 12. In this embodiment, the detector is in the form of a magnet 72 and the indicator is in the form of a magnetic element 74. The magnetic arrangement 70 includes a sectionally-planar, circular central socket 76 that is encircled by a sectionally-planar, circular outer lip 78, where the planes of the socket 76 and the lip 78 are substantially parallel (as seen in Figures 11a and 11c). The central socket 76 is positioned adjacent to the magnet 72. There is a step change in height between the central socket 76 and the lip 78 via an intermediary portion or wall 80. In particular, the socket 76 and intermediary portion 80 meet at an obtuse angle, and the intermediary portion 80 and lip 78 also meet at an obtuse angle.

The magnetic element 70 is in the form of a disc made from a ferrous material so as to be attracted to the magnet 72 when situated within the central socket 76. In particular, the magnetic element 70 is made from mild steel. The magnetic element 70 is coloured to improve its visibility by paint, for instance red paint.

5

The position of the magnetic element 70 relative to magnet 72 is indicative of either an intact configuration or a damaged configuration, as well be described in more detail below.

- 10 The magnetic arrangement 74 further includes a plurality of circular, circumferentially-arranged, edge sockets 82, equally angularly spaced from one another surrounding the central socket 76. In this embodiment, there are eight edge sockets 82 spaced apart from one another by 45 degrees. However, any number of sockets may be used in dependence on the size of the magnetic
15 element 70 and/or the distance from the central socket 76 to each edge socket 82, and the angle of separation between each edge socket 82 varies accordingly.

Figures 11a and 11b show side and top views, respectively, of the indicator or magnetic element 70 in an intact configuration. This configuration is characterised
20 with the magnetic element 70 being held in the central socket 76 by the magnet 72.

Figures 11c and 11d show side and bottom views of the indicator or magnetic element 70 in a damaged configuration. This configuration is characterised with
25 the magnetic element 70 being positioned in one of the circumferential or edge sockets 82. In particular, each circumferential socket 82 is arranged to secure the magnetic element 70 in the damaged configuration in line with a direction of displacement. Viewed from below, as in Figure 11d, the magnetic arrangement 74 includes eight transparent or translucent windows 84, each corresponding to and
30 adjacent to one of the edge sockets 82. The windows 84 are arrow-shaped, pointing directly away from the central socket 76. As seen in Figure 11d, when the magnetic element 70 is positioned in one of the edge sockets 82, it may be viewed from below the magnetic arrangement 74 through the corresponding window 84.

The magnetic arrangement 74 and, in particular, the magnetic element 70 is oriented substantially tangentially to the shell 12 when it is integrated within the helmet 10 (Figure 2). The magnetic element 70 is arranged to be held by the magnet 72 for impacts indicative of the intact configuration and allowed to depart from the magnet 72 for impacts indicative of the damaged configuration.

When the helmet 10 (Figure 2) experiences an impact at or above those bound of the indication range, the force resulting from the impact is sufficient to overcome the magnetic field of the magnet 72. In this case, from a starting position depicted in Figures 11a and 11b, the magnetic element 70 moves laterally and completely over the wall 80 and lip 78, and 'drops' into, and is secured in, one of the edge sockets 82 as depicted in Figures 11c and 11d. The edge socket 82 in which the element 70 comes to rest is indicative of the direction of impact experienced by the helmet 10 (Figure 2), and so this embodiment has the added feature of giving extra information about an impact to a user, specifically, the position of the helmet 10 at which the impact was received. The lip 78 partially overhangs the edges sockets 82 and the element 70 when in one of the edge sockets 82. It can be seen in Figure 11c that this means the magnetic element 70 is held captive within the edge socket 82 and cannot easily move back to the central socket 76.

The aforementioned embodiments are by no means limiting but rather illustrative of the various ways in which this invention can be implemented. In principle, this invention can be extended to all types of helmets whether sports helmets or types of helmet such as a vocational helmet, e.g. a builder's hat. For the case of a builder's hat, the operation of the detector and the indicator are the same, though it should be noted that there would only be a shell and no liner, since the liner is replaced by strapping. In these cases, the aforementioned instructions for carrying out the invention should be adapted accordingly. For instance, the test line should be adapted to the appropriate testing standard for the type of helmet and country of using the helmet. For those helmets, such as builder's hats, which are not tested according to a so called test line, the detector and indicator should be integrated within the helmet in the vicinity of the rim.

CLAIMS

1. A helmet comprising; a shell for receiving an impact; a detector coupled to the
5 shell to detect the impact; and an indicator arranged to provide an indication
that the helmet is damaged when the impact detected by the detector is
greater than or equal to 35 G and less than 50 G.
2. The helmet of Claim 1 wherein the indicator is arranged to provide the
10 indication when the impact detected by the detector is greater than or equal to
40 G and less than 50 G.
3. The helmet of Claim 2 wherein the indicator is arranged to provide the
indication when the impact detected by the detector is greater than or equal to
15 45 G and less than 50 G.
4. The helmet of Claim 2 wherein the indicator is arranged to provide the
indication when the impact detected by the detector is greater than or equal to
40 G and less than or equal to 45 G.
20
5. The helmet of Claim 1 wherein the indicator is arranged to provide the
indication when the impact detected by the detector is greater than or equal to
35 G and less than or equal to 45 G.
- 25 6. The helmet of Claim 5 wherein the indicator is arranged to provide the
indication when the impact detected by the detector is greater than or equal to
35 G and less than 40 or equal to G.
7. The helmet of any preceding claim wherein the detector is positioned
30 substantially on a dorsal line of the helmet.
8. The helmet of any preceding claim wherein the detector is positioned below a
test line of the helmet.

9. The helmet of Claim 8 wherein the detector is positioned in the vicinity of a rim of the shell.
10. The helmet of any preceding claim wherein the indicator is a visual indicator.
- 5 11. The helmet of any preceding claim wherein the detector is a mechanical detector.
12. The helmet of Claim 11 wherein the detector is integrally formed with the indicator in the form of a capsule comprising first and second compartments separated by a diaphragm, the capsule comprising a fluid stored in the first compartment before the impact, in use, and wherein the diaphragm is arranged to fail to allow fluid into the second compartment to provide the indication.
- 10 13. The helmet of Claim 12 wherein the capsule is elongate.
14. The helmet of any preceding claim wherein the capsule is mounted tangentially relative to the shell.
- 15 15. The helmet of any of Claims 12 to 14 wherein the capsule is integrated within the helmet by a resilient clip.
16. The helmet of Claim 15 wherein the shell and the resilient clip are formed together as a substantially monolithic structure.
- 20 17. The helmet of Claim 15 or Claim 16 wherein the resilient clip comprises a resilient bias in order to maintain contact between the shell and the capsule.
- 25 18. The helmet of Claim 10 wherein the detector comprises a magnet and the indicator comprises a magnetic element arranged to be held by the magnet before the impact, in-use, and allowed to depart from the magnet to provide the indication.
- 30

19. The helmet of Claim 18 wherein the magnetic element is substantially planar in section and oriented substantially tangentially to the shell.
- 5 20. The helmet of Claim 18 or Claim 19 comprising a central socket for securing the magnetic element before the impact, in-use, and a plurality of circumferentially arranged sockets, each circumferential socket arranged to secure the magnetic element in line with a direction of displacement, to provide the indication.
- 10 21. The helmet of any preceding claim wherein the helmet comprises a liner connected to the shell by a permanent connector, and wherein the detector and the indicator are positioned intermediate the shell and the liner.
- 15 22. The helmet of Claim 21 and Claim 10 wherein the shell comprises a window for viewing the indicator, in-use.
- 20 23. The helmet of Claim 11 wherein the helmet comprises a liner connected to the shell by a rupturable mechanism, the rupturable mechanism forming the detector and arranged to fail to displace the liner relative to the shell to provide the indication.
- 25 24. The helmet of Claim 23 when dependent on Claim 10 and Claim 11 wherein the visual indicator comprises a mark intermediate the shell and the liner, the mark positioned to be hidden before the impact, in-use, and exposed as a result of the displacement of the layer relative to the shell to provide the indication.
- 25 25. The helmet of any preceding claim being a sports helmet.
- 30 26. A helmet as described substantially herein with reference to the accompanying Figures.

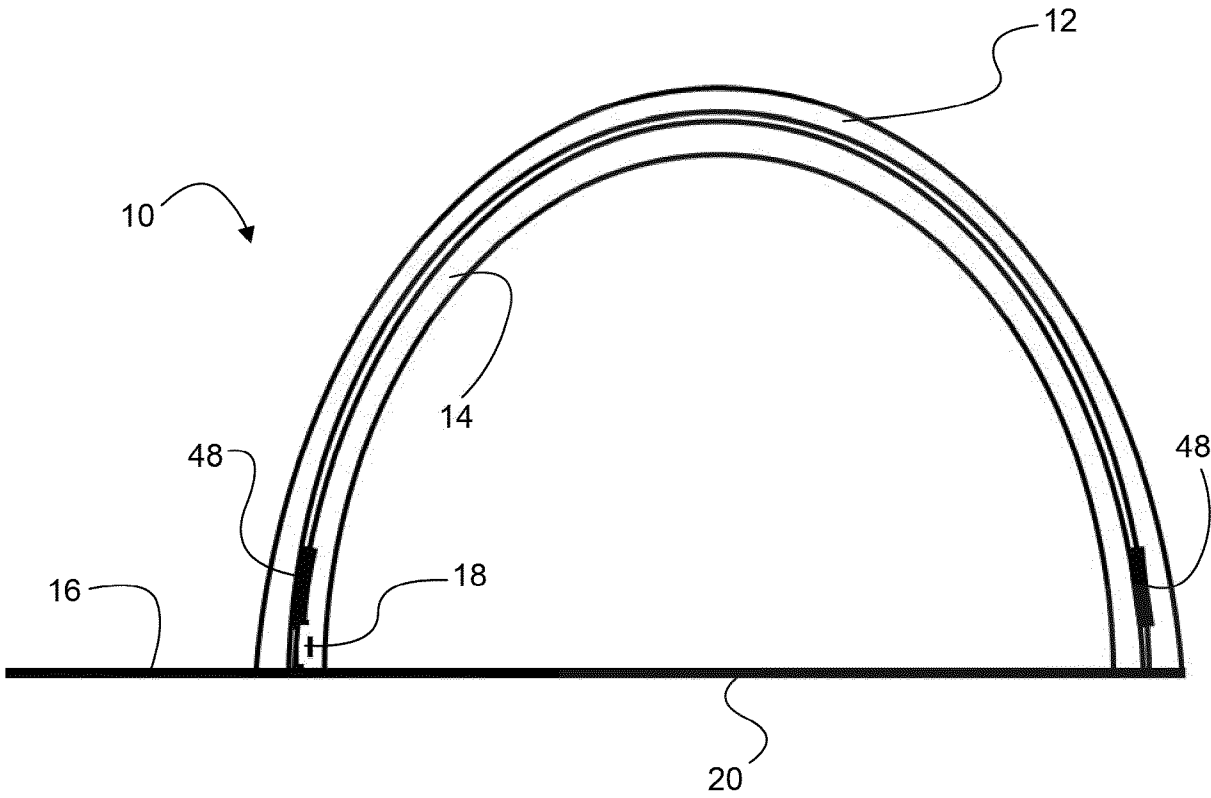


Figure 1

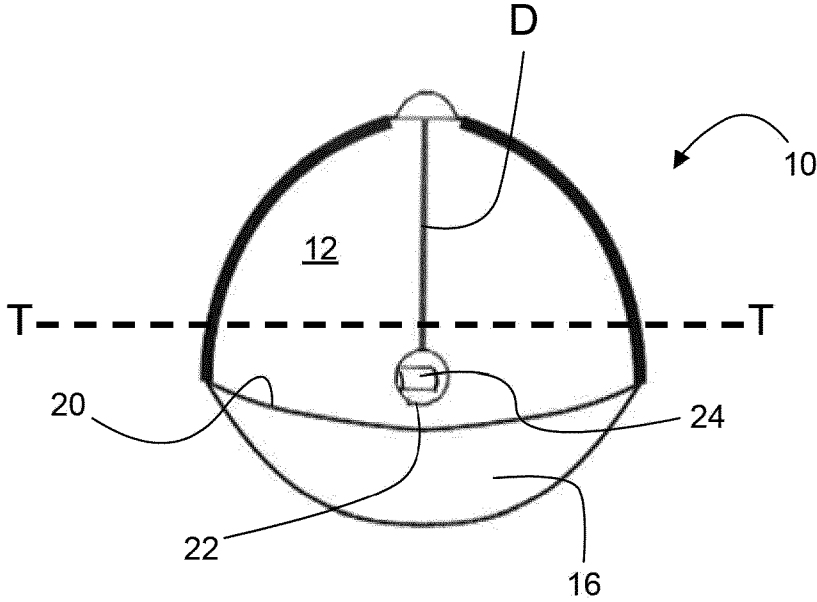


Figure 2

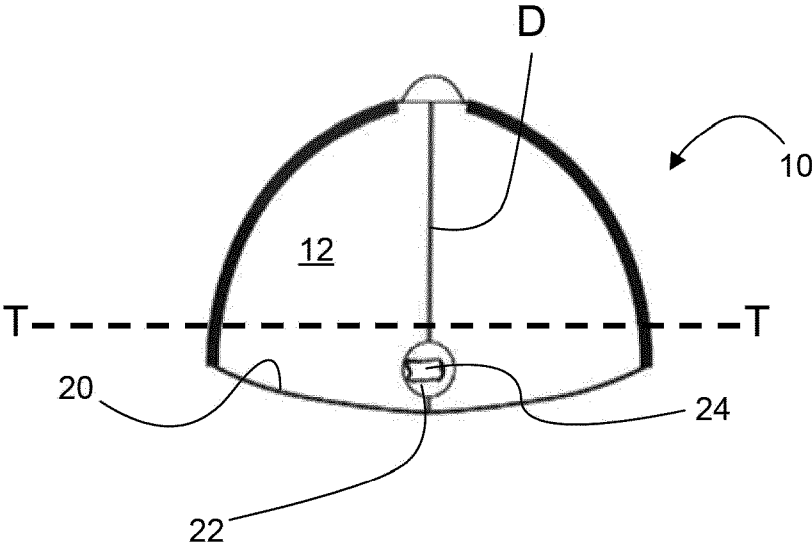


Figure 5

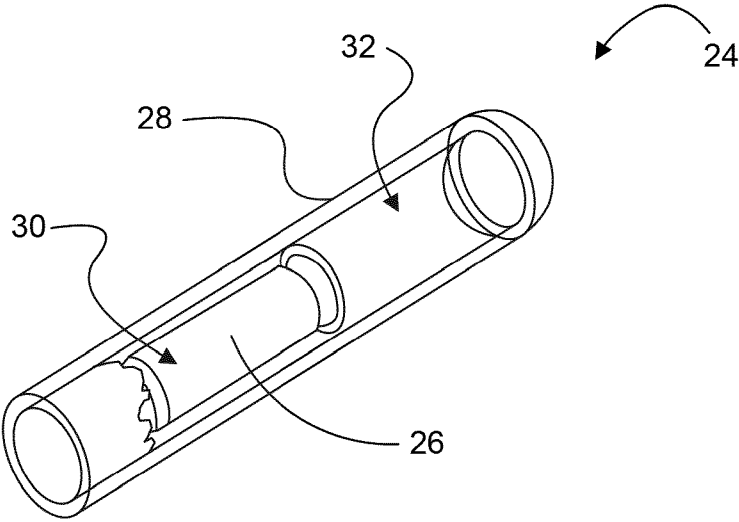


Figure 3a

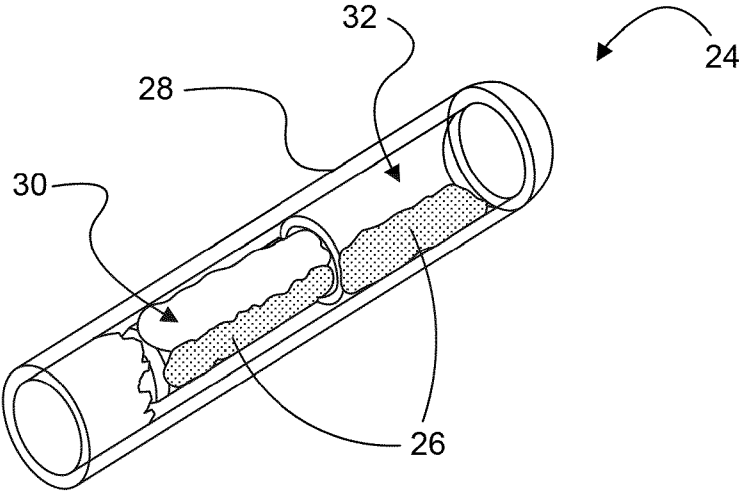


Figure 3b

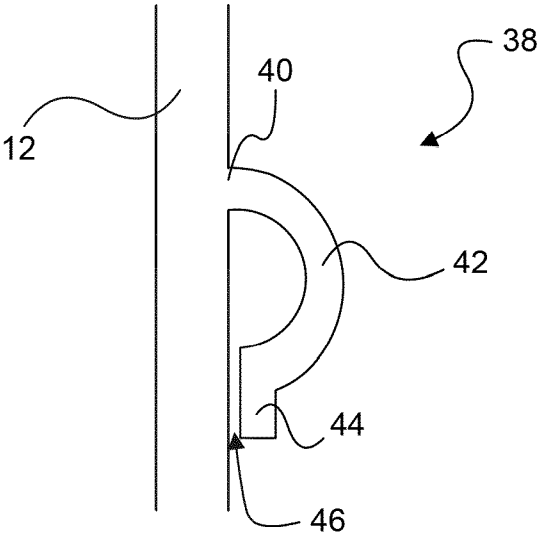


Figure 4a

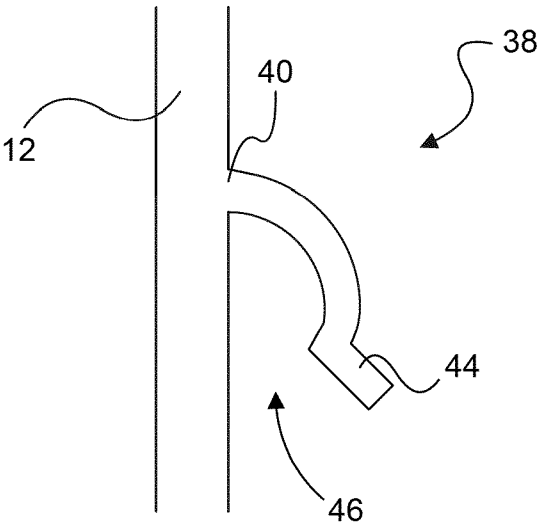


Figure 4b

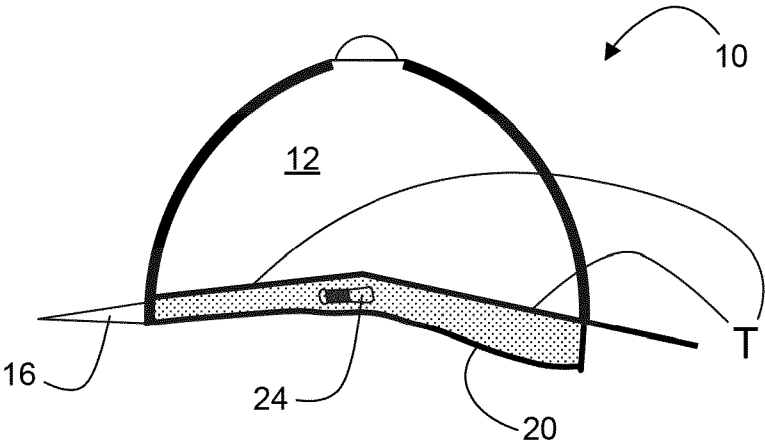


Figure 6a

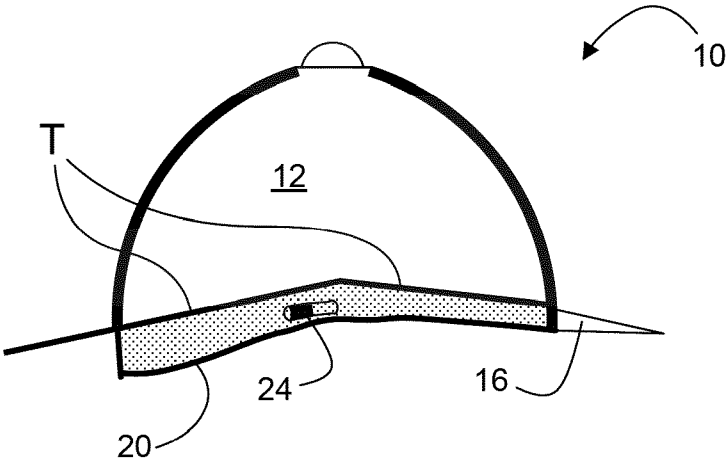


Figure 6b

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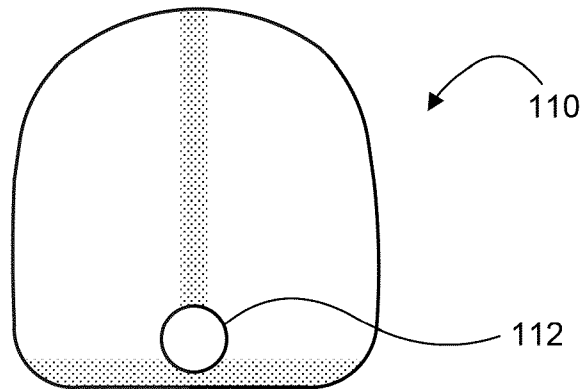


Figure 7a

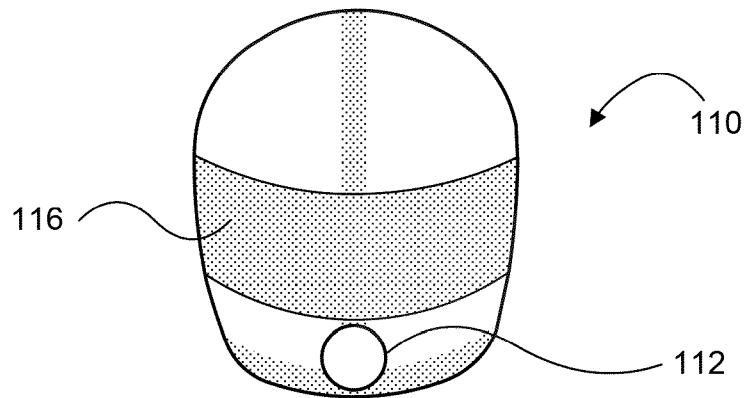


Figure 7b

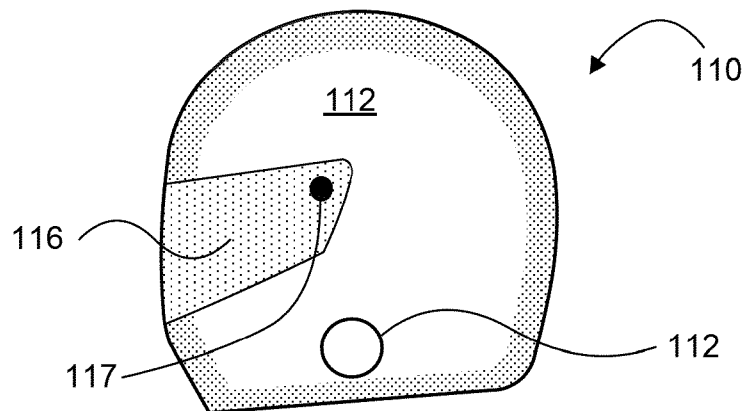


Figure 7c

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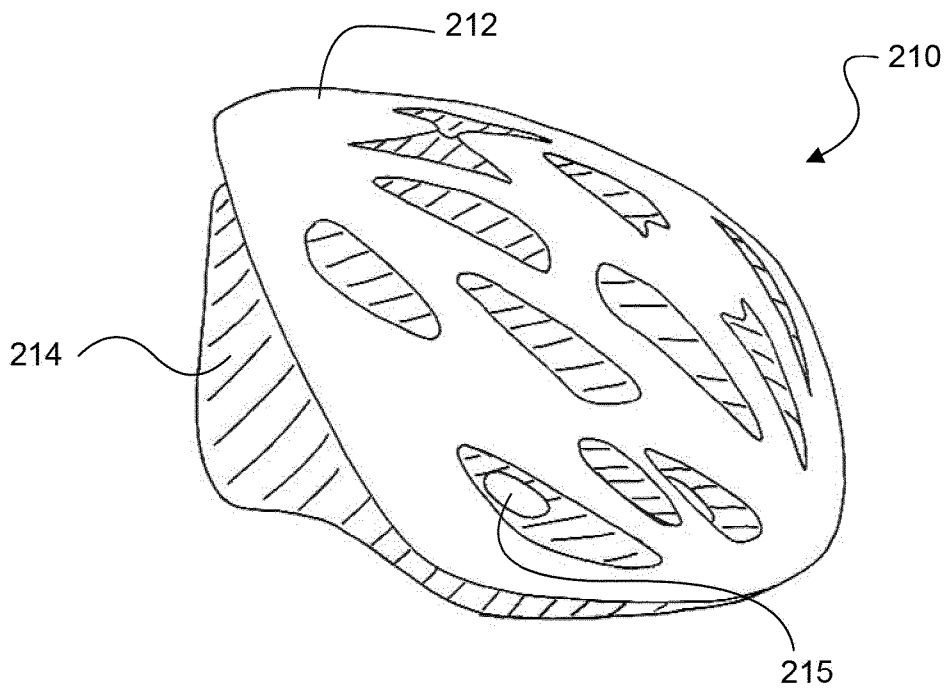


Figure 8

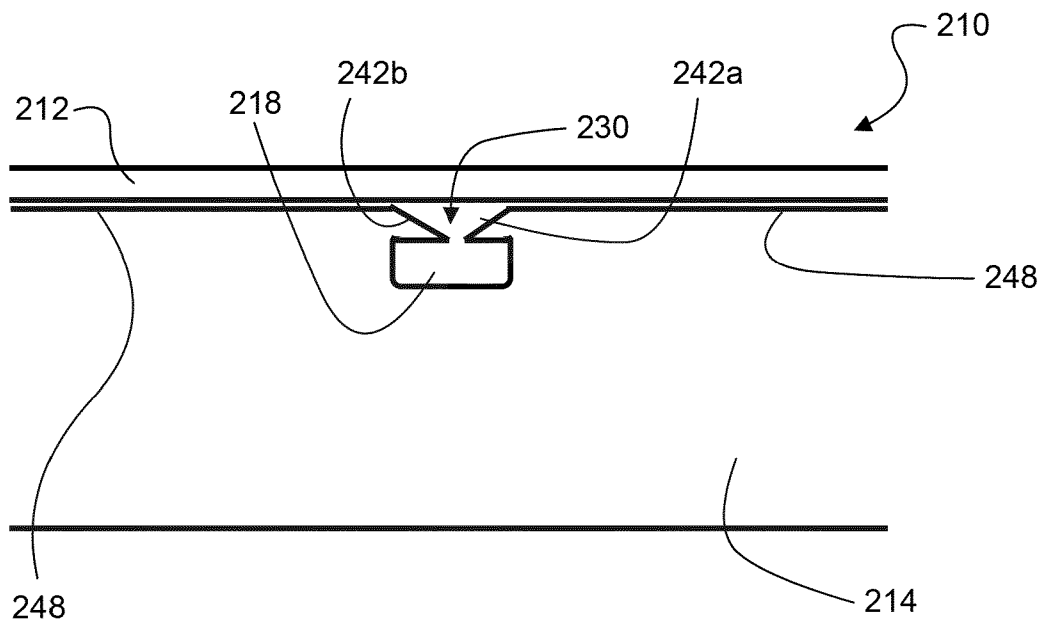


Figure 9

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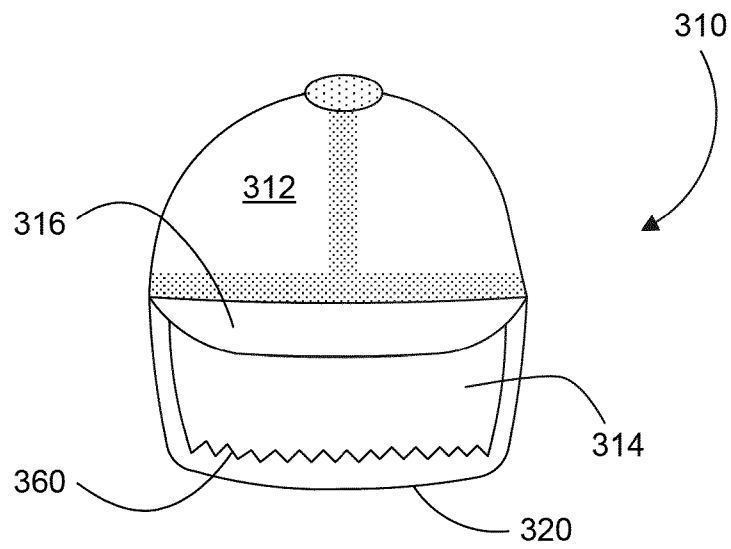


Figure 10a

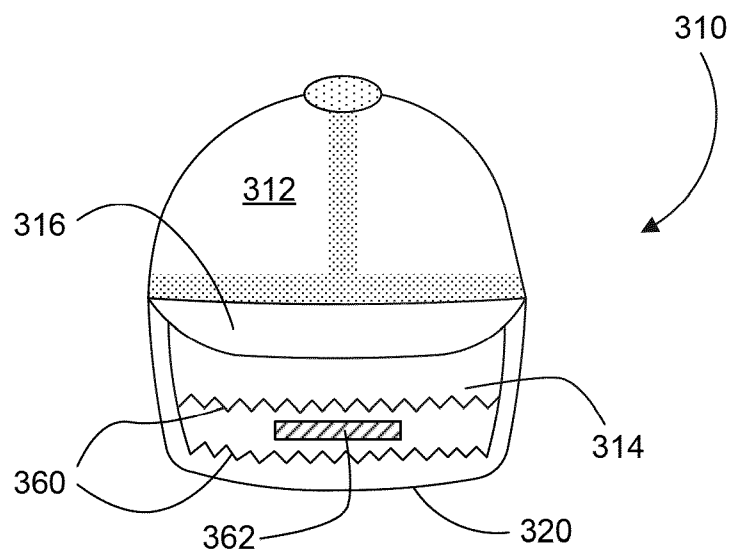


Figure 10b

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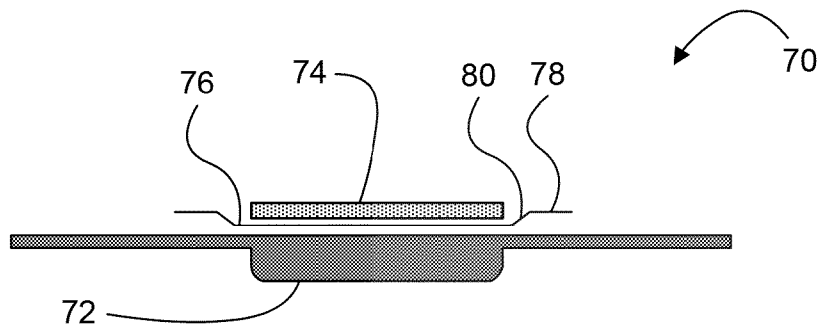


Figure 11a

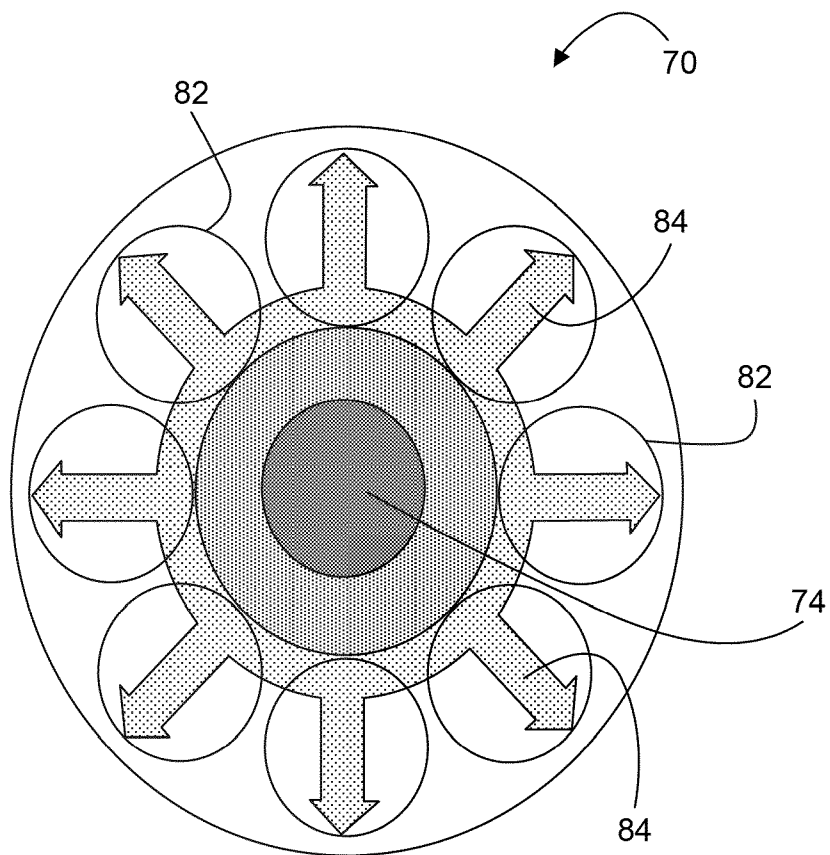


Figure 11b

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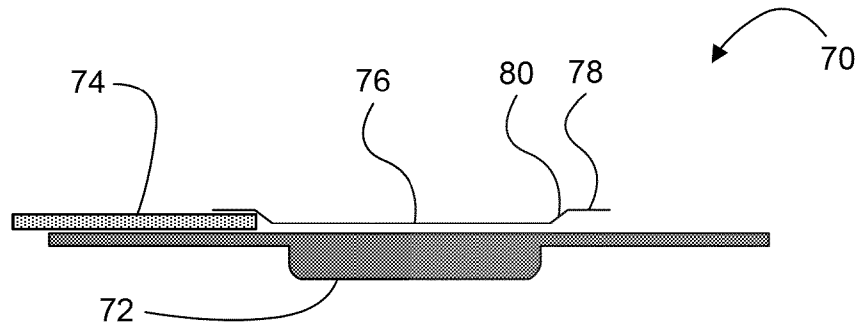


Figure 11c

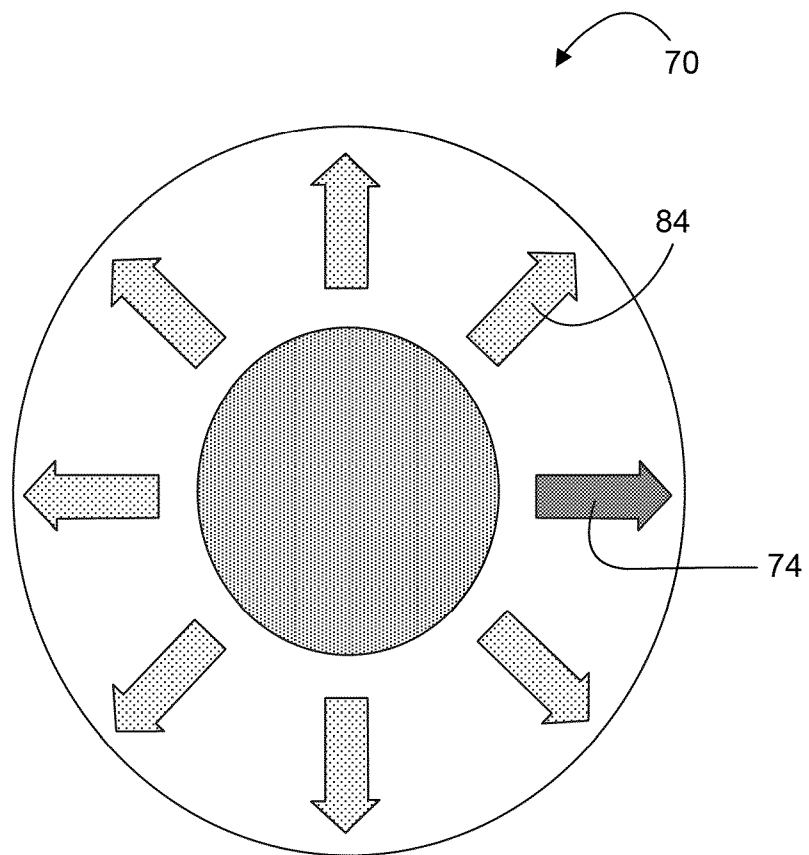


Figure 11d

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/057138

A. CLASSIFICATION OF SUBJECT MATTER
INV. A42B3/06
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A42B G01M G01P

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/089480 A1 (BECK GREGORY S [US]) 26 April 2007 (2007-04-26) paragraphs [0008], [0050], [0052], [0054] - [0056], [0069], [0072]; figures 1,3,7 -----	1-7,10, 12-17, 21,22, 25,26
X	US 7 878 140 B1 (STEELE WILLIAM R [US] ET AL) 1 February 2011 (2011-02-01) column 4, line 56 - column 6, line 22; figure 3 -----	1-6,10, 12-17
X	US 6 301 718 B1 (RIGAL JEAN-PIERRE [FR]) 16 October 2001 (2001-10-16) column 2, lines 7-46; figures 1-3 ----- -/-	1-10, 12-17,25



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

20 June 2016

Date of mailing of the international search report

27/06/2016

Name and mailing address of the ISA/

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Authorized officer

D'Souza, Jennifer

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/057138

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International application No

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