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Other: **WPI, EPODOC**

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(54) Title of the Invention: **Impact detection arrangement**
Abstract Title: **Impact detection arrangement for use with sports headwear**

(57) An impact detection arrangement 30 for coupling to sports headwear to be worn by a user. The arrangement 30 has a sensor 38 for detecting an indication of an acceleration change experienced by the user's head. A visual indicator 44, such as an arrangement of LEDs, provides a visual signal when the detected acceleration change exceeds a threshold. The arrangement 30 may also include a casing 50, which may have first and second housing parts 52, 54 for encapsulating the sensor 38 and LEDs respectively. Advantageously, the present invention draws attention to a player who has experienced a high g-force to their head, immediately alerting anyone in the vicinity that a medical check is needed to assess symptoms caused by the impact. Sports headwear comprising a pocket for receiving the arrangement 30 and apparatus including the arrangement 30 and the sports headwear are also disclosed.

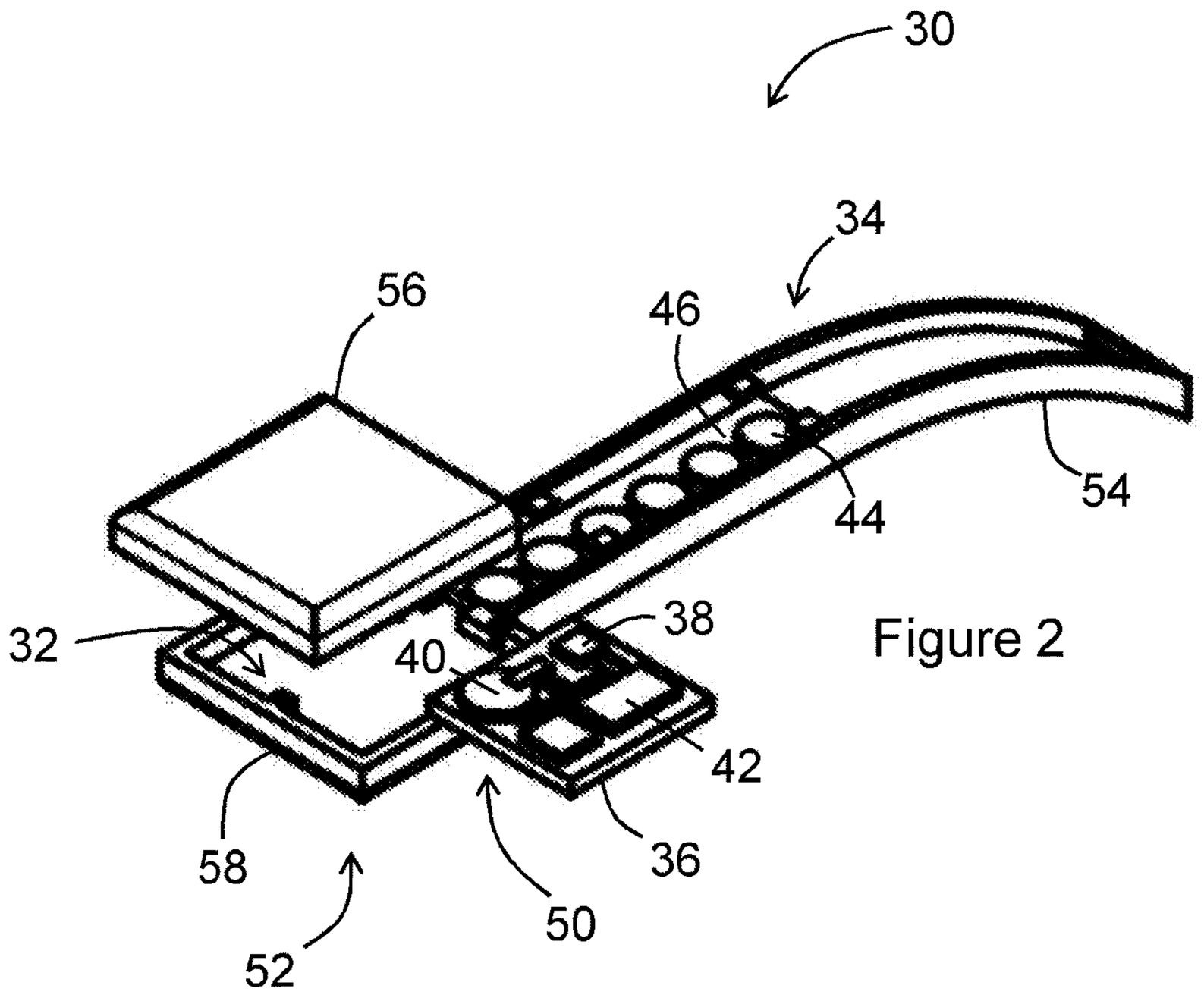

Figure 2

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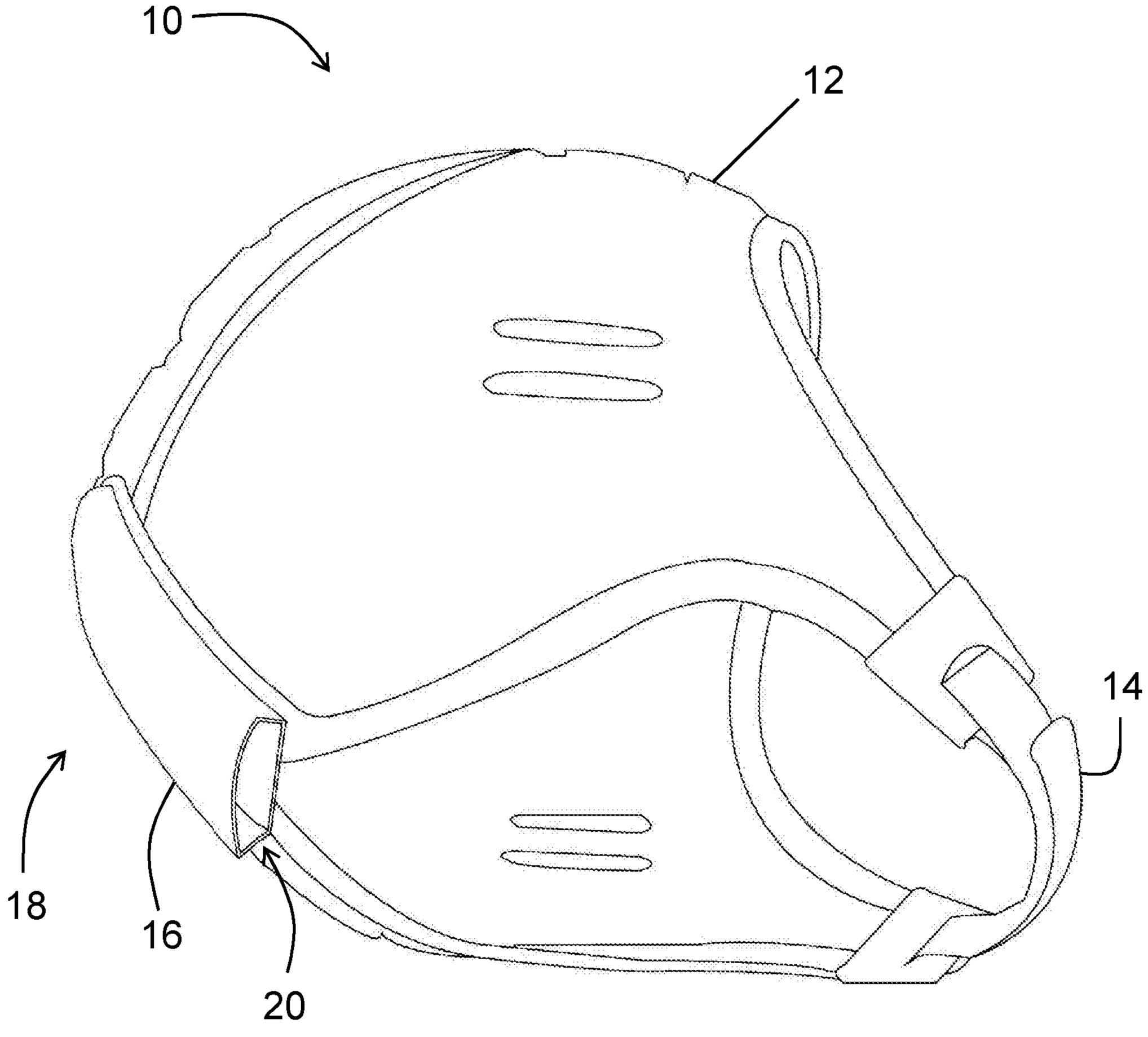

Figure 1

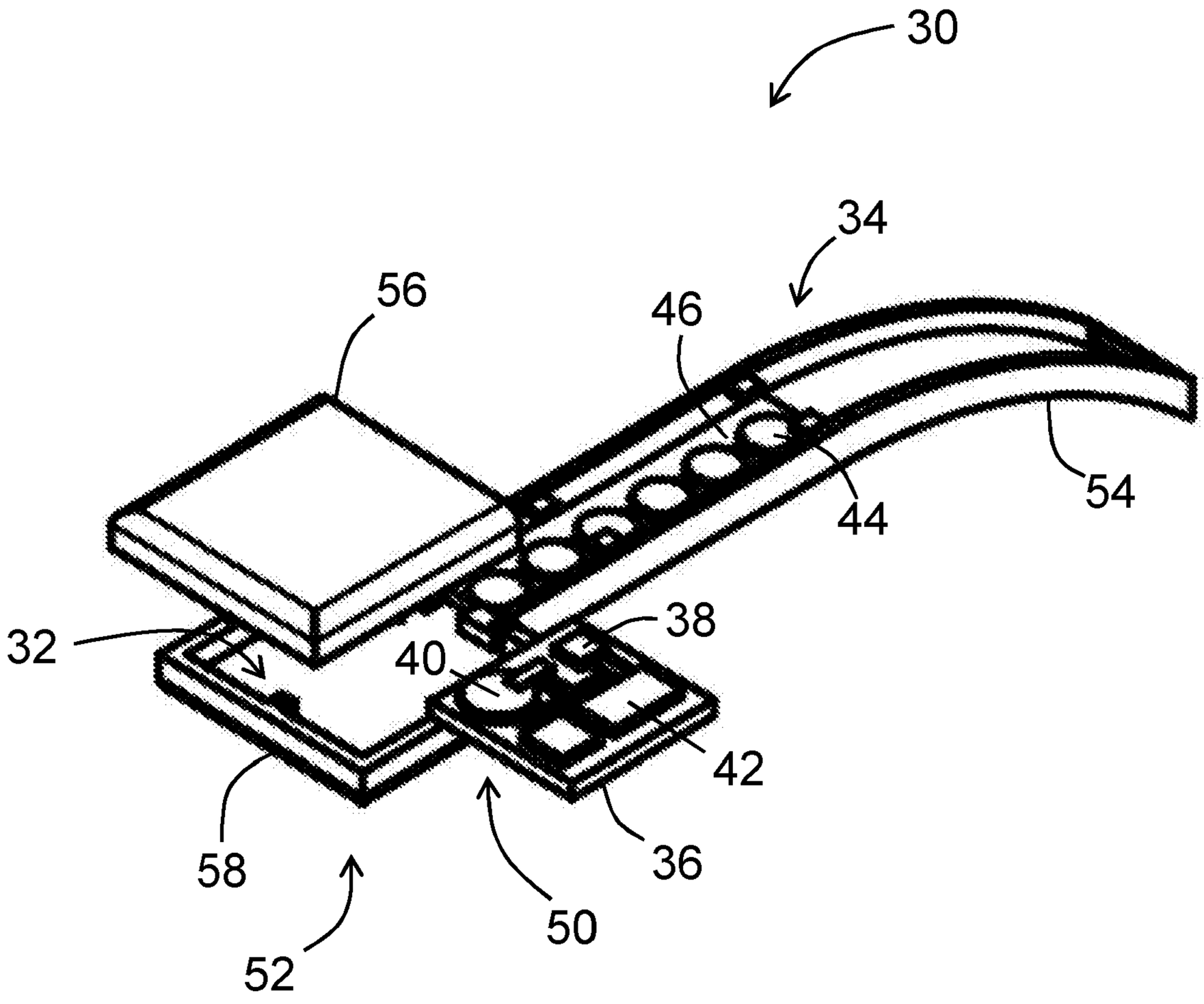

Figure 2

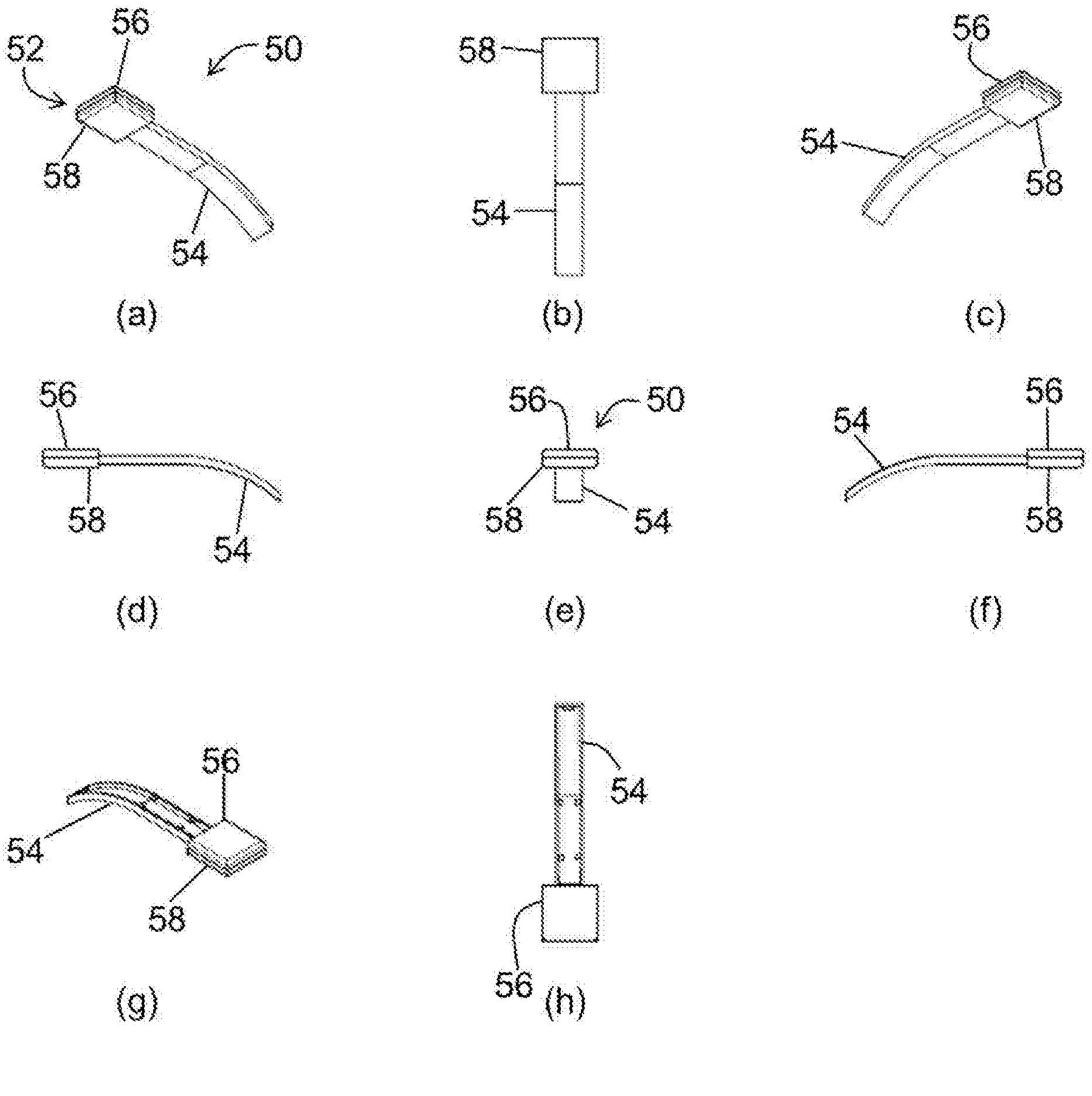
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Figure 3

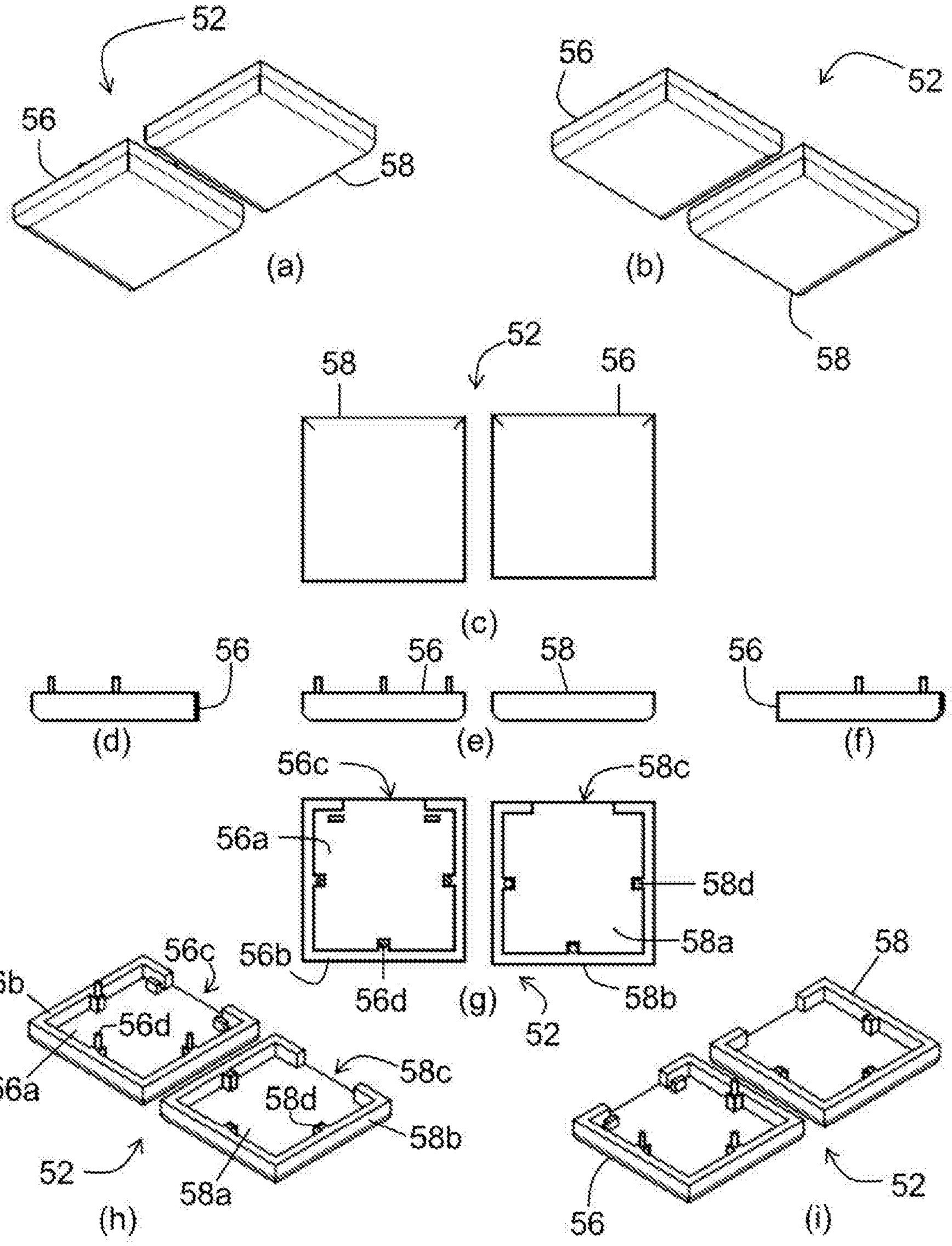
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Figure 4

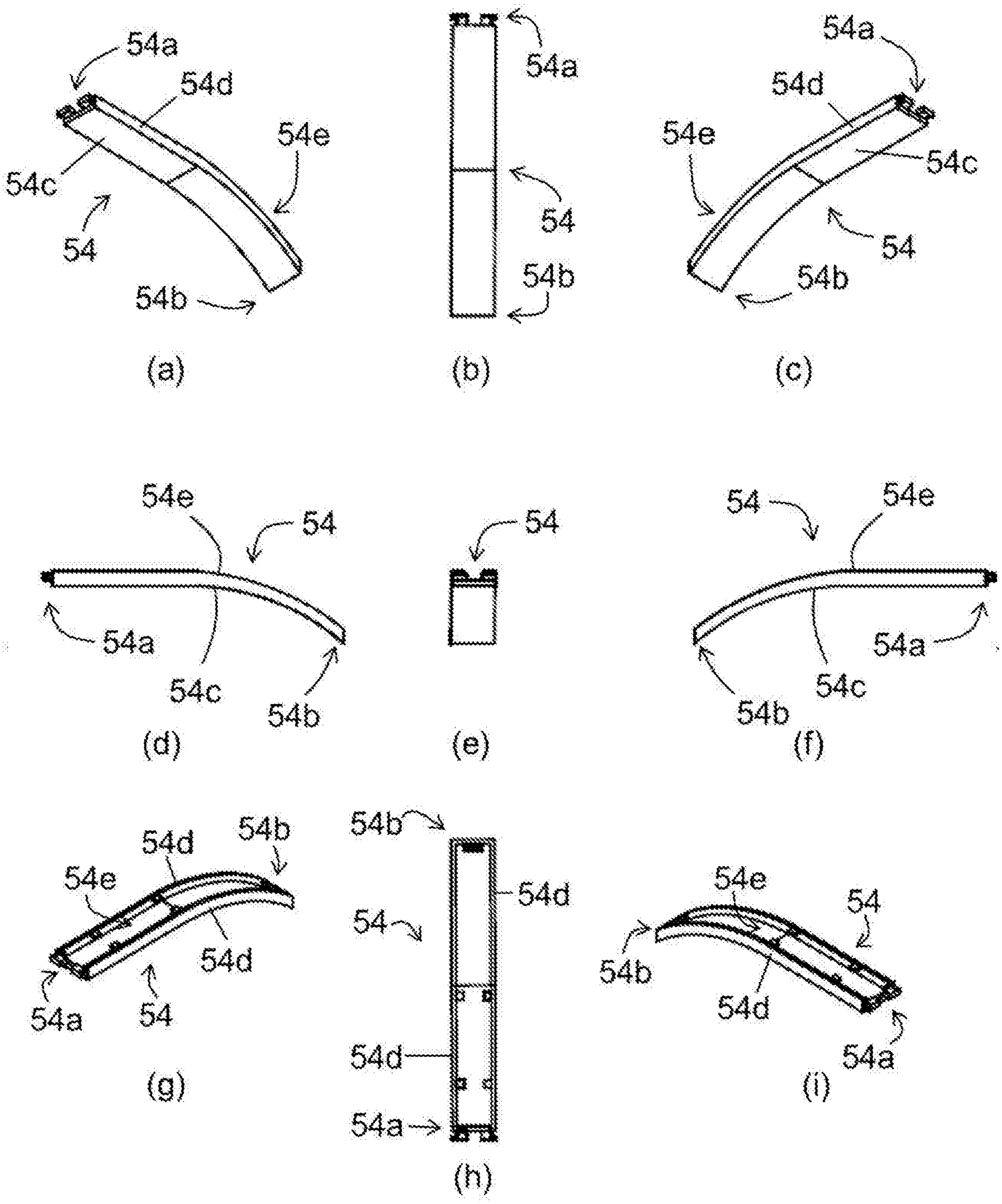
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Figure 5

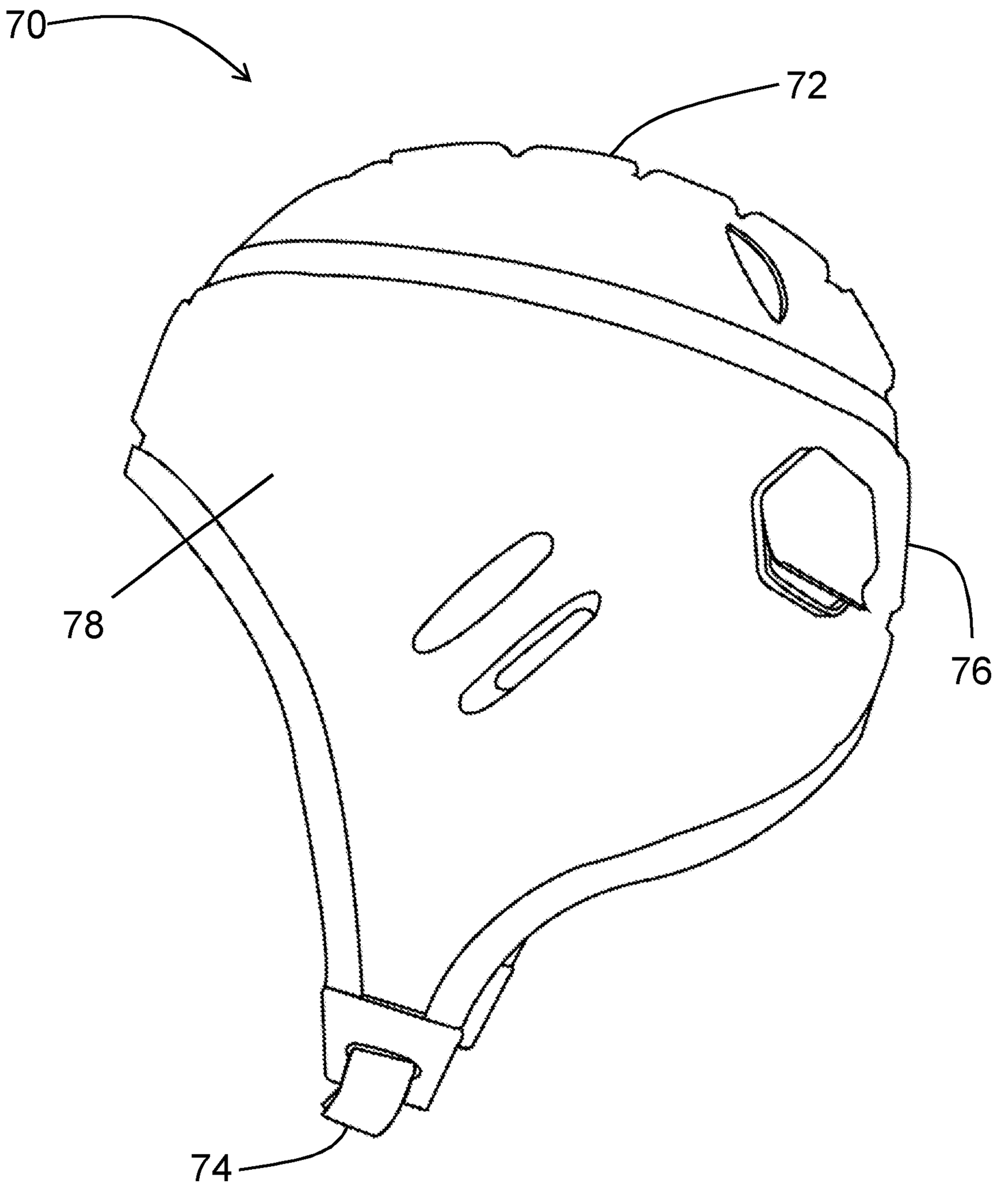


Figure 6

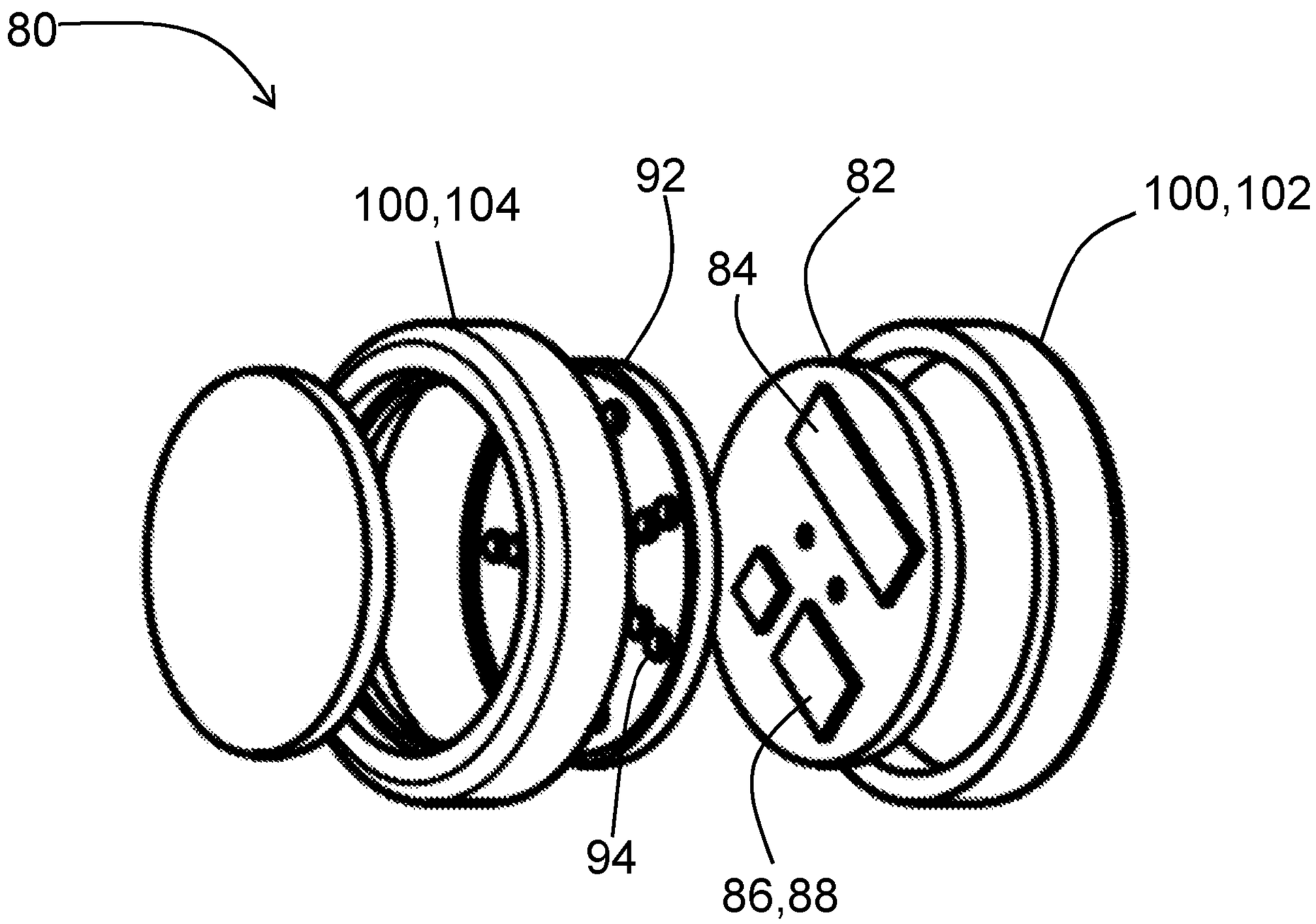
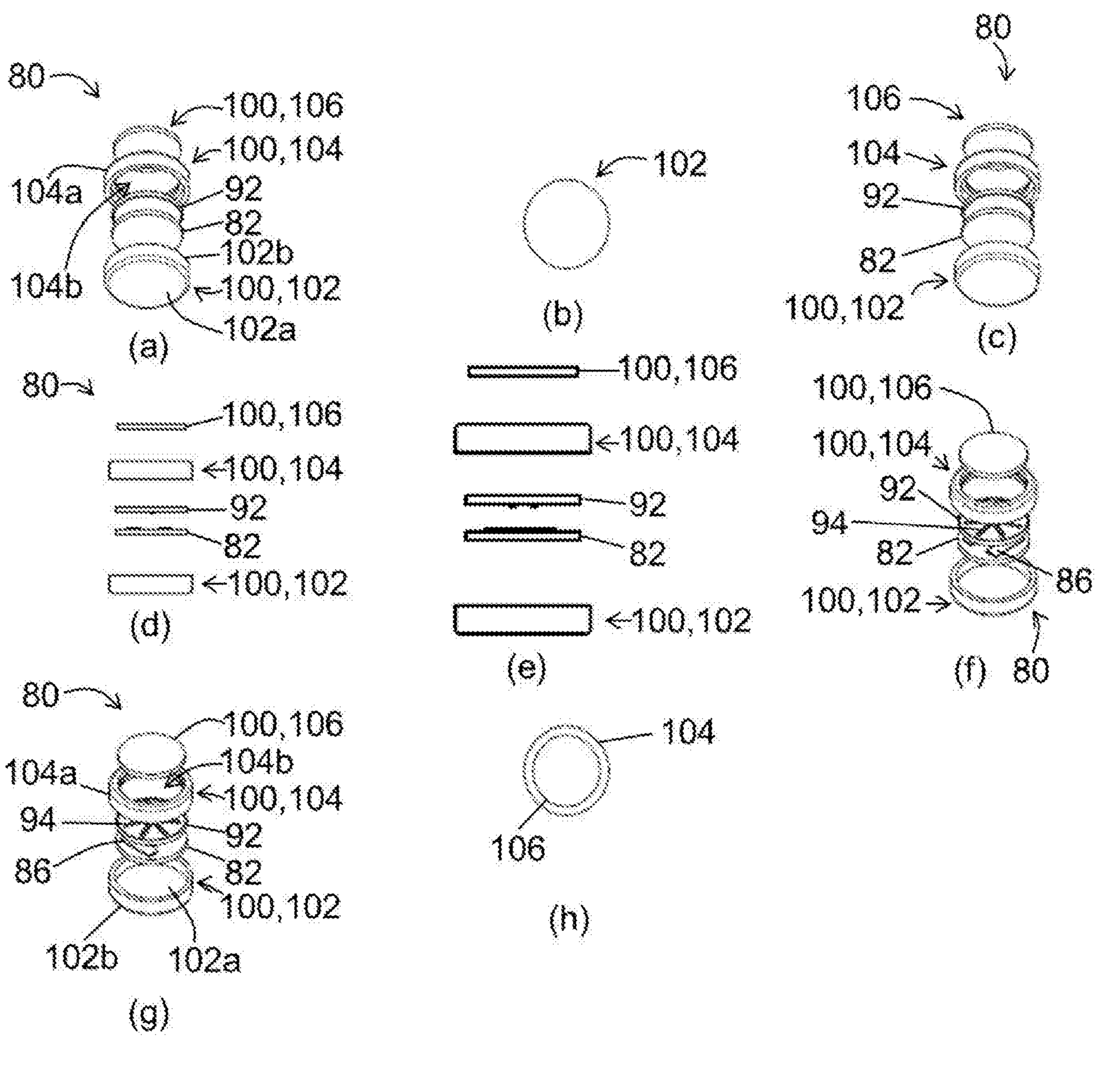


Figure 7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(g)
104
106
(h)

Figure 8

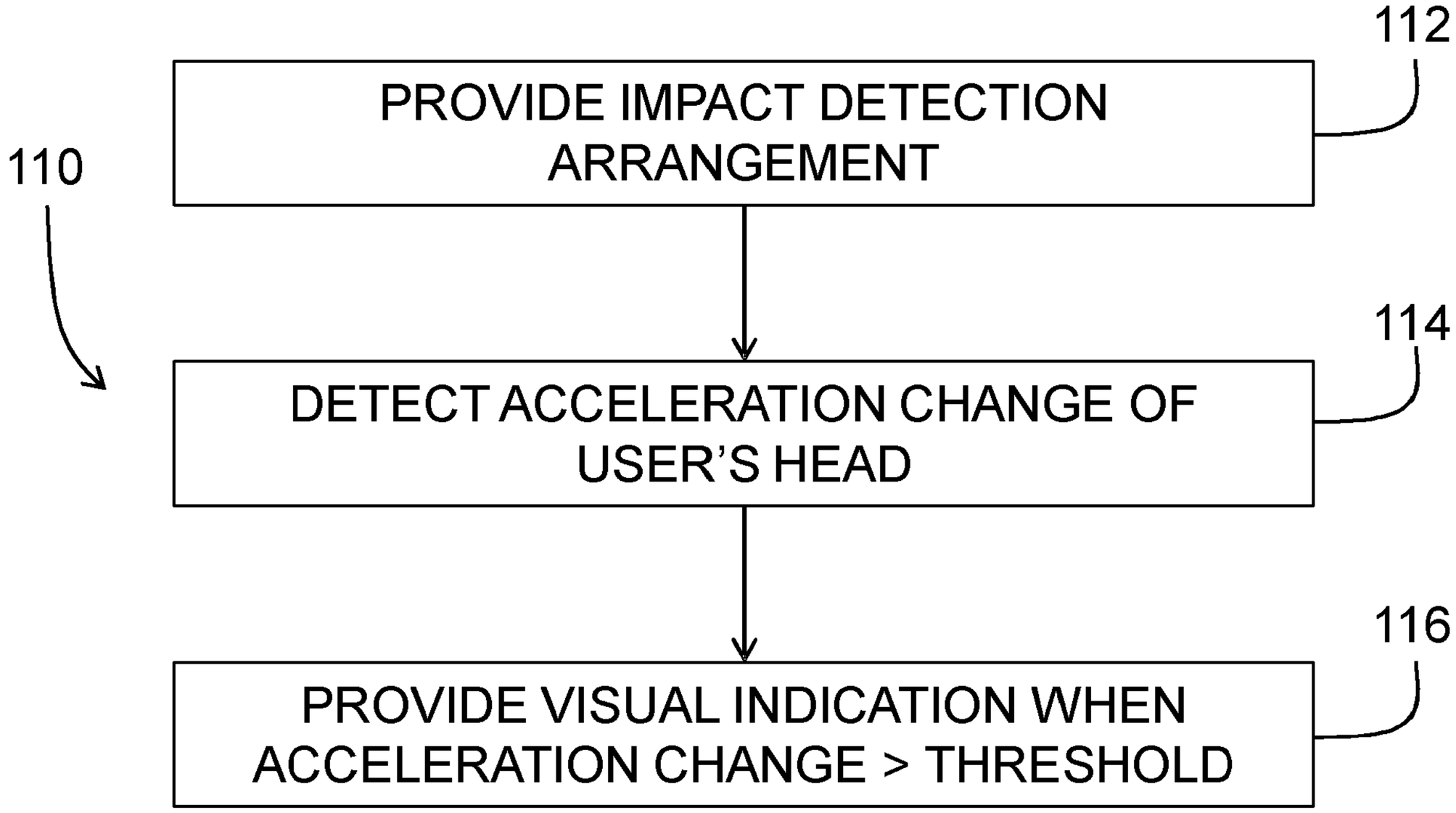
112
PROVIDE IMPACT DETECTION ARRANGEMENT
110
114
DETECT ACCELERATION CHANGE OF USER'S HEAD
116
PROVIDE VISUAL INDICATION WHEN ACCELERATION CHANGE > THRESHOLD

Figure 9

IMPACT DETECTION ARRANGEMENT

FIELD OF THE INVENTION

The present invention relates to detecting impacts received during sport. In particular, but not exclusively, the invention relates to an impact detection arrangement for coupling to sports headwear, e.g. protective headwear, to be worn by a user.

BACKGROUND

There is an increasing awareness of the risks of concussion in various different types of sporting activity, in particular high-contact sports such as rugby and gridiron football, but also other sports such as horse riding, cycling and skiing. A concussion may be regarded as a functional injury to the brain caused by a relatively large and fast change in acceleration of the head. In particular, this very quick change in movement causes the brain to press against the skull, resulting in injury. In rugby or gridiron football, such a rapid change in acceleration can often be caused by a player receiving or experiencing a high impact force to the head, neck or other part of their body, e.g. by being tackled by another player.

Second impact syndrome is a subsequent concussion being experienced prior to complete recovery from a previous concussion. In particular, second impact syndrome results from acute, serious brain swelling, which can cause vascular congestion and increased intracranial pressure that occurs rapidly, making it difficult to control. Second impact syndrome can result in serious, long-term brain damage, and can even be fatal.

Currently in sport, the effects of high impacts to a person's head are assessed by a referee or member of coaching staff based on the person's reaction or whether the referee or coaching staff recognise the person displaying any symptoms associated with concussion, such as amnesia, confusion, headache or loss of consciousness. Clearly, such an approach has the potential for a concussion to not be properly recognised or diagnosed, for example because the person receiving the high impact downplays symptoms they are experiencing or because symptoms are not properly recognised by other players, officials or coaching staff that are present. The consequences of a concussion not being properly diagnosed, such that the person is permitted to continue taking part in the sporting activity, are potentially severe, e.g. second impact syndrome.

It is against this background to which the present invention is set.

SUMMARY OF THE INVENTION

According to an aspect of the invention there is provided an impact detection arrangement. The arrangement is for coupling to sports headwear that is to be worn by a user or player. The arrangement comprises a sensor configured to detect an indication of an acceleration change experienced by the user's head when the sports headwear is being worn. In particular, the sensor is configured to receive data indicative of the acceleration change experienced by the user's head. The arrangement also comprises a visual indicator configured to provide a visual indication when the detected acceleration change exceeds a threshold change value. The sensor may comprise an accelerometer. The sensor may comprise a gyroscope.

The impact received by the user can be, but need not be, an impact received directly to the user's head. For instance, the user may receive an impact to their neck or body, e.g. by being tackled by another player, which causes a sudden or rapid acceleration change of the user's head, specifically to their brain. That is, an impact to the player at any part of their body can cause the player's head to jolt.

By coupling the impact detection arrangement to the head guard, the arrangement is secured relative to the player's head so that movement of the player's head may be detected by the sensor. In particular, the arrangement or device acts as a recognition device of high-impact changes to the user's head area, mimicking the movement of the brain inside the skull. Specifically, by coupling the arrangement directly to the head, the arrangement can detect and relay the effects of directional changes that occur inside the skull of the user's brain. This direct coupling or attachment to the user's head provides a more accurate measurement of the head movement.

In the present invention, relatively high g-forces experienced by sports players, in particular rapid acceleration changes to a player's head or brain, are detected or recognised and then a warning that such an impact has been received is relayed visually to anyone in the vicinity of the player, e.g. team-mates, opponents, referees, coaches, spectators, etc. Advantageously, the present invention allows for immediate attention to be drawn to a player who has experienced a high g-force to their head, and therefore immediately alerts anyone in the vicinity that a medical check is needed to assess symptoms caused by the impact so that a determination may be made as to whether the player may continue partaking in the sporting activity. Specifically, provision of a visual

indication, e.g. a light, that a high impact has occurred removes the uncertainty of attempting to identify when a player needs a medical check based solely on the player reporting the impact, or another person witnessing an impact and determining that the impact was sufficiently high to necessitate a medical check. A visual indication or cue that is visible to anyone in the vicinity of the player removes the risk of a player not reporting that they have experienced a high impact or of anyone else in the vicinity simply not witnessing a high impact. This means that players needing a medical check or medical attention may be easily identified, and reduces the chance of concussive symptoms being misdiagnosed or missed completely. This reduces the likelihood of a player suffering repetitive knocks or impacts, and so reduces the chances of a player suffering from an injury even more severe than concussion. Also, a visual cue visible to various people means that the responsibility of acting on a high-impact event then does not fall on a single person responsible for making an assessment as to whether medical attention is needed. In addition, the visual cue removes the risk of bias from the player receiving the impact, i.e. to downplay the level of the received impact. The invention provides a simple and easy to use arrangement that removes any uncertainty of how received impact data is to be used. That is, when the visual indication is activated then it is clear that a medical check is needed.

The arrangement is a wearable device that may be attached to, or incorporated into, an existing piece of equipment, i.e. head guard. The head guard may be a standard piece of equipment or designed specifically to incorporate the impact detection arrangement.

The visual indicator may be electrical or mechanical. For instance, the visual indicator may comprise a light indicator.

The light indicator may comprise one or more LEDs. Advantageously, LEDs may have a relatively high-luminosity output, and therefore provide a clearer indication when a high impact has been received.

The visual indicator may be arranged atop the sensor, or generally adjacent to the sensor.

The sensor may be positioned on a first substrate, e.g. a printable circuit board. The visual indicator may be positioned on a second substrate separate from the first substrate. There may be an electrical connection between the first and second

substrates. In particular, opening or closing of a switch on the first substrate may cause activation or deactivation of the visual indicator, e.g. to cause the LEDs to light up or switch off. Power to such an electrical circuit may be provided by a battery on the first substrate, e.g. a coin battery.

The threshold may be user-adjustable. The relevant threshold, i.e. the impact level at which a player or user needs to receive a medical check, may vary for different ages, levels and/or sports. For instance, the relevant threshold for a rugby player wearing a scrum cap may be different from a gridiron player wearing a gridiron helmet. Advantageously, a user-adjustable threshold provides flexibility of use between different sports and individuals.

The threshold change value may be a first threshold change value greater than a second threshold change value. The visual indicator may be configured to provide the visual indication when the detected acceleration change exceeds the second threshold change value a predetermined number of times greater than one. Advantageously, consecutive, smaller impacts may therefore be recognised.

The arrangement may comprise a casing, shell or housing arranged to house the sensor and the visual indicator. Such a casing provides protection for the components within.

The housing may be formed from a flexible material. Conveniently, therefore, the arrangement may flex or mould in dependence on particular movements of the user's head and body to reduce the chance of the arrangement causing injury.

At least part of the housing may be formed from a transparent or translucent material. In particular, the visual indicator may be positioned adjacent such transparent material. Advantageously, this allows the visual indication, e.g. light, provided by the visual indicator to be visible by spectators, referees or other players.

The housing may be formed from thermoplastic polyurethane. This is a particularly suitable material for providing the necessary rigidity and flexibility required of the housing, and thereby guards against causing injury to the user or opponent during use.

The housing may be generally elongate.

The housing may be shaped to conform to a curvature of the user's head.

The housing may comprise a first housing part, or sensor housing part, arranged to house the sensor. The housing may comprise a second housing part, or visual indicator housing part, arranged to house the visual indicator.

Conveniently, the sensor housing part may be arranged in use at, or adjacent to, a rear side of the user's neck. Advantageously, this is an area of the user's body that is less likely to receive direct impacts during certain sports, e.g. rugby, while positioning the sensor housing part here may still allow relatively easy connection to the head gear.

The arrangement may comprise a locking mechanism arranged to connect the first and second housing parts together. Conveniently, the first (sensor) housing part may be disconnected from the rest of the arrangement to, for example, reset the sensor or adjust the threshold while the rest of the arrangement may remain in situ coupled to the head gear.

The housing may be generally circular. Advantageously, this may result in a relatively compact arrangement. In the case of a rugby scrum cap, a generally circular arrangement comprising a circular housing may conveniently by received into a foam pocket of a padded part of the scrum cap. This results in a relatively discreet apparatus that does not alter the overall shape of bulk of the head wear to be worn by the player.

The sensor may be configured to receive data indicative of the acceleration change experienced by the user's head. The arrangement may comprise a wireless transmitter configured to transmit the received acceleration data off-board the arrangement. The acceleration data may be transmitted to a mobile device, optionally in real time. Advantageously, by providing such data to a mobile or handheld device a relatively large amount of data may be collected and used to identify and track head impact levels throughout the duration an entire sporting contest. In turn, this may lead to improved diagnosis from medical staff, either on the side-lines or elsewhere, who may not have witnessed a particular incident involving an impact.

According to another aspect of the invention there is provided sports headwear comprising a main body arranged to receive a user's head, and a pocket coupled to the main body and arranged to receive the impact detection arrangement described above.

The impact detection arrangement is therefore coupled to the sports headwear. In this way, the impact detection arrangement can track and detect g-forces experienced by a user's head, in particular their brain, to determine whether a brain injury, e.g. concussion, may have occurred as a result of a high impact to the player or user.

The pocket may be positioned at rear side of the sports headwear. Advantageously, positioning the arrangement in such a manner reduces the likelihood of a direct impact to the arrangement being received.

The pocket may be positioned centrally on the main body of the head guard, i.e. centrally relative to the user's head. Advantageously, such positioning may provide more accurate measurements for impacts received on either side of the user, i.e. either side of the user's head or body.

The pocket may be attached to the main body by sewing. Conveniently, the pocket may be attached to the main body during manufacture of the head gear.

The pocket may be in the form of a fabric sleeve. The sleeve may be breathable. Advantageously, the sleeve provides a barrier to protect the arrangement, for example from dirt or to provide water resistance. This also allows relatively easy insertion and removal of the arrangement to, for example, reset the arrangement after an above-threshold impact.

The sleeve may include a strap or belt that further secures the pocket to the main body of the head guard. In particular, the strap may extend from a lower end to upper end of the pocket, and may be wrapped around the head guard to further secure or fasten the arrangement to the head guard. For instance, the strap may be secured by means of a hook-and-loop attachment, e.g. Velcro®.

The pocket may be integrally formed with the main body.

The sports headwear may be a rugby head guard or scrum cap.

According to another aspect of the invention there is provided apparatus for sports impact detection. The apparatus comprises the impact detection arrangement described above. The apparatus comprises the sports headwear described above. The sports

headwear is arranged to be worn on a user's head and the impact detection arrangement is arranged to be coupled to the sports headwear to detect acceleration change experienced by the user's head upon the user receiving an impact.

According to another aspect of the invention there is provided an impact detection method. The method comprises providing an impact detection arrangement for coupling to sports headwear to be worn by a user. The arrangement has a sensor and a visual indicator. The method comprises detecting, using the sensor, an indication of an acceleration change experienced by the user's head when the sports headwear is being worn. The method comprises providing a visual indication using the visual indicator when the detected acceleration change exceeds a threshold change value.

BRIEF DESCRIPTION OF THE DRAWINGS

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 schematic view of a rugby head guard having a pocket;

Figure 2 shows a schematic view of an impact detection arrangement for being received in the pocket of Figure 1;

Figures 3(a)-3(h) show perspective views of a housing of the impact detection arrangement of Figure 2;

Figures 4(a)-4(i) show perspective views of a first housing section of the housing of Figures 3(a)-3(f);

Figures 5(a)-5(i) show perspective views of a second housing section of the housing of Figures 3(a)-3(f);

Figure 6 shows a schematic view of a rugby head guard having a pocket;

Figure 7 shows a perspective view of an impact detection arrangement for being received in the pocket of Figure 6;

Figures 8(a)-8(h) show further perspective views of the impact detection arrangement of Figure 7; and,

Figure 9 shows the steps of a method undertaken by the impact detection arrangement of Figure 2 and Figure 7.

DETAILED DESCRIPTION

Figure 1 schematically illustrates sports headwear in the form of a rugby head guard 10, also referred to as a scrum cap, in accordance with an example of the invention. Scrum caps are commonly worn by rugby players to protect their ears, in particular to protect their ears when contesting a scrum. Typically, the head guard is formed from soft, thin material such as foam. The head guard 10 has a main body 12 for receiving the head of a player or user, and straps 14 attached to the main body 12 that may be secured together when the user is wearing the head guard 10 to secure the head guard 10 to the user. In particular, the straps 14 may be secured together under or around the user's chin or jaw.

The head guard 10 includes a pocket 16 at a rear side 18 of the head guard 10. The pocket 16 is in the form of an elongate slot that has a pocket opening 20 at a lower side 22 of the head guard 10 and which faces in a generally downwards direction (when worn by a standing user). The pocket 16 is integral with the main body 12 of the head guard 10, and the pocket 16 is attached to, or formed with, the main body 12 during manufacture of the head guard 10. For instance, the pocket 16 may be sewn onto the main body 12 during manufacture of the head guard 10. The pocket 16 is arranged to receive therein an impact detection arrangement (not shown), as is discussed in detail below.

Figure 2 schematically illustrates an example of an impact detection arrangement 30 that may be inserted into the pocket 16 of the head guard 10 (shown in Figure 1). In particular, the arrangement 30 is for detecting impacts received by a user that is wearing the head guard 10 when playing rugby. Specifically, the arrangement 30 is for detecting high impacts received by the user, e.g. when the user is tackled by an opponent, and for alerting other people in the vicinity when a received impact is greater than a threshold level.

The arrangement 30 includes a sensor section 32 and a lighting section 34 adjacent to the sensor section 32. The sensor section 32 may also be referred to as the first section 32, and the lighting section 34 may also be referred to as the second section 34. The sensor section 32 includes a printable circuit board 36, or microchip or substrate, having a sensor 38 in the form of an accelerometer and gyroscope. The circuit board 36 also has a battery source in the form of a coin battery 40, also referred to as a button cell. The battery 40 is connected to, and provides electrical power to, the sensor 38. The circuit board 36 also has a wireless radio transmitter 42. The lighting section 34 includes a

visual indicator in the form of a plurality of light emitting diodes (LEDs) 44. In particular, the lighting section 34 includes a row of five, mutually adjacent LEDs 44. Each of the LEDs 44 is located on a respective circuit board 46. The battery 40 is also connected to the LEDs 44 to provide electrical power to the LEDs 44.

The arrangement 30 includes a casing or housing 50 for housing the circuit boards 36, 46. With continued reference to Figure 2, and additional reference to Figures 3(a)-3(h) – which show various views of the housing 50 – the housing 50 includes a sensor housing part 52, also referred to as a first housing part 52, defining the first section 32 and a light housing part 54, also referred to as a second housing part 54, defining the second section 34, where the sensor and light housing parts 52, 54 are connected together.

The housing 50 is formed from a material that protects the components it houses therein, i.e. the circuit boards 36, 46, but is also flexible. In the described example, the housing 50 is formed from thermoplastic polyurethane.

With continued reference to Figure 2 and Figures 3(a)-3(h), and additional reference to Figures 4(a)-4(i) – which show various views of the sensor housing part 52 – the sensor housing part 52 has an upper part 56 and a lower part 58. Each of the upper and lower parts 56, 58 is of generally rectangular shape and are brought together to form a generally cuboidal first section 32. Each of the upper and lower parts 56, 58 has a respective base cover 56a, 58a and side walls 56b, 58b extending around the perimeter of the base covers 56a, 58a. The side walls 56b, 58b each are discontinuous along one side of the respective base covers 56a, 58a to form a gap or space 56c, 58c in the walls 56b, 58b. When the upper and lower parts 56, 58 are brought together to form the sensor housing part 52 the gaps 56c, 58c are aligned to form an aperture. The upper and lower parts 56, 58 have respective connectors 56d, 58d for joining or connecting the upper and lower parts 56, 58 together. In particular, the upper part 56 has a male connector 56d at each side thereof, which is to be inserted into a respective female connector 58d of the lower part 58 so as to connect the upper and lower parts together 56, 58.

Purely by way of example, various dimensions of the sensor housing part 52 may be as follows. The sensor housing part 52 may be generally square having sides of approximately 30 mm. The depth of each of the upper and lower parts 56, 58 may be approximately 5 mm. The male connectors 56d may be approximately 3 mm in length and approximately 1 mm wide. It will be understood that any appropriate dimensions may be used.

With continued reference to Figure 2 and Figures 3(a)-3(h), and additional reference to Figures 5(a)-5(i) – which show various views of the light housing part 54 – the light housing part 54 is elongate and, in use, extends from a lower part to an upper part of a user's head at the rear of the user's head. In particular, the light housing part 54 is curved or shaped to conform to a curvature of the user's head, specifically the rear side of the head. The light housing part 54 may extend in a straight or linear manner from a lower end 54a and then curve to conform to the curvature of the user's head towards an upper end 54b of the light housing part 54. In the described example, the light housing part 54 is curved from approximately half way along the light housing part 54 to its upper end 54b, although any appropriate variant is envisaged.

Along the length of the light housing part 54, a rear part 54c and side parts 54d of the light housing part 54 are formed from the flexible material, e.g. thermoplastic polyurethane, mentioned above. A front part 54e opposite the rear part 54c is formed from a transparent material. When the LEDs 44 are positioned in the light housing part 54 they are arranged to face outwardly towards the front part 54e of the light housing part 54, and the transparent material of the front part 54e allows light from the LEDs 44 to be visible outside of the light housing part 54. The transparent material may be thermoplastic polyurethane.

The light housing part 54 includes a locking mechanism 54f at its lower end 54a in the form of resilient clips 54f. The clips 54f are arranged to be received into the aperture formed by the gaps 56c, 58c in the sensor housing part 52. In particular, the clips 54f engage with the sensor housing part 52 to secure or lock the light housing part 54 to the sensor housing part 52. The resiliency of the clips means that the light housing part 54 can conveniently be engaged and disengaged from the sensor housing part 52 as desired.

Purely by way of example, various dimensions of the light housing part 54 may be as follows. The light housing part 54 may be approximately 100 mm in length, approximately 15 mm in width, and approximately 5 mm in depth. The side parts 54d may be approximately 1.5 mm in width. Each of the clips 54e may be approximately 5 mm in width. It will be understood that any appropriate dimensions may be used.

Figure 6 schematically illustrates sports headwear in the form of a rugby head guard 70 in accordance with another example of the invention. Similarly to the previous example, the head guard 70 includes a main body 72 and straps 74. The main body 72 is again formed from soft, thin material such as foam. Also similarly to the previous example, the

head guard 70 includes a pocket 76; however, unlike in the previous example, the pocket 76 is of generally circular shape. The pocket 76 is integral with the main body 72 of the head guard 70, and the pocket 76 is formed with the main body 72 during manufacture of the head guard 70. As seen in Figure 6, the main body 72 of the head guard 70 has a design formed by spaced apart, shaped padded parts 78. In the described example, the padded parts 78 are generally octagonal in shape; however, any appropriate shape, or mix of shapes may be used, e.g. triangles, rectangles, square, pentagons, hexagons, heptagons, nonagons, decagons, etc. In the described example, the pocket 76 is of substantially the same size as one of the shaped padded parts 78 and is located where one (or more) of the padded parts 78 would otherwise be.

Figure 7 schematically illustrates an exploded view of an impact detection arrangement 80 in accordance with another example of the invention, where the arrangement 80 may be inserted or received into the pocket 76 of the head guard 70 (shown in Figure 6). The arrangement 80 is generally circular and the pocket 76 is sized to receive the arrangement 80. That is, the arrangement 80 may be embedded within the head guard 70. Note that in different examples the arrangement 80 and pocket 76 may be of any suitable shape.

As for the arrangement 30 of the previous example, the arrangement 80 is for detecting impacts received by a user that is wearing the head guard 70 when playing sport, in particular rugby. Specifically, the arrangement 80 is for detecting high impacts received by the user, and for alerting other people in the vicinity when a received impact is greater than a threshold level.

With continued reference to Figure 7, and additional reference to Figures 8(a)-8(h) – which show exploded views of the arrangement 80 – the arrangement 80 includes a printable (sensor) circuit board 82, or microchip or substrate, having a sensor 84 in the form of an accelerometer and gyroscope. The circuit board 82 also has a battery source in the form of a coin battery 86. The circuit board 82 also has a wireless radio transmitter 88. The arrangement 80 also includes another (lighting) substrate or circuit board 92 having a visual indicator in the form of a plurality of LEDs 94. In the described example, the LEDs 94 are arranged to form a pattern in the form of a number of spokes emanating from a centre to an edge of the substrate 92; however, any suitable pattern of LEDs may be created.

The arrangement 80 also includes a casing or housing, generally referred to using reference numeral 100, for housing the circuit boards 82, 92. The housing 100 includes a

base housing part 102, a ring housing part 104, and a housing cover part 106. As in the previously-described example, the housing 100 is formed from a flexible material, in particular thermoplastic polyurethane. The base housing part 102 has a base 102a and a rim 102b. The sensor circuit board 82 is received into the base housing part 102 so that it is adjacent to the base 102a and surrounded by the rim 102b. The lighting circuit board 92 may then be received into the base housing part 102 so that it is adjacent to, in particular atop, the sensor circuit board 82 and also surrounded by the rim 102b. The ring housing part 104 may then be placed on the base housing part 102 to encase or encapsulate the sensor and lighting substrates 82, 92. In particular, a rim 104a of the ring housing part 104 overlies the base housing part rim 102b. Note that the ring housing part 104 has an opening 104b at its top. The housing cover part 106 is transparent and is sized to be received into, and secured relative to, the opening 104b of the ring housing part 104. When the housing 100 is assembled, the LEDs 94 are visible through the transparent housing cover part 106.

Purely by way of example, the diameter of the base housing part 102 may be approximately 25 mm, the diameter of the sensor and lighting substrates or circuit boards 82, 92 may be approximately 21 mm, and the diameter of the transparent housing cover part 106 may be approximately 20 mm. It will be understood that any appropriate dimensions may be used.

Figure 9 summarises the steps of a method 110 performed by each of the arrangements 30, 80 in the above-described examples in order to detect and report a high impact experienced by a user when the arrangements 30, 80 are operational when a user is partaking in a sporting activity. In particular, prior to use the impact detection arrangement 30, 80 is coupled to the head guard 10, 70 by means of the pocket 16, 76, and the user dons the head guard 10, 70, in particular by the user's head being received into the main body 12, 72 of the head guard 10, 70. The provision of the impact detection arrangement 30, 80 for coupling to sports headwear, i.e. the head guard 10, 70, to be worn by a user may be regarded as step 112 of the method 110.

With the head guard 10, 70 secured to the user's head, the arrangement 30, 80 is thereby also secured relative to the user's head. The sensor 38, 84 is therefore operable to detect changes in movement of the user's head. Specifically, the sensor 38, 84 is arranged to detect a change in acceleration of the user's head, also referred to as a g-force experienced by the user's head. That is, the accelerometer 38, 84 measures the directional change of the user's head and, in particular, the rate of this change. This

detection or measurement of acceleration change may be regarded as step 114 in the method 110.

In the case of a shock, e.g. a collision, the g-force can be relatively large for a relatively short period. During sporting activity, such a shock can occur when a player is tackled or otherwise collides or impacts with another player. Note that a relatively large g-force may be experienced by a player's head even if the impact causing the large acceleration change is not received directly on the head. Along with a high impact to the head itself, a tackle where the direct impact is to the neck or other part of the body may also cause a large acceleration change to the head. When a player's head experiences a large acceleration change caused by a high impact, the player is at risk of concussion and needs to be checked by medical personnel before being allowed to continue playing, in particular to guard against second impact syndrome. It is therefore imperative that high g-forces experienced by the player's head are detected and communicated.

In order to achieve this, at step 116 the visual indicator in the form of LEDs 44, 94 are arranged to activate, i.e. to light up, when the acceleration change or g-force detected by the sensor 38, 84 rises above a threshold value. This provides a visual indication or warning to other people in the vicinity of the player, e.g. other players, referees, coaching staff, that the player has received a high impact and should be checked for signs of concussion before being permitted to continue playing. Specifically, the sensor 38, 84 is connected to, and calibrated by, a microprocessor of the circuit board 36, 82 that recognises when the received or detected impact exceeds the threshold change value. Upon exceeding the threshold, a switch of the circuit board 36, 82 is arranged to open to cause the visual indicator to activate, i.e. to cause the LEDs 44, 94 to illuminate.

In the described example, the LEDs 44, 94 remain on upon detection of the above-threshold g-force until the arrangement 30, 80 has been reset, e.g. until the player has been checked. In different examples, the LEDs may remain on for a predetermined amount of time upon detection of the above-threshold g-force.

In the described example, the threshold change value is a predetermined threshold value. For instance, an appropriate threshold for an adult player may be approximately 60 G, where G is a measure of the g-force change, i.e. a measure of acceleration change relative to free fall. It will be understood that this particular value if for illustration only, and any appropriate threshold value may be used.

In some examples, the threshold may be user-adjustable to be suitable for a particular user. For example, the appropriate threshold value for a child player may be less than for an adult player. The threshold value may therefore by adjusted and set in dependence on the particular user. In addition to, or alternatively to, the threshold being varied based on the age of the user, the threshold may also be varied in dependence on the level of sporting activity at which the player is participating. In rugby for example, the threshold may be varied depending on whether the player or user is participating in professional rugby or amateur rugby. For instance, the threshold value may be lower for amateur level than for professional level.

The wireless radio transmitter 42, 88 may be used to send impact data collected by the microchip 36, 82 from the arrangement 30, 80 to a mobile device, e.g. a mobile smartphone or tablet device. In particular, the impact data received by the mobile device may be recorded and monitored, for example via a specific application, so that a user of the mobile device can track and monitor the received impacts to make a determination as to whether medical attention is needed or to provide specific medical advice based on the received impact data. The signals may be sent in real time so that users of the mobile device on the side lines may be provided with live updates. Note that all of the detected impact data, and not necessarily just data above the threshold value, may be sent to the mobile device. The transmitted signals including the impact data may be in the form of, for example, Bluetooth® signals or radio-frequency identification (RFID) signals. For instance, the signals may be in the form of high-frequency sound waves as they may be clearer or have less disruption than other types of signals.

It will be appreciated that various changes and modifications may be made to the above-described embodiments and examples without departing from the scope of the present invention as defined in the accompanying claims.

In the above-described examples, the impact detection arrangement is coupled to a rugby head guard and used to detect impacts to a rugby player wearing the head guard when playing rugby. In different examples, however, the impact detection arrangement may be used to detect impacts received by a person taking part in a different sport. In particular, the impact detection arrangement may be coupled to sports headgear other than a rugby head guard. Examples of other sports in which the impact detection arrangement may be used include, but are not limited to, cycling and gridiron football. The sports headgear to which the impact detection arrangement is coupled may be

protective headgear, a helmet, used in these or other sports, or another form of sports headgear.

In the above-described examples, the impact detection arrangement has a single threshold g-force change value where a single impact above said threshold is considered to provide a concussion risk and therefore causes the visual indicator to be activated. However, when a player receives a number (greater than one) of impacts over a certain level (but less than the threshold) then the player may similarly be at risk of concussion. In different examples, therefore, there is a second threshold value less than the (first) threshold value, whereby the visual indicator is arranged to activate when the detected g-force change rises above the second threshold value a predetermined number of times greater than one.

In the above-described examples, one or more LEDs are used to provide visual indication of a high impact having occurred. In different examples, however, a different form of visual indicator may be used. For instance, different kinds of lights other than LEDs may be used. Also, the visual indicator need to not be an electronic visual indicator, e.g. light indicator, and could instead, for example, be in the form of a dye in a transparent container, where the dye is released (and can be seen) when the detected g-force is above the threshold.

In the above-described examples, the impact detection arrangement is coupled to the head guard by means of a pocket associated with the head guard, e.g. the pocket may be sewn onto the head guard, during manufacture or otherwise, or the pocket may be integrally formed with the head guard. In different examples, the impact detection arrangement may be coupled to the head guard without the need of a pocket to receive the head guard. In the case of rugby specifically, the impact detection arrangement may be attached or connected directly to the rugby head guard. In particular, the arrangement may be attached to an internal plate positioned at an inner side of the head guard. The plate may have connection points or features, such as sprockets, that extend or fit through eyelets holding lacing of the head guard, and may in turn connect to corresponding connection points on the arrangement, so as to secure the arrangement to the head guard, and therefore secure the arrangement relative to the user's head.

In the above-described examples, the visual indicator (in the form of LEDs) is either in an 'off-state', i.e. when the received impacts have not exceeded the threshold, or an 'on-state', i.e. when a received impact exceeds the threshold. In different examples, however, the visual indicator may activate (light up) in a gradual manner. For instance,

the level of luminosity of the visual indicator may indicate the number of impacts over a certain threshold that the player has received, where a greater luminosity means a greater number of high impacts.

CLAIMS

1. Impact detection arrangement for coupling to sports headwear to be worn by a user, the arrangement comprising:

a sensor configured to detect an indication of an acceleration change experienced by the user's head when the sports headwear is being worn; and,

a visual indicator configured to provide a visual indication when the detected acceleration change exceeds a threshold.

2. Impact detection arrangement according to Claim 1, wherein the sensor comprises an accelerometer.

3. Impact detection arrangement according to any previous claim, wherein the visual indicator comprises a light indicator.

4. Impact detection arrangement according to Claim 3, wherein the light indicator comprises one or more LEDs.

5. Impact detection arrangement according to any previous claim, wherein the sensor is positioned on a first substrate and the visual indicator is positioned on a second substrate separate from the first substrate.

6. Impact detection arrangement according to any previous claim, wherein the visual indicator is arranged atop the sensor.

7. Impact detection arrangement according to any previous claim, wherein the threshold is user-adjustable.

8. Impact detection arrangement according to any previous claim, wherein the threshold is a first threshold greater than a second threshold, and wherein the visual indicator is configured to provide the visual indication when the detected acceleration change exceeds the second threshold a predetermined number of times greater than one.

9. Impact detection arrangement according to any previous claim, the arrangement comprising a housing arranged to house the sensor and the visual indicator.

10. Impact detection arrangement according to Claim 9, wherein the housing is formed from a flexible material.

11. Impact detection arrangement according to Claim 9 or Claim 10, wherein at least part of the housing is formed from a transparent material.

12. Impact detection arrangement according to any of Claims 9 to 11, wherein the housing is formed from thermoplastic polyurethane.

13. Impact detection arrangement according to any of Claims 9 to 12, wherein the housing is generally elongate.

14. Impact detection arrangement according to any of Claims 9 to 13, wherein the housing is shaped to conform to a curvature of the user's head.

15. Impact detection arrangement according to any of Claims 9 to 14, wherein the housing comprises a first housing part arranged to house the sensor and a second housing part configured to house the visual indicator.

16. Impact detection arrangement according to Claim 15, wherein the arrangement comprises a locking mechanism arranged to connect the first and second housing parts together.

17. Impact detection arrangement according to any of Claims 9 to 12, wherein the housing is generally circular.

18. Impact detection arrangement according to any previous claim, wherein the sensor is configured to receive data indicative of the acceleration change experienced by the user's head, and wherein the arrangement comprises a wireless transmitter configured to transmit the received acceleration data off-board the arrangement, optionally wherein the acceleration data is transmitted to a mobile device.

19. Sports headwear, comprising: a main body arranged to receive a user's head; and, a pocket coupled to the main body and arranged to receive the impact detection arrangement of any previous claim, so as to couple the impact detection arrangement to the sports headwear.

20. Sports headwear according to Claim 19, wherein the pocket is positioned at rear side of the sports headwear, optionally wherein the pocket is positioned at a central part of the main body of the head guard.

21. Sports headwear according to Claim 19 or Claim 20, wherein the pocket is in the form of a fabric sleeve.

22. Sports headwear according to any of Claims 19 to 21, wherein the pocket is integrally formed with the main body.

23. Sports headwear according to any of Claims 19 to 22, wherein the sports headwear is a rugby head guard.

24. Apparatus for sports impact detection, the apparatus comprising:

the impact detection arrangement of any of Claims 1 to 18; and,

the sports headwear of any of Claims 19 to 23,

wherein the sports headwear is arranged to be worn on a user's head and the impact detection arrangement is arranged to be coupled to the sports headwear to detect acceleration change experienced by the user's head upon the user receiving an impact.

25. An impact detection method, comprising:

providing an impact detection arrangement for coupling to sports headwear to be worn by a user, the arrangement having a sensor and a visual indicator;

detecting, using the sensor, an indication of an acceleration change experienced by the user's head when the sports headwear is being worn; and,

providing a visual indication using the visual indicator when the detected acceleration change exceeds a threshold.

Intellectual Property Office

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Claims searched:	1-18, 24, 25	**Date of search:**	25 October 2019

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-18, 24, 25	US 2015/196252 A1 (IULIANO & WALKER) See figures 1-9 and paragraphs [0042] to [0045] and [0054] to [0059].
X	1-18, 24, 25	US 2015/109129 A1 (MERRIL et al.) See figures 1, 2 and 5 and paragraphs [0026] to [0032].
X	1-18, 24, 25	US 2012/124720 A1 (EVANS & CIRCO) See figures 1-3 and paragraphs [0039] and [0044].
X	1-18, 24, 25	US 2006/038694 A1 (NAUNHEIM et al.) See figures 1-5 and paragraphs [0021] to [0031].
X	1-18, 24, 25	US 8556831 B (FABER & ARJOMAND) See figures 1-3, column 8, lines 48-67, column 9, lines 26-32 and column 10, lines 18-60.
X	1-18, 24, 25	US 9775396 B (OLIVARES) See figures 1-3 and 45, column 5, lines 24-27, column 23, line 48 to column 24, line 24 and column 25, lines 39-56.
X	1-4, 7-14, 17, 18, 24, 25	US 2011/219852 A1 (KASTEN) See all figures and paragraphs [0022], [0026] and [0032].

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

A42B; A63B

The following online and other databases have been used in the preparation of this search report

Intellectual Property Office

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
A42B	0003/04	01/01/2006
A41D	0013/00	01/01/2006
A63B	0071/10	01/01/2006
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