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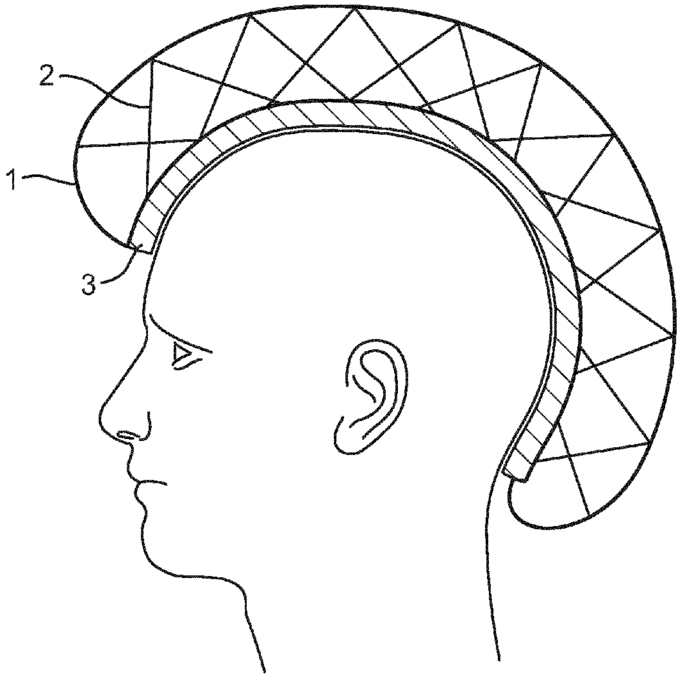
(54) **Title**: HELMET

Fig. 2



(57) **Abstract**: A helmet (10) comprising: an airbag (1) having an airbag wall surrounding an internal cavity; and one or more tensional reinforcements (2) extending through the internal cavity between different points on the airbag wall.

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HELMET

The present invention relates helmets. In particular, the invention relates to the provision of a helmet with an airbag that has reinforcements.

Helmets are known for use in various activities. These activities include combat and industrial purposes, such as protective helmets for soldiers and hard-hats or helmets used by builders, mine-workers, or operators of industrial machinery for example. Helmets are also common in sporting activities. For example, protective helmets are used in ice hockey, cycling, motorcycling, motor-car racing, skiing, snow-boarding, skating, skateboarding, equestrian activities, American football, baseball, rugby, cricket, lacrosse, climbing, airsoft and paintballing.

Helmets can be of fixed size or adjustable, to fit different sizes and shapes of head. In some types of helmet, e.g. commonly in ice-hockey helmets, the adjustability can be provided by moving parts of the helmet to change the outer and inner dimensions of the helmet. This can be achieved by having a helmet with two or more parts which can move with respect to each other. In other cases, e.g. commonly in cycling helmets, the helmet is provided with an attachment device for fixing the helmet to the user’s head, and it is the attachment device that can vary in dimension to fit the user’s head whilst the main body or shell of the helmet remains the same size. Combinations of these adjustment mechanisms are also possible.

Helmets are often made of an outer shell, that is usually hard and made of a plastic or a composite material, and an energy absorbing layer called a liner. Nowadays, a protective helmet has to be designed so as to satisfy certain legal requirements which relate to inter alia the maximum acceleration that may occur in the centre of gravity of the brain at a specified load. Typically, tests are performed, in which what is known as a dummy skull equipped with a helmet is subjected to a radial blow towards the head. This has resulted in modem helmets having good energy- absorption capacity in the case of blows radially against the skull. Progress has also been made (e.g. WO 2001/045526 and WO 2011/139224) in developing helmets to lessen the energy transmitted from oblique blows (i.e. which combine both tangential and radial components), by absorbing or dissipating rotation energy.

Such oblique impacts (in the absence of protection) result in both translational acceleration and angular acceleration of the brain. Angular acceleration causes the brain to rotate within the skull creating injuries on bodily elements connecting the brain to the skull and also to the brain itself.

Examples of rotational injuries include subdural haematomas (SDH), bleeding as a consequence of blood vessels rapturing, and diffuse axonal injuries (DAI), which can be summarized as nerve fibres being over stretched as a consequence of high shear deformations in the brain tissue.

Depending on the characteristics of the rotational force, such as the duration, amplitude and rate of increase, either SDH, DAI or a combination of these injuries can be suffered. Generally speaking, SDH occur in the case of accelerations of short duration and great amplitude, while DAI occur in the case of longer and more widespread acceleration loads.

It has also been suggested to incorporate an airbag element into helmets. In this context, and the context of this document more generally, the term 'airbag' is not used restrictively to be literally limited to a bag filled with air. Rather, as in the automotive industry, the term is used to refer to an inflated or inflatable 'cushion', provided to protect a user in the event of an impact. For example, US 6,418,564 discusses the possibility of providing an inflatable collar around the lower perimeter of a helmet.

However, the prior art devices do not consider the affect of airbags on oblique impacts. The present invention aims to at least partially address this problem.

The invention is described below by way of non-limiting examples, with reference to the accompanying drawings, in which:

Fig.1 is a diagram of a user wearing an airbag-equipped helmet, wherein the airbag being of the dynamic type and uninflated;

Fig. 2 is a diagram of the user and helmet as in Fig. 1, but wherein the airbag is inflated;

Fig. 3 is a diagram of an inflated airbag, such as that of Fig. 2, undergoing an angled impact;

Fig. 4 is a diagram of a user wearing an airbag-equipped helmet, wherein the airbag is of a pre-inflated variety;

Fig. 5A shows a plan view of the top of an airbag which is formed by coiling a tube-shaped compartment;

Fig. 5B shows an airbag comprising individual compartments separated by walls or membranes.

The present invention aims to provide an airbag-equipped helmet that provides increased protection when the helmet undergoes angled impact. By providing an airbag that has internal reinforcements, the airbag can be optimised to reduce the rotational forces that would otherwise be transmitted to the head during an impact. Therefore, such a reinforced or armoured airbag can provide increased protection against injury for a user wherein the airbag equipped helmet.

Figure 1 depicts a cross-section of an airbag-equipped helmet 10 being worn by a user 20. The helmet 10 may be of any type previously mentioned, but in particularly preferred embodiments may be a bicycle or motorcycle helmet.

The airbag 1 of the helmet 10 is not particularly limited in type. In particular, the term “airbag” is not intended to be interpreted to be limited solely to bags filled with air. Rather, as in the automotive sector, it is intended to refer to devices of the type which are inflated or inflatable to provide a cushion when a user undergoes an impact. As such, the airbag 1 may be filled by any suitable gas, which may or may not include air, or even a liquid if appropriate. In particular embodiments, the airbag 1 may be filled, or be designed to be filled predominantly with nitrogen.

Further, the airbag 1 may not be a single compartment or “bag”, but may be formed of several interlinking or connected compartments. Alternatively, the airbag 1 may be formed by a single compartment but arranged in a folded or contorted configuration. For example, Fig. 5A shows a plan view of the top of an airbag 1 which is formed by coiling a tube-shaped compartment. Fig. 5B shows an airbag 1 comprising individual compartments 51 separated by walls or membranes 50 (shown in the Figure, but internal to the airbag 1 in practice). The compartments 51 can be interlinked, as shown, via openings 52 in the walls 50.

The material used to create the wall of the airbag 1 is not particularly limited. Any suitable material can be used. For example, the airbag wall can be made from nylon fabric. The fabric can be provided with any suitable coatings or treatments. For example silicone or urethane coatings can provide heat resistance

The airbag 1 shown in Fig. 1 is a “dynamic” airbag, meaning that the airbag 1 is uninflated until it is required – i.e. it is only deployed to its ‘active’ state to provide protection in the event of an impact. As such, the helmet 10 is provided with a generator device 4, for generating the gas to inflate the airbag 1 when required. The gas generator 4 typically comprises chemicals that can be mixed together to rapidly produce large amounts of the required gas, when triggered. Alternatively, the gas generator 4 could be a compressed gas cylinder, or any other suitable device for releasing gas to quickly to inflate the airbag 1 when the user 20 is undergoing an impact.

The generator 4 may also comprise a controller for detecting an imminent impact. Such an arrangement is convenient, as the controller triggers the release of the gas by the generator 4. However, the controller can be positioned at any desired location on the helmet 10. The controller can be any type of device that can detect an imminent impact and trigger the generator 4 accordingly. For example, the controller can comprise an accelerometer to detect sudden changes in the acceleration of a user’s head, which are indicative of an impact or imminent impact. In a preferred embodiment, the accelerometer is a microelectromechanical systems (MEMS) accelerometer.

Although the preceding discussion has focussed on the airbag 1 element of the helmet 10, the helmet 10 may also comprise other protective elements (although, in some embodiments, the airbag 1 may be provided as the sole protective element). In the example shown in Fig. 1, the helmet 10 is provided with a further protective layer 3, which could help to reduce some or all of the radial force in an impact. Such a layer could be made of foam material like expanded polystyrene (EPS), expanded polypropylene (EPP), polyurethane (PU) or strain rate sensitive foams such as marketed under the brand-names Poron™ and D3O™. Alternatively the layer could be of the hard shell variety, made of any suitable hard polymer material such as polycarbonate (PC), polyvinylchloride (PVC) or acrylonitrile butadiene styrene (ABS) for example. The protective layer 3 could be part of the airbag 1 (i.e. the inner surface), or could be a separate layer that is attached to the airbag 1.

In some arrangements, the protective layer 3 can comprise two or more layers. In particular, the protective layer 3 may incorporate a sliding layer for allowing rotation between other layers in protective layer 3, or between layer 3 and the user’s head, or between layer 3 and the airbag 1. Such a sliding facilitator may be provided as a discrete layer of a low friction material, for example. Alternatively, the sliding facilitator may be present as a low friction surface treatment on the surface of another layer in the protective layer 3 or on the airbag 1. Such sliding facilitators are known from e.g. WO 2001/045526 and WO 2011/139224, which are herein incorporated by reference in their entirety.

Fig. 2 shows the helmet of Fig. 1 after the airbag 1 has been inflated. As such, it is more readily observed in Fig. 2 that the internal cavity of the airbag 1 is provided with reinforcements 2. The reinforcements 2 extend through the internal cavity of the airbag 1. The reinforcement 2 extend between different points on the airbag wall. Those points are predominantly on opposite sides of the internal cavity when the airbag 1 is inflated. At least some of the reinforcements 2 are held in tension when the airbag 1 is inflated (and there is no external impact force acting on the helmet).

In Fig. 2 the reinforcements 2 are shown as a network or web of fibres or threads. However, the nature of the reinforcements 2 is not particularly limited. The reinforcements 2 could be provided, for example, as membranes, beams or tubes extending between points within the airbag cavity.

The reinforcements 2 are arranged to reduce the rotational energy that would otherwise be transmitted to the head in the event of an impact on the helmet 10. This is achieved by the reinforcements 2 controlling the way in which the outer surface of the airbag 1 deforms during an impact. In particular, the outer surface of the airbag 1 is controlled to deform in such a way that the rotational energy that would otherwise be transmitted to the head of the user 20 is minimised. This can be achieved, for example, by the reinforcements 2 controlling the outer surface of the airbag 1 to deform in a particular way and provide a particular shape to the outer surface of the airbag 1. Put another way, the reinforcements 2 can limit the way in which the airbag 1 deforms so that the airbag takes a shape during impact other than that which would be taken in the absence of the reinforcements 2. By adjusting the shape, e.g. to be substantially flat in the region of impact, the motion of the head of the user 20 with respect to the impact location can be encouraged to be translational rather than rotational. As a result, the rotational acceleration experienced by the head of the user 20 is reduced.

For example, in Figure 3, the airbag 1 is shown undergoing a tangential/angled impact. Following the impact, some of the reinforcements 2' remain in tension due to their arrangement within the cavity of the airbag, and may even undergo some stretch. Other reinforcements 2'' do not remain in tension, and become flaccid or floppy. The combination of the reinforcements 2' in tension and reinforcements 2'' not in tension, control the shape of the outer surface of the airbag 1. In the example of Fig. 3, and as discussed above, the outer surface of the airbag becomes substantially flat, allowing for a greater possibility that the user's head slides with respect to the object being impacted upon, as opposed to undergoing sudden angular acceleration. As such, the rotational energy transmitted to the user's head is reduced.

The reinforcements 2 may also absorb some compression forces. As such, the arrangement of the reinforcements 2 may be optimised to also provide an element of impact protection as well as reducing the likelihood of brain injuries via a reduction in the transmission of rotation energy. That is, even if the airbag 1 is involved in an impact so fast that the airbag 1 is bottomed out, the reinforcements 2 can provide some additional protection.

To assist in increasing the likelihood of sliding during an impact, the outer surface of the airbag 1 can comprise or be treated with a low friction material, for example. Alternatively, the material of the airbag 1 itself can be a low friction material.

Fig. 4 depicts an alternative embodiment of an airbag-equipped helmet 10 being worn by a user 20.

In this embodiment, the helmet 10 is provided with an airbag 1, comprising reinforcements 2, and optional further protective layers 3 (arranged between the airbag and the user's head) as previously discussed. However, in this arrangement the airbag is a "constant" or "pre-inflated" airbag. That is, the airbag is not provided with any triggering and/or inflation mechanism. The airbag is simply inflated before the user equips the helmet, and remains inflated whether or not the user is involved in an impact.

As a result, the outer surface of the airbag can further comprise an additional protective layer 5. Protective outer layer 5 can be of the hard shell variety, or could comprise further materials such as compressive foams to provide impact protection. The outer protective layer 5 may be a single continuous layer, or may comprise separate zones or cells which are individually attached to the airbag 1. In any case, the outer layer 5 still permits the deformation of the airbag 1 in the case of an impact (i.e. through being relatively weak, or by being provided with suitable articulation to allow parts of the layer 5 to move with respect to other parts).

An advantage of providing a constant or pre-filled airbag 1 is that the helmet 10 is simpler to manufacture, and less likely to fail through technological malfunction. Further, if the airbag 1 does fail, it will be immediately noticed by the user. However, in some activities, the increased size of a constant or pre-filled airbag helmet 10 may be detrimental to the user's ability to participate in the relevant activity due to the increased size of the helmet. As such, in those activities, a dynamic airbag may be more appropriate.

The provision of the outer protective layer 5 also provides an advantage in terms of protecting the airbag from puncture. Such an advantage can also be obtained by providing an outer layer on a dynamic airbag helmet such as shown in Figs. 1-3, without inhibiting the ability of the airbag 1 to deploy (e.g. because the layer either breaks apart or divides into smaller parts in a predefined way when the airbag 1 is activated). In either case (i.e. for either a dynamic or constant airbag 1), having an airbag exposed as the outermost layer of the helmet runs the risk of the material of the outer wall of the airbag 1 being damaged by the surroundings. For example, for a cycling helmet, the helmet 10 may be scratched by thorns or twigs when cycling through/near foliage. Such damage may not be enough to cause deployment of a dynamic airbag 1, but could prevent the airbag 1 from operating correctly in the future (e.g. by puncturing the material of the airbag 1). As such, an outer protective layer 5 mitigates against the risk of such damage, allowing the airbag 1 to operate as intended in the event of an impact.

The outer protective layer 5 may also be provided with a sliding facilitator so that the protective layer 5 can slide with respect to the outside of the airbag 1. Where the layer 5 is provided as separate pieces or cells, each piece or cell may be provided with its own sliding facilitator.

The above description is by way of example only. The skilled reader will appreciate that other embodiments are possible and covered by the attached claims.

CLAIMS

1. A helmet comprising:
   an airbag having an airbag wall surrounding an internal cavity; and
   one or more tensional reinforcements extending through the internal cavity between different points on the airbag wall.

2. A helmet according to claim 1, wherein the tensional reinforcements are arranged to reduce the rotational energy that would otherwise be transmitted to the head in the event of an impact.

3. A helmet according to claim 1 or claim 2, wherein the airbag is pre-inflated.

4. A helmet according to claim 3, further comprising an outer shell, provided radially outward of the airbag.

5. A helmet according to claim 1 or claim 2, wherein the airbag is a dynamic airbag that inflates in the event of an impact.

6. A helmet according to claim 5, further comprising a pressurised gas canister or gas generator for providing gas to the internal cavity in the event of an impact.

7. A helmet according to claim 6, further comprising a controller for detecting an impact or imminent impact and instigating the provision of gas from the pressurised gas canister or gas generator to the internal cavity.

8. A helmet according to claim 6, wherein the controller comprises an accelerometer, preferably a microelectromechanical systems (MEMS) accelerometer, to detect an impact or imminent impact.

9. A helmet according to any one of the preceding claims, further comprising an inner shell provided radially inwards of the airbag.

10. A helmet according to claim 9, wherein the inner shell is a hard shell, or is made from a foam material, optionally EPP or EPS, for absorbing some or all of the compressive force in an impact.

11. A helmet according to any one of the preceding claims, further comprising a sliding facilitator provided between the inner shell and the airbag, to facilitate rotation between the airbag and the inner shell in the event of an oblique impact on the helmet.

12. A helmet according to any one of the preceding claims, wherein the tensional reinforcements are flexible or stiff.

13. A helmet according to any one of the preceding claims, wherein the tensional reinforcements are threads, membranes, beams or tubes.

14. A helmet according to any one of the preceding claims, wherein the outermost airbag wall comprises a material, or is treated, for facilitating sliding of the airbag with respect to an object being impacted upon.

15. A helmet according to any one of the preceding claims, wherein, in the event of an impact, the arrangement of the tensional reinforcements reduces the rotational energy that would otherwise be transmitted to the head of a wearer of the helmet, but allows for local compression of the airbag in the region impacted upon.

Fig. 1

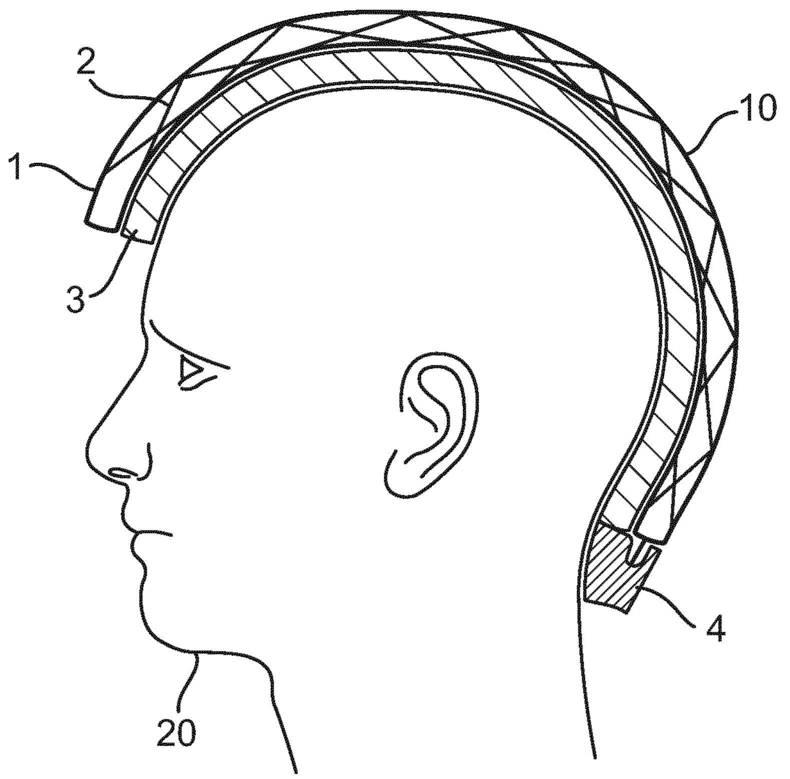

Fig. 2

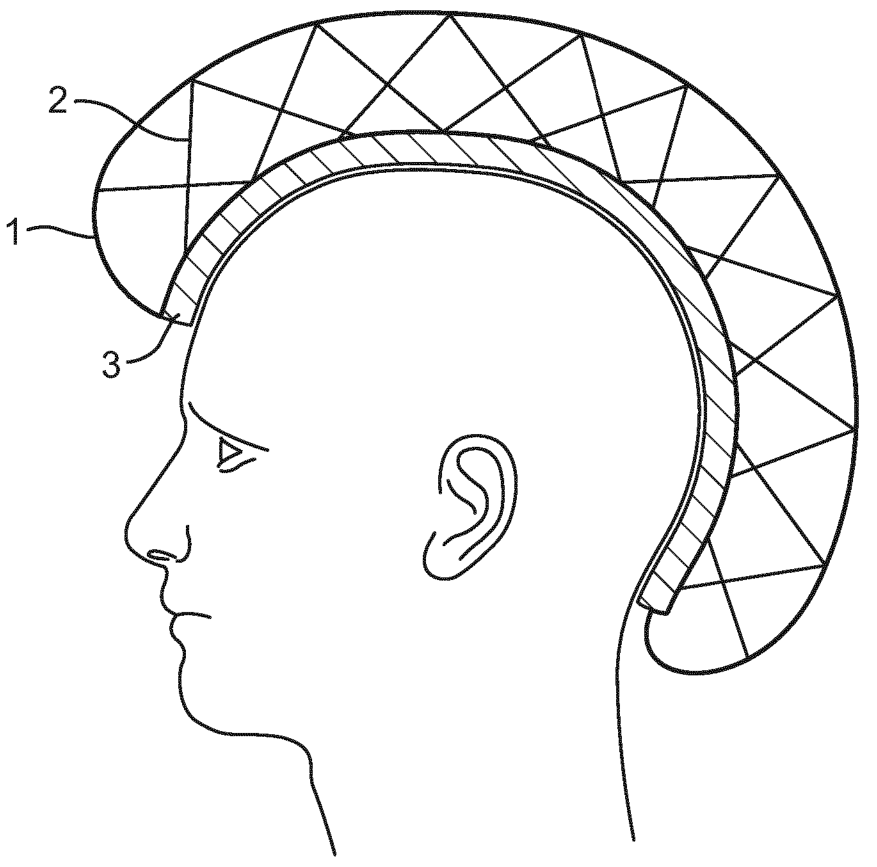

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Fig. 3

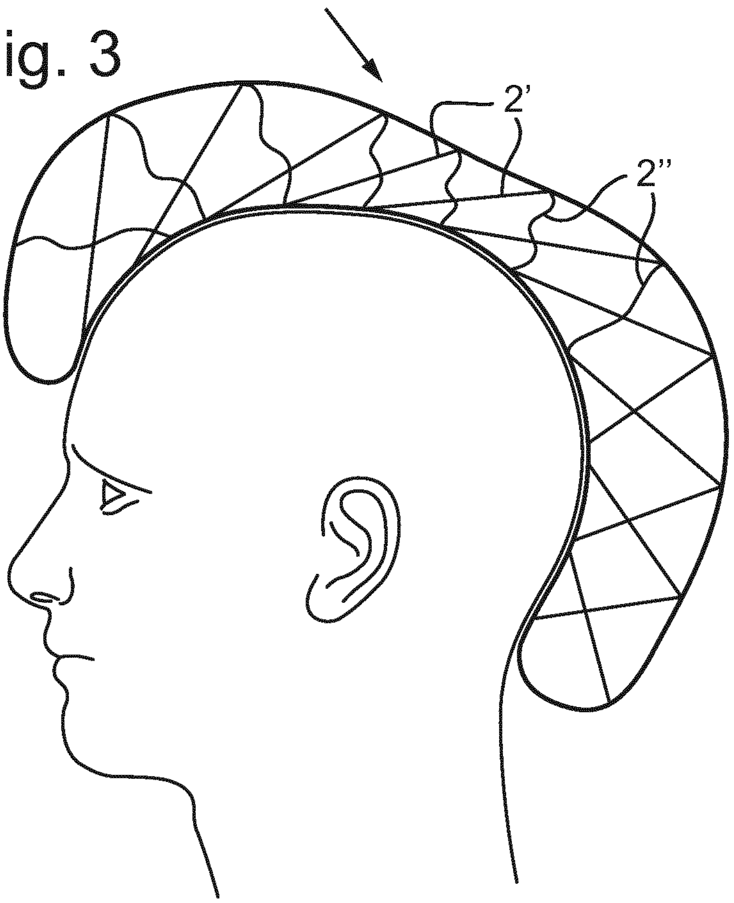


Fig. 4

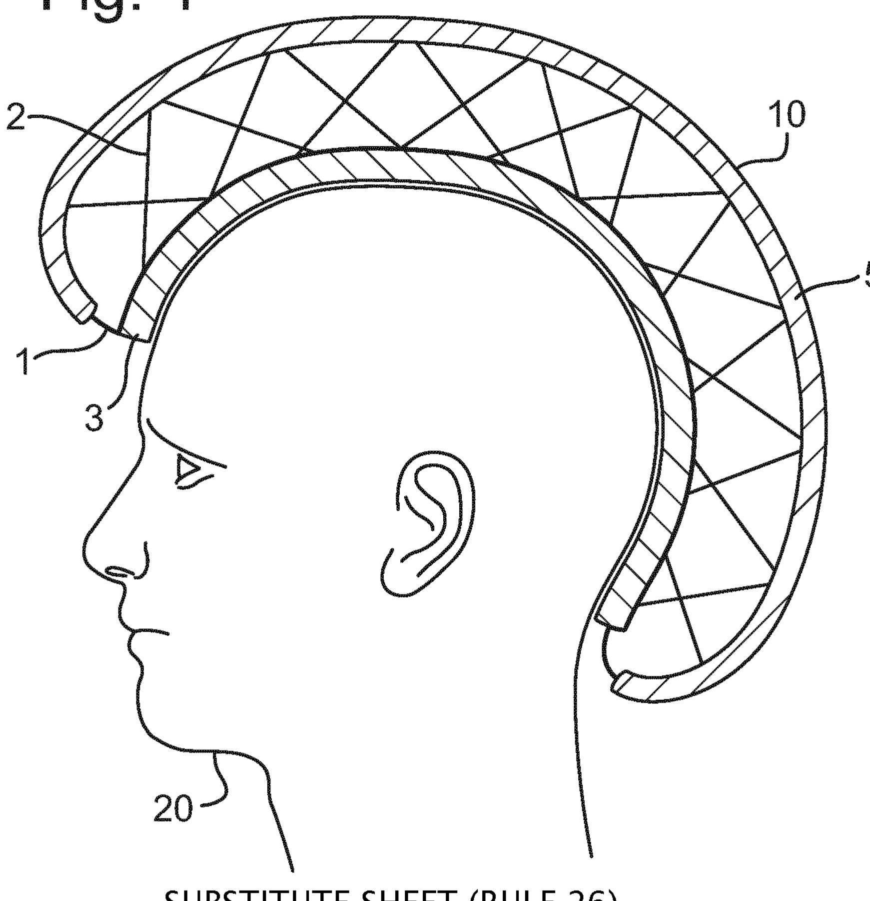


Fig. 5a

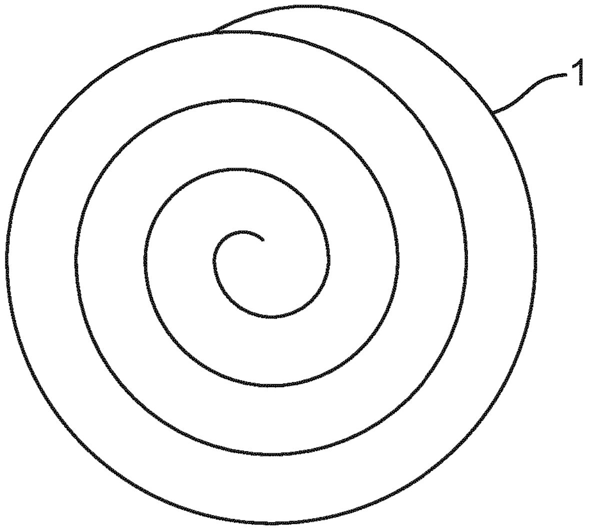
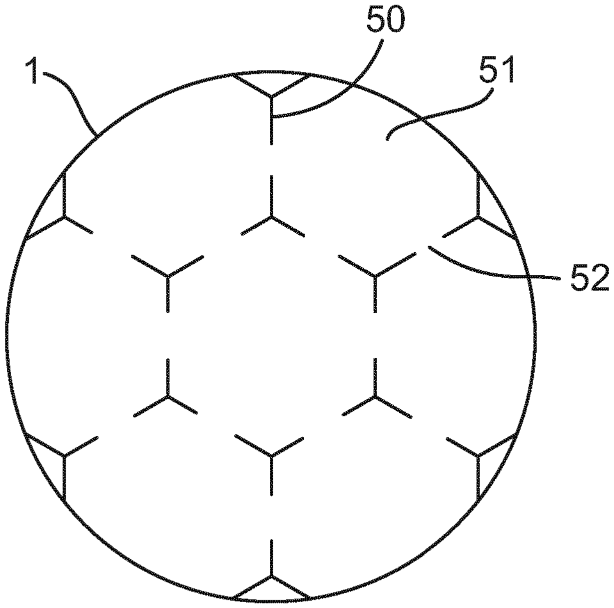


Fig. 5b



INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. A42B3/04 A42B3/06 A42B3/12
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 A41D

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 8 046 845 B1 (GARCIA FELIPE [US] ET AL) 1 November 2011 (2011-11-01)	1-4,9, 10,12, 13,15
Y	column 2, line 44 - column 5, line 45; figures 1,5a,5b,6	11,14
X	DE 89 11 519 U1 (PREUSS, NORBERT) 4 January 1990 (1990-01-04) paragraphs [0004] - [0006]; figures 1-3	1,2, 4-10,12, 13,15
X	EP 2 329 732 A2 (DAINESE SPA [IT]) 8 June 2011 (2011-06-08) paragraphs [0043], [0070] - [0078]; figure 5	1,3,12, 13

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/065418

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 01/45526 A1 (VON HOLST HANS [SE]; HALLDIN PETER [SE]) 28 June 2001 (2001-06-28) cited in the application	11
A	page 4, line 10 - page 6, line 16; figures 1,3	1

Y	US 2015/164174 A1 (WEST J STEPHEN [US]) 18 June 2015 (2015-06-18)	14
A	paragraphs [0026] - [0030], [0034], [0036]; figure 3	1

A	FR 2 773 676 A1 (RUDOLF PIERRE [FR]) 23 July 1999 (1999-07-23) pages 7-10; figures 2,3	1,4-8

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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