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(56) References cited:

WO-A1-2020/078913 US-A1- 2011 167 532
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Description

[0001] The present invention relates to connectors between two parts of an apparatus. In particular the present invention relates to an apparatus, such as a helmet, that may include a sliding interface between two components.

[0002] 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 may be used in ice hockey, cycling, motorcycling, motor-car racing, skiing, snowboarding, skating, skateboarding, equestrian activities, American football, baseball, rugby, soccer, cricket, lacrosse, climbing, golf, airsoft, roller derby and paintballing.

[0003] 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 head mount for fixing the helmet to the user's head, and it is the head mount that can vary in dimension to fit the user's head whilst the main body or shell of the helmet remains the same size. In some cases, comfort padding within the helmet can act as the head mount. The head mount can also be provided in the form of a plurality of physically separate parts, for example a plurality of comfort pads which are not interconnected with each other. Such head mounts for seating the helmet on a user's head may be used together with additional strapping (such as a chin strap) to further secure the helmet in place. Combinations of these adjustment mechanisms are also possible.

[0004] 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. In other arrangements, such as a rugby scrum cap, a helmet may have no hard outer shell, and the helmet as a whole may be flexible. In any case, 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 modern 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 201 /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 and/or redirecting it into translational energy rather than rotational energy.

[0005] 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.

[0006] Examples of rotational injuries include Mild Traumatic Brain Injuries (MTBI) such as concussion, and Severe Traumatic Brain Injuries (STBI) such as subdural haematomas (SDH), bleeding as a consequence of blood vessels rupturing, 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.

[0007] Depending on the characteristics of the rotational force, such as the duration, amplitude and rate of increase, either concussion, 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.

[0008] In helmets such as those disclosed in WO 2001/045526 and WO 2011/139224 that may reduce the rotational energy transmitted to the brain caused by oblique impacts, two parts of the helmet may be configured to slide relative to each other following an oblique impact. Connectors may be provided that, whilst connecting the parts of a helmet together, permit movement of the parts relative to each other under an impact.

[0009] WO 2020/078913 A1 discloses a pad for mounting to a helmet comprising layers of textile, cloth, fabric or felt and a low friction interface between layers.

[0010] In order to provide such a helmet, it may be desirable to provide two components that can slide relative to each other, providing a sliding interface. It may also be desirable to be able to provide such a sliding interface without substantially increasing the manufacturing costs and/or effort.

[0011] The invention is defined by the appended claims.

[0012] The invention is described in detail below, with reference to the accompanying figures, in which:

Fig1 depicts a cross-section through a helmet for providing protection against oblique impacts;

Fig 2 is a diagram showing the functioning principle of the helmet of Fig 1;

Figs 3A, 3B & 3C show variations of the structure of the helmet of Fig 1;

Figs 4 and 5 schematically depict another arrangement of a helmet;

Figs 6 to 9 schematically depict further arrangements of helmets;

Fig 10 schematically depicts another arrangement of a helmet;

Fig. 11 schematically depicts another arrangement of a helmet;

Fig. 12 schematically depicts another arrangement of a helmet;

Fig. 13 shows an example helmet including an example connector;

Fig. 14 shows a schematic cross-sectional view of an example connector;

Fig. 15 shows a schematic perspective view of the example connector;

Fig. 16 shows an example of a fabric material for constructing the example connector.

[0013] The proportions of the thicknesses of the various layers in the helmets depicted in the figures have been exaggerated in the drawings for the sake of clarity and can of course be adapted according to need and requirements.

[0014] Fig 1 depicts a first helmet 1 of the sort discussed in WO 01/45526, intended for providing protection against oblique impacts, and which does not form part of the claimed invention.

[0015] Protective helmet 1 is constructed with an outer shell 2 and, arranged inside the outer shell 2, an inner shell 3 that is intended for contact with the head of the wearer.

[0016] Arranged between the outer shell 2 and the inner shell 3 is a sliding layer 4 (also called a sliding facilitator or low friction layer), which may enable displacement between the outer shell 2 and the inner shell 3. In particular, as discussed below, a sliding layer 4 or sliding facilitator may be configured such that sliding may occur between two parts during an impact. For example, it may be configured to enable sliding under forces associated with an impact on the helmet 1 that is expected to be survivable for the wearer of the helmet 1. In some arrangements, it may be desirable to configure the sliding layer 4 such that the coefficient of friction is between 0.001 and 0.3 and/or below 0.15.

[0017] Arranged in the edge portion of the helmet 1, in the Fig 1 depiction, may be one or more connecting members 5 which interconnect the outer shell 2 and the inner shell 3. In some arrangements, the connectors may counteract mutual displacement between the outer shell 2 and the inner shell 3 by absorbing energy. However, this is not essential. Further, even where this feature is present, the amount of energy absorbed is usually minimal in comparison to the energy absorbed by the inner shell 3 during an impact. In other arrangements, connecting members 5 may not be present at all.

[0018] Further, the location of these connecting members 5 can be varied (for example, being positioned away from the edge portion, and connecting the outer shell 2 and the inner shell 3 through the sliding layer 4).

[0019] The outer shell 2 is preferably relatively thin and strong so as to withstand impact of various types. The outer shell 2 could be made of a polymer material such as polycarbonate (PC), polyvinylchloride (PVC) or acryloni-

trile butadiene styrene (ABS) for example. Advantageously, the polymer material can be fibre-reinforced, using materials such as glass-fibre, Aramid, Twaron, carbon-fibre or Kevlar.

[0020] The inner shell 3 is considerably thicker and acts as an energy absorbing layer. As such, it is capable of damping or absorbing impacts against the head. It can advantageously be made of foam material like expanded polystyrene (EPS), expanded polypropylene (EPP), expanded polyurethane (EPU), vinyl nitrile foam; or other materials forming a honeycomb-like structure, for example; or strain rate sensitive foams such as marketed under the brand-names Poron™ and D30™. The construction can be varied in different ways, which emerge below, with, for example, a number of layers of different materials.

[0021] Inner shell 3 is designed for absorbing the energy of an impact. Other elements of the helmet 1 will absorb that energy to a limited extent (e.g. the hard outer shell 2 or so-called 'comfort padding' provided within the inner shell 3), but that is not their primary purpose and their contribution to the energy absorption is minimal compared to the energy absorption of the inner shell 3. Indeed, although some other elements such as comfort padding may be made of 'compressible' materials, and as such considered as 'energy absorbing' in other contexts, it is well recognised in the field of helmets that compressible materials are not necessarily 'energy absorbing' in the sense of absorbing a meaningful amount of energy during an impact, for the purposes of reducing the harm to the wearer of the helmet.

[0022] A number of different materials and embodiments can be used as the sliding layer 4 or sliding facilitator, for example oil, Teflon™, microspheres, air, rubber, polycarbonate (PC), a fabric material such as felt, etc. Such a layer may have a thickness of roughly 0.1-5 mm, but other thicknesses can also be used, depending on the material selected and the performance desired. The number of sliding layers and their positioning can also be varied, and an example of this is discussed below (with reference to Fig 3b).

[0023] As connecting members 5, use can be made of, for example, deformable strips of plastic or metal which are anchored in the outer shell and the inner shell in a suitable manner.

[0024] Fig 2 shows the functioning principle of protective helmet 1, in which the helmet 1 and a skull 10 of a wearer are assumed to be semi-cylindrical, with the skull 10 being mounted on a longitudinal axis 11. Torsional force and torque are transmitted to the skull 10 when the helmet 1 is subjected to an oblique impact K. The impact force K gives rise to both a tangential force K_T and a radial force K_R against the protective helmet 1. In this particular context, only the helmet-rotating tangential force K_T and its effect are of interest.

[0025] As can be seen, the force K gives rise to a displacement 12 of the outer shell 2 relative to the inner shell 3, the connecting members 5 being deformed. Sig-

nificant reductions in the torsional force transmitted to the skull 10 can be obtained with such an arrangement. A typical reduction may be roughly 25% but reductions as high as 90% may be possible in some instances. This is a result of the sliding motion between the inner shell 3 and the outer shell 2 reducing the amount of energy which is transferred into radial acceleration.

[0026] Sliding motion can also occur in the circumferential direction of the protective helmet 1, although this is not depicted. This can be as a consequence of circumferential angular rotation between the outer shell 2 and the inner shell 3 (i.e. during an impact the outer shell 2 can be rotated by a circumferential angle relative to the inner shell 3).

[0027] Other arrangements of the protective helmet 1 are also possible. A few possible variants are shown in Fig 3. In Fig 3a, the inner shell 3 is constructed from a relatively thin outer layer 3" and a relatively thick inner layer 3'. The outer layer 3" is preferably harder than the inner layer 3', to help facilitate the sliding with respect to outer shell 2. In Fig 3b, the inner shell 3 is constructed in the same manner as in Fig 3a. In this case, however, there are two sliding layers 4, between which there is an intermediate shell 6. The two sliding layers 4 can, if so desired, be embodied differently and made of different materials. One possibility, for example, is to have lower friction in the outer sliding layer than in the inner. In Fig 3c, the energy absorbing layer 3 is embodied differently from previously. In this case, the energy absorbing layer is divided into inner and outer parts 3' and 3" and a sliding layer 4 is provided between them. The inner part 3" may, for example, be the same material as the outer part 3'.

[0028] Fig 4 depicts a second helmet 1 of the sort discussed in WO 2011/139224, which is also intended for providing protection against oblique impacts, and which does not form part of the claimed invention.

[0029] In Fig 4, helmet 1 comprises an energy absorbing layer 3, similar to the inner shell 3 of the helmet of Fig 1. The outer surface of the energy absorbing layer 3 may be provided from the same material as the energy absorbing layer 3 (i.e. there may be no additional outer shell), or the outer surface could be a rigid shell 2 (see Fig 5) equivalent to the outer shell 2 of the helmet shown in Fig 1. In that case, the rigid shell 2 may be made from a different material than the energy absorbing layer 3. The helmet 1 of Fig 4 has a plurality of vents 7, which are optional, extending through both the energy absorbing layer 3 and the outer shell 2, thereby allowing airflow through the helmet 1.

[0030] Head mount 13 is provided configured to mount the helmet on (and/or attach helmet 1 to) a wearer's head. As previously discussed, this may be desirable when energy absorbing layer 3 and rigid shell 2 cannot be adjusted in size, as it allows for the different size heads to be accommodated by adjusting the size of the head mount 13. The head mount 13 could be made of an elastic or semi-elastic polymer material, such as PC, ABS, PVC or PTFE, Polyketone and Polypropylene, or a natural

fibre material such as cotton cloth. For example, a cap of textile or a net could form the head mount 13.

[0031] Although the head mount 13 is shown as comprising a headband portion with further strap portions extending from the front, back, left and right sides, the particular configuration of the head mount 13 can vary according to the configuration of the helmet. In some cases the head mount may be more like a continuous (shaped) sheet, perhaps with holes or gaps, e.g. corresponding to the positions of vents 7, to allow air-flow through the helmet.

[0032] Fig 4 also depicts an optional adjustment device 6 for adjusting the diameter of the head band of the head mount 13 for the particular wearer. In other arrangements, the head band could be an elastic head band in which case the adjustment device 6 could be excluded.

[0033] A sliding facilitator 4 is provided radially inwards of the energy absorbing layer 3. The sliding facilitator 4 is adapted to slide against the energy absorbing layer or against the head mount 13 that is provided for attaching the helmet to a wearer's head.

[0034] The sliding facilitator 4 is provided to assist sliding of the energy absorbing layer 3 in relation to an head mount 13, in the same manner as discussed above. The sliding facilitator 4 may be a material having a low coefficient of friction, or may be coated with such a material.

[0035] As such, in the Fig 4 helmet, the sliding facilitator 8 may be provided on or integrated with the innermost side of the energy absorbing layer 3, facing the head mount 13.

[0036] However, it is equally conceivable that the sliding facilitator 4 may be provided on or integrated with the outer surface of the head mount 13, for the same purpose of providing slidability between the energy absorbing layer 3 and the head mount 13. That is, in particular arrangements, the head mount 13 itself can be adapted to act as a sliding facilitator 4 and may comprise a low friction material.

[0037] In other words, the sliding facilitator 4 is provided radially inwards of the energy absorbing layer 3. The sliding facilitator can also be provided radially outwards of the head mount 13.

[0038] When the head mount 13 is formed as a cap or net (as discussed above), sliding facilitators 4 may be provided as patches of low friction material.

[0039] The low friction material may be a waxy polymer, such as PTFE, ABS, PVC, PC, Nylon, PFA, EEP, PE, UHMWPE, Polyketone and Polypropylene, or a powder material which could be infused with a lubricant. The low friction material could be a fabric material. As discussed, this low friction material could be applied to either one, or both of the sliding facilitator and the energy absorbing layer.

[0040] The head mount 13 can be fixed to the energy absorbing layer 3 and/ or the outer shell 2 by means of fixing members 5, such as the four fixing members 5a, 5b, 5c and 5d in Fig 4. These may be adapted to absorb

energy by deforming in an elastic, semi-elastic or plastic way. However, this is not essential. Further, even where this feature is present, the amount of energy absorbed is usually minimal in comparison to the energy absorbed by the energy absorbing layer 3 during an impact.

[0041] According to the arrangement shown in Fig 4 the four fixing members 5a, 5b, 5c and 5d are suspension members 5a, 5b, 5c, 5d, having first and second portions 8, 9, wherein the first portions 8 of the suspension members 5a, 5b, 5c, 5d are adapted to be fixed to the head mount 13, and the second portions 9 of the suspension members 5a, 5b, 5c, 5d are adapted to be fixed to the energy absorbing layer 3.

[0042] Fig 5 shows an arrangement of a helmet similar to the helmet in Fig 4, when placed on a wearer's head. The helmet 1 of Fig 5 comprises a hard outer shell 2 made from a different material than the energy absorbing layer 3. In contrast to Fig 4, in Fig 5 the head mount 13 is fixed to the energy absorbing layer 3 by means of two fixing members 5a, 5b, which are adapted to absorb energy and forces elastically, semi-elastically or plastically.

[0043] A frontal oblique impact I creating a rotational force to the helmet is shown in Fig 5. The oblique impact I causes the energy absorbing layer 3 to slide in relation to the head mount 13. The head mount 13 is fixed to the energy absorbing layer 3 by means of the fixing members 5a, 5b. Although only two such fixing members are shown, for the sake of clarity, in practice many such fixing members may be present. The fixing members 5 can absorb the rotational forces by deforming elastically or semi-elastically. In other arrangements, the deformation may be plastic, even resulting in the severing of one or more of the fixing members 5. In the case of plastic deformation, at least the fixing members 5 will need to be replaced after an impact. In some case a combination of plastic and elastic deformation in the fixing members 5 may occur, i.e. some fixing members 5 rupture, absorbing energy plastically, whilst other fixing members deform and absorb forces elastically.

[0044] In general, in the helmets of Fig 4 and Fig 5, during an impact the energy absorbing layer 3 acts as an impact absorber by compressing, in the same way as the inner shell of the Fig 1 helmet. If an outer shell 2 is used, it will help spread out the impact energy over the energy absorbing layer 3. The sliding facilitator 4 will also allow sliding between the head mount and the energy absorbing layer. This allows for a controlled way to dissipate energy that would otherwise be transmitted as rotational energy to the brain. The energy can be dissipated by friction heat, energy absorbing layer deformation or deformation or displacement of the fixing members. The reduced energy transmission results in reduced rotational acceleration affecting the brain, thus reducing the rotation of the brain within the skull. The risk of rotational injuries including MTBI and STBI such as subdural haematomas, SDH, blood vessel rupturing, concussions and DAI is thereby reduced.

[0045] Connectors, according to the claimed invention,

that may be used within a helmet are described below. It should be appreciated that these connectors may be used in a variety of contexts and are not to be limited to use within helmets. For example, they may be used in other devices that provide impact protection, such as body armour or padding for sports equipment. In the context of helmets, the connectors may, in particular, be used in place of the previously known connecting members and/or fixing members of the arrangements discussed above.

[0046] In an arrangement, the connector may be used with a helmet 1 of the type shown in Figure 6. The helmet shown in Figure 6 has a similar configuration to that discussed above in respect of Figures 4 and 5. In particular, the helmet has a relatively hard outer shell 2 and an energy absorbing layer 3. A head mount is provided in the form of a helmet liner 15. The liner 15 may include comfort padding as discussed above. In general, the liner 15 and/or any comfort padding may not absorb a significant proportion of the energy of an impact in comparison with the energy absorbed by the energy absorbing layer 3.

[0047] The liner 15 may be removable. This may enable the liner to be cleaned and/or may enable the provision of liners that are modified to fit a specific wearer.

[0048] Between the liner 15 and the energy absorbing layer 3, there is provided an inner shell 14 formed from a relatively hard material, namely a material that is harder than the energy absorbing layer 3. The inner shell 14 may be moulded to the energy absorbing layer 3 and may be made from any of the materials discussed above in connection with the formation of the outer shell 2. In alternative arrangements, the inner shell 14 may be formed from a fabric material, optionally coated with a low friction material.

[0049] In the arrangement of Figure 6, a low friction interface is provided between the inner shell 14 and the liner 15. This may be implemented by the appropriate selection of at least one of the material used to form the outer surface of the liner 15 or the material used to form the inner shell 14. Alternatively or additionally, a low friction coating may be applied to at least one of the opposing surfaces of the inner shell 14 and the liner 15. Alternatively or additionally, a lubricant may be applied to at least one of the opposing surfaces of the inner shell 14 and the liner 15.

[0050] As shown, the liner 15 may be connected to the remainder of the helmet 1 by way of one or more connectors 20, discussed in further detail below. Selection of the location of the connectors 20 and the number of connectors 20 to use may depend upon the configuration of the remainder of the helmet.

[0051] In an arrangement such as shown in Figure 6, at least one connector 20 may be connected to the inner shell 14. Alternatively or additionally, one or more of the connectors 20 may be connected to another part of the remainder of the helmet 1, such as the energy absorbing layer 3 and/or the outer shell 2. The connectors 20 may also be connected to two or more parts of the remainder

of the helmet 1.

[0052] Figure 7 depicts a further alternative arrangement of a helmet 1. As shown, the helmet 1 of this arrangement includes a plurality of independent sections of comfort padding 16. Each section of comfort padding 16 may be connected to the remainder of the helmet by one or more connectors 20.

[0053] The sections of comfort padding 16 may have a sliding interface provided between the sections of comfort padding 16 and the remainder of the helmet 1. In such an arrangement, the sections of comfort padding 16 may provide a similar function to that of the liner 15 of the arrangement shown in Figure 6. The options discussed above for provision of a sliding interface between a liner and a helmet also apply to the sliding interface between the sections of comfort padding and the helmet.

[0054] It should also be appreciated that the arrangement of Figure 7, namely the provision of a plurality of independently mounted sections of comfort padding 16 provided with a sliding interface between the sections of comfort padding 16 and the remainder of the helmet, may be combined with any form of helmet, including those such as depicted in Figures 1 to 5 that also have a sliding interface provided between two other parts of the helmet.

[0055] Figures 8 and 9 show equivalent arrangements to those of Figures 6 and 7, except that the inner shell 14 is applied to the liner 15 (in Fig 8) or comfort padding 16 (in Fig 9). In the case of Figure 9, the inner shell 14 may only be a partial shell or a plurality of sections of shell, as compared to the substantially full shell arrangements of Figures 6 to 8. Indeed, in both Figures 8 and 9 the inner shell 14 may also be characterised as a relatively hard coating on the liner 15 or comfort padding 16. As for Figures 6 and 7, the inner shell 14 is formed from a relatively hard material, namely a material that is harder than the energy absorbing layer 3. For example, the material could be PTFE, ABS, PVC, PC, Nylon, PFA, EEP, PE and UHMWPE. The material may be bonded to the outer side of the liner 15 or comfort padding 16 to simplify the manufacturing process. Such bonding could be through any means, such as by adhesive or by high frequency welding or stitching. In alternative arrangements, the inner shell 14 may be formed from a fabric material, optionally coated with a low friction material.

[0056] In Figures 8 and 9 a low friction interface is provided between the inner shell 14 and the energy absorbing layer 3. This may be implemented by the appropriate selection of at least one of the material used to form the outer surface of the energy absorbing layer 3 or the material used to form the inner shell 14. Alternatively or additionally, a low friction coating may be applied to at least one of the opposing surfaces of the inner shell 14 and the energy absorbing layer 3. Alternatively or additionally, a lubricant may be applied to at least one of the opposing surfaces of the inner shell 14 and the energy absorbing layer 3.

[0057] In Figures 8 and 9, at least one connector 20 may be connected to the inner shell 14. Alternatively or

additionally, one or more of the connectors 20 may be connected to another part of the remainder of the liner 15 or comfort padding 16.

[0058] In another arrangement, the connector may be used with a helmet 1 of the type shown in Figure 10. The helmet shown in Figure 10 has a similar configuration to that discussed above in respect of Figures 1, 2, 3A and 3B. In particular, the helmet has a relatively hard outer shell 2 and an energy absorbing layer 3 configured to slide relative to each other. At least one connector 20 may be connected to the outer shell 2 and the energy absorbing layer 3. Alternatively, the connector may be connected one or more intermediate sliding layers associated with one or both of the outer shell 2 and the energy absorbing layer 2, which provide low friction.

[0059] In yet another arrangement, the connector may be used with a helmet 1 of the type shown in Figure 11. The helmet shown in Figure 11 has a similar configuration to that discussed above in respect of Figure 3B. In particular, the helmet has a relatively hard outer shell 2 and an energy absorbing layer 3 which is divided into outer and inner parts 3A, 3B configured to slide relative to each other. At least one connector 20 may be connected to the outer and inner parts 3A, 3B of the energy absorbing layer 3. Alternatively, the connector may be connected one or more intermediate sliding layers associated with one or both of the outer and inner parts 3A, 3B of the energy absorbing layer 3, which provide low friction.

[0060] Figure 12 depicts yet another alternative arrangement of a helmet 1. In this arrangement, one or more outer plates 17 may be mounted to a helmet 1 having at least an energy absorbing layer 3 and a relatively hard layer 2 formed outward of the energy absorbing layer 2. It should be understood that such an arrangement of outer plates 17 may be added to any helmet according to any of the arrangements discussed above, namely having a sliding interface between at least two of the layers of the helmet 1.

[0061] The outer plates 17 may be mounted to the relatively hard layer 2 in a manner that provides a low friction interface between the outer surface of the relatively hard layer 2 and that least a part of a surface of the outer plate 17 that is in contact with the outer surface of the relatively hard layer 2, at least under an impact to the outer plate 17. In some arrangements, an intermediate low friction layer may be provided between the hard layer 2 and the plates 17.

[0062] In addition, the manner of mounting the outer plates 17 may be such that, under an impact to an outer plate 17, the outer plate 17 can slide across the relatively hard layer 2 (or intermediate low friction layer). Each outer plate 17 may be connected to the remainder of the helmet 1 by one or more connectors 20.

[0063] In such an arrangement, in the event of an impact on the helmet 1, it can be expected that the impact would be incident on one or a limited number of the outer plates 17. Therefore, by configuring the helmet such that

the one or more outer plates 17 can move relative to the relatively hard layer 2 and any outer plates 17 that have not been subject to an impact, the surface receiving the impact, namely one or a limited number of outer plates 17, can move relative to the remainder of the helmet 1. In the case of an oblique impact or a tangential impact, this may reduce the transfer of rotational forces to the remainder of the helmet. In turn, this may reduce the rotational acceleration imparted on the brain of a wearer of the helmet and/or reduce brain injuries.

[0064] Possible arrangements of connectors 20 will now be described. For convenience the connectors will generally be described as connecting an energy absorbing layer 3 of a helmet 1 to a head mount 15, as is shown in Fig. 13. The helmet 1 shown in Fig 13 is of the type shown in Fig. 8. However, it should be appreciated that the connector 20 may be used for connecting any two parts of an apparatus together, e.g. any of the layers described above. Furthermore, where below the connector 20 is described as having a first component connected to a first part of an apparatus and a second component connected to a second part of an apparatus it should be appreciated that, with suitable modifications, this may be reversed.

[0065] Fig. 14 is schematically show a cross-section through a connector 20 according to the disclosure. The layers of the helmet shown in Fig. 14 are separated so that they can be discerned more easily from the Figure. In reality these layers may contact each other, particularly where described below as being connected to each other. Figure 15 shows the same connector 20 from a different, perspective view. Accordingly, only one side of the connector 20 is fully visible in Fig. 15.

[0066] The connector 20 comprises first and second layers 21, 22. The first and second layers 21, 22 are arranged adjacent each other and configured to slide against each other at a sliding interface 25. Therefore, the connector is able to connect the energy absorbing layer 3 and head mount 4 of the helmet in Fig. 13 while allowing sliding between the energy absorbing layer and head mount. The connector 20 comprises a first connecting means 23 connected to the first layer 21 and configured to connect to the energy absorbing layer and a second connecting means 24 connected to the second layer 22 and configured to connect to the head mount. Accordingly, the first and second layers 21, 22 to allow the first and second connecting means 23, 24 to move relative to each other.

[0067] At least one of the first and second connecting means 23, 24 may comprise a hook-and-loop material, such as Velcro™. Where the first or second connecting means 23, 24 comprises a hook-and-loop material, the part of the helmet to which it is attached should comprises complementary hook-and-loop material. At least one of the first and second connecting means 23, 24 may comprise double-sided adhesive tape.

[0068] Preferably, the first connecting means configured to connect to the energy absorbing layer 3 comprises a hook-and-loop material and the second connect-

ing means configured to connect to the head mount 15 comprises double-sided adhesive tape. The hook-and-loop attachment provides a relatively non-permanent, detachable connection, whereas the double-sided tape provides a relatively permanent connection. The first and second layers 21, 22 may alternatively be attached to parts of the helmet by another method of non-permanent, detachable or permanent attachment.

[0069] As shown in Fig. 14, the first and second layers 21, 22 may be connected to each other at a region of the connector surrounding the sliding interface 25. Specifically, the first and second layers may be connected to each other at a peripheral region of the connector 20 and the sliding interface may be provided in a central region of the connector 20. Preferably the first and second connecting means 23, 24 are located opposite the sliding interface 25, i.e. in the central region. Most preferably, the first and second connecting means 23, 24 are located opposite a centre of the sliding interface as shown in Figs. 14 and 15.

[0070] The first and second layers 21, 22 may be connected by an adhesive layer, e.g. formed from a hot-melt adhesive. The first and second layers 21, 22 may be formed from at least one of a textile, a cloth, a fabric and a felt. Therefore, the first and second layers 21, 22 may be attached using other methods typically used to attach layers of fabric together, such as stitching. The layers of material may also be attached by the use of a layer of plastic to heat seal or weld the layers of material together.

[0071] The shape of the connector 20 is not particularly limited. However, the connector is substantially circular in shape, as shown in Figs 13 and 15. The size of the connector is preferably less than 75mm, more preferably less than 50mm, in diameter (or largest dimension for non-circular shapes).

[0072] The first layer 21 may move relative to the second layer 22 in a plane substantially parallel to each of the layers 21, 22. Each of the layers may be elastic to allow parallel motion of the first layer 21 relative to the second layer of material 22 when either of the first 21 or second 22 layers are attached to parts of the helmet. The elasticity of either or both of the first 21 or second 22 layers may be selected to provide a desired amount of relative parallel movement between the first 21 and second 22 layers. The parallel movement corresponds to movement in a plane substantially perpendicular to the radial direction of the helmet 1, i.e. parallel to adjacent surfaces of the helmet layers.

[0073] The sliding interface 25 is preferably a low friction interface. In this context, a low friction interface may be configured such that sliding contact is still possible even under the loading that may be expected in use. In the context of a helmet, for example, it may be desirable for sliding to be maintained in the event of an impact that is expected to be survivable for the wearer of the helmet. This may be provided, for example, by the provision of an interface between the two surfaces at which the coeffi-

cient of friction is between 0.001 and 0.3 and/or below 0.15.

[0074] The first and second layers 21, 22 are formed from at least one of a textile, a cloth, a fabric and a felt. The layers 21, 22 may be formed from a woven material. The first and second layers may both be formed from the same material or the layers may be formed from different materials. Fig. 16 schematically shows an example material 30 from which the first and/or second layers may be formed. The material 30 may have a distinct grain 31 and direction, as illustrated by the arrow in Fig. 16. Preferably, the materials forming both of the first and second layers 21, 22 have a distinct grain direction.

[0075] The grain may be defined by the orientation and/or the texture of the fibres forming the layers. The interaction between the surfaces of the layers of material when the grains are arranged at 90 degrees to each other may result in a lower coefficient of friction than when the grains are arranged parallel to each other. Accordingly, the first and second layers 21, 22 may be arranged such that a grain direction of the first layer and a grain direction of the second layer are non-parallel. Preferably, the grain direction of the first layer and the grain direction of the second layer are angled between 45 degrees and 90 degrees relative to each other. Most preferably, the grain direction of the first layer and the grain direction of the second layer are substantially perpendicular to each other.

[0076] One suitable type of material forming the first and second layers 21, 22 is a tricot fabric. For example, a three-bar tricot fabric consisting of 85% 40-denier semi dull nylon and/or 15% 140-denier spandex may be used as one of, or optionally both, the first layer 21 and the second layer 22. Tricot knit fabric may be made of materials including, at least one of, cotton, wool, silk, rayon, nylon, and combinations thereof. A tricot fabric may mean a plain warp-knit fabric (such as nylon, wool, rayon, silk, or cotton) that is a close-knit design with fibres running lengthwise while employing an inter-loop yarn pattern. The close-knit design may be substantially inelastic. The yarn may zigzag vertically, following a single column or wale of knitting. One side of the tricot fabric may feature fine ribs running in the length-wise direction while the other side features ribs that run in the crosswise direction.

[0077] Tricot fabric may appear to have a shiny side and an opposite side that is duller. When the shiny sides of two pieces of tricot fabric are placed face-to-face and the two pieces of fabric are oriented such that the machine direction of manufacture of each piece of fabric is arranged to be substantially perpendicular to that of the other piece, the interface between the two pieces of fabric demonstrates a very low coefficient of friction. The machine direction may be defined as that direction in which the fabric, when made, moves forward through a knitting machine. The machine orientation may be defined as the grain of the fabric. A substantially perpendicular orientation of the machine direction of the fabrics produces an

interface that has a lower coefficient of friction than if the pieces of fabric were positioned such that the machine direction were substantially parallel. The sliding interface 25 may therefore be formed using two layers of tricot material arranged as discussed above as the first layer 21 and the second layer 22. When a user is wearing the helmet 1 including the connector 20 with layers formed in this way, the layers may slide out of a perpendicular relationship while the helmet 1 is worn and/or during an impact to the helmet 1. The low friction properties of the sliding interface 25 may be maintained when the layers are not orientated precisely perpendicular to each other. However, the more perpendicular the orientation, the lower the coefficient of friction of the interface may be.

[0078] Variations of the above described embodiments are possible in light of the above teachings. It is to be understood that the invention may be practiced otherwise and specifically described herein without departing from the scope of the invention, as defined by the appended claims.

Claims

1. A connector (20) for connecting two layers (3, 15) of an apparatus, the connector (20) comprising:
 - a first layer (21), formed from at least one of a textile, a cloth, a fabric and a felt;
 - a first connecting means (23) connected to the first layer (21) and configured to attach to one of the two layers (3, 15) of the apparatus; and
 - a second layer (22), formed from at least one of a textile, a cloth, a fabric and a felt;
 - wherein the first and second layers (21, 22) are arranged adjacent each other and configured to slide against each other at a sliding interface (25) so as to allow the first and second layers (21, 22) to move relative to each other; **characterised by** comprising:
 - a second connecting means (24) connected to the second layer (22) and configured to connect to the other of the two layers (3, 15) of the apparatus.
2. The connector of claim 1, wherein the first connecting means (23) is connected to the first layer (21) at a location opposite the sliding interface (25).
3. The connector of claim 1 or 2, wherein the first connecting means (23) comprises a hook-and-loop material.
4. The connector of any preceding claim, wherein the second connecting means (24) is connected to the second layer (22) at a location opposite the sliding interface (25).

5. The connector of any preceding claim, wherein the second connecting means (24) comprises double-sided adhesive tape.
6. The connector of any preceding claim, wherein the first and second layers (21,22) are arranged such that a grain direction of the first layer and a grain direction of the second layer are non-parallel, optionally wherein the grain direction of the first layer and the grain direction of the second layer are angled between 45 degrees and 90 degrees relative to each other, optionally wherein the grain direction of the first layer and the grain direction of the second layer are substantially perpendicular to each other.
7. The connector of any preceding claim, wherein the first and second layers (21, 22) are each formed from a tricot fabric, optionally wherein the tricot fabrics forming the first and second layers comprise a shiny side and an dull side, the shiny sides of the tricot fabrics are arranged face-to-face a the sliding interface (25), and the tricot fabrics are oriented such that the machine directions of manufacture of the tricot fabrics are arranged to be perpendicular to each other.
8. The connector of any preceding claim, wherein the first and second layers (21, 22) are connected to each other at a region of the connector surrounding the sliding interface (25), optionally wherein the first and second layers are connected to each other at a peripheral region of the connector and the sliding interface is provided in a central region of the connector, optionally wherein the first and second layers are connected by an adhesive layer, optionally wherein the adhesive layer is formed from a hot-melt adhesive.
9. The connector of any preceding claim, wherein the connector (20) is substantially circular in shape, optionally wherein the connector has a diameter of less than 50mm.
10. An apparatus comprising:
 - an inner layer (15);
 - an outer layer (3); and
 - the connector (20) according to any preceding claim connected to the inner and outer layers (15, 3) so as to allow relative sliding between the inner and outer layers (15, 3) at a further sliding interface, in response to an impact to the apparatus.
11. The apparatus of claim 10, wherein the first connecting means (23) is connected to the first layer (21) of the connector (20) and the outer layer (3) of the apparatus, wherein the first connecting means com-

prises a hook-and-loop material, and the second connecting means (24) is connected to the second layer (22) of the connector and the inner layer (15) of the apparatus, wherein the second connecting means comprises double-sided adhesive tape.

12. The apparatus of any one of claims 10 to 11, wherein the apparatus is a helmet (1).
13. The apparatus of claim 12 wherein the outer layer (3) is an energy absorbing layer and the inner layer (15) is a head mount configured to mount the helmet on a wearer's head.
14. The apparatus of claim 12, wherein the outer layer is a low friction layer (4) located radially inward of an energy absorbing layer (3) of the helmet (1) and the inner layer (15) is a head mount configured to mount the helmet on a wearer's head.
15. The apparatus of to claim 13 or 14, wherein the head mount comprises comfort padding.

25 Patentansprüche

1. Verbindungsstück (20) zum Verbinden von zwei Schichten (3, 15) einer Vorrichtung, wobei das Verbindungsstück (20) Folgendes umfasst:
 - eine erste Schicht (21), die aus mindestens einem aus einem Textil, einem Stoff, einem Gewebe und einem Filz gebildet ist;
 - ein erstes Verbindungsmittel (23), das mit der ersten Schicht (21) verbunden ist und konfiguriert ist, um an eine aus den zwei Schichten (3, 15) der Vorrichtung befestigt zu sein; und
 - eine zweite Schicht (22), die aus mindestens einem aus einem Textil, einem Stoff, einem Gewebe und einem Filz gebildet ist;
 - wobei die erste und zweite Schicht (21, 22) benachbart zueinander angeordnet sind und konfiguriert sind, um an einer Gleitschnittstelle (25) gegeneinander zu gleiten, um zuzulassen, dass sich die erste und zweite Schicht (21, 22) relativ zueinander bewegen, **dadurch gekennzeichnet, dass** es Folgendes umfasst:
 - ein zweites Verbindungsmittel (24), das mit der zweiten Schicht (22) verbunden ist und konfiguriert ist, um mit der anderen aus den zwei Schichten (3, 15) der Vorrichtung verbunden zu sein.
2. Verbindungsstück nach Anspruch 1, wobei das erste Verbindungsmittel (23) mit der ersten Schicht (21) an einer Stelle gegenüber der Gleitschnittstelle (25) verbunden ist.

3. Verbindungsstück nach Anspruch 1 oder 2, wobei das erste Verbindungsmittel (23) ein Klettmaterial umfasst.
4. Verbindungsstück nach einem vorhergehenden Anspruch, wobei das zweite Verbindungsmittel (24) mit der zweiten Schicht (22) an einer Stelle gegenüber der Gleitschnittstelle (25) verbunden ist. 5
5. Verbindungsstück nach einem vorhergehenden Anspruch, wobei das zweite Verbindungsmittel (24) doppelseitiges Klebeband umfasst. 10
6. Verbindungsstück nach einem vorhergehenden Anspruch, wobei die erste und zweite Schicht (21, 22) angeordnet sind, sodass eine Faserrichtung der ersten Schicht und eine Faserrichtung der zweiten Schicht nicht parallel sind, wobei optional die Faserrichtung der ersten Schicht und die Faserrichtung der zweiten Schicht zwischen 45 Grad und 90 Grad relativ zueinander gewinkelt sind, wobei optional die Faserrichtung der ersten Schicht und die Faserrichtung der zweiten Schicht im Wesentlichen senkrecht zueinander sind. 15 20
7. Verbindungsstück nach einem vorhergehenden Anspruch, wobei die erste und zweite Schicht (21, 22) jeweils aus einem Trikotstoff gebildet sind, wobei optional die Trikotstoffe, die die erste und zweite Schicht bilden, eine glänzende Seite und eine matte Seite umfassen, wobei die glänzenden Seiten der Trikotstoffe gegenüber der Gleitschnittstelle (25) angeordnet sind, und die Trikotstoffe ausgerichtet sind, sodass die Maschinenrichtungen der Herstellung der Trikotstoffe angeordnet sind, um senkrecht zueinander zu sein. 25 30 35
8. Verbindungsstück nach einem vorhergehenden Anspruch, wobei die erste und zweite Schicht (21, 22) an einem Bereich des Verbindungsstücks miteinander verbunden sind, der die Gleitschnittstelle (25) umgibt, wobei optional die erste und zweite Schicht an einem Umfangsbereich des Verbindungsstücks miteinander verbunden sind und die Gleitschnittstelle in einem zentralen Bereich des Verbindungsstücks bereitgestellt ist, wobei optional die erste und zweite Schicht durch eine Haftschrift verbunden sind, wobei optional die Haftschrift aus einem Schmelzklebstoff gebildet ist. 40 45
9. Verbindungsstück nach einem vorhergehenden Anspruch, wobei das Verbindungsstück (20) im Wesentlichen kreisförmig ist, wobei optional das Verbindungsstück einen Durchmesser von weniger als 50 mm aufweist. 50
10. Vorrichtung, umfassend:
 - eine Innenschicht (15);
 - eine Außenschicht (3); und
 - das Verbindungsstück (20) nach einem vorhergehenden Anspruch, das mit der Innen- und Außenschicht (15, 3) verbunden ist, um ein relatives Gleiten zwischen der Innen- und Außenschicht (15, 3) an einer weiteren Gleitschnittstelle zuzulassen, als Reaktion auf einen Aufprall auf die Vorrichtung.
11. Vorrichtung nach Anspruch 10, wobei das erste Verbindungsmittel (23) mit der ersten Schicht (21) des Verbindungsstücks (20) und der Außenschicht (3) der Vorrichtung verbunden ist, wobei das erste Verbindungsstück ein Klettmaterial umfasst, und das zweite Verbindungsmittel (24) mit der zweiten Schicht (22) des Verbindungsstücks und der Innenschicht (15) der Vorrichtung verbunden ist, wobei das zweite Verbindungsmittel doppelseitiges Klebeband umfasst.
12. Vorrichtung nach einem der Ansprüche 10 bis 11, wobei die Vorrichtung ein Helm (1) ist.
13. Vorrichtung nach Anspruch 12, wobei die Außenschicht (3) eine energieabsorbierende Schicht ist und die Innenschicht (15) eine Kopfhalterung ist, die konfiguriert ist, um den Helm auf einem Kopf eines Trägers anzubringen. 25 30
14. Vorrichtung nach Anspruch 12, wobei die Außenschicht eine reibungsarme Schicht (4) ist, die sich radial innerhalb einer energieabsorbierenden Schicht (3) des Helms (1) befindet, und die Innenschicht (15) eine Kopfhalterung ist, die konfiguriert ist, um den Helm auf einem Kopf eines Trägers anzubringen. 35
15. Vorrichtung nach Anspruch 13 oder 14, wobei die Kopfhalterung Komfortpolsterung umfasst.

Revendications

1. Raccord (20) destiné à relier deux couches (3, 15) d'un dispositif, le raccord (20) comprenant :
 - une première couche (21), constituée d'au moins une matière parmi un textile, un tissu, une étoffe et un feutre,
 - un premier moyen de raccordement (23) raccordé à la première couche (21) et conçu pour être fixé à l'une des deux couches (3, 15) du dispositif, et
 - une deuxième couche (22), constituée d'au moins une matière parmi un textile, un tissu, une étoffe et un feutre ;
 - la première et la deuxième couche (21, 22) étant

- agencées l'une à côté de l'autre et conçues pour glisser l'une contre l'autre au niveau d'une interface de glissement (25) de manière à permettre aux première et deuxième couches (21, 22) d'être mobiles l'une par rapport à l'autre ;
caractérisé en ce qu'il comprend :
 un deuxième moyen de raccordement (24) raccordé à la deuxième couche (22) et conçu pour être raccordé à l'autre des deux couches (3, 15) du dispositif.
2. Raccord selon la revendication 1, dans lequel le premier moyen de raccordement (23) est raccordé à la première couche (21) à un emplacement opposé à l'interface de glissement (25).
 3. Raccord selon la revendication 1 ou 2, dans lequel le premier moyen de raccordement (23) comprend un matériau auto-agrippant.
 4. Raccord selon l'une quelconque des revendications précédentes, dans lequel le deuxième moyen de raccordement (24) est raccordé à la deuxième couche (22) à un emplacement opposé à l'interface de glissement (25).
 5. Raccord selon l'une quelconque des revendications précédentes, dans lequel le deuxième moyen de raccordement (24) comprend un ruban adhésif double face.
 6. Raccord selon l'une quelconque des revendications précédentes, dans lequel la première et la deuxième couche (21, 22) sont agencées de façon que la direction du grain de la première couche et la direction du grain de la deuxième couche ne soient pas parallèles, la direction du grain de la première couche et la direction du grain de la deuxième couche formant éventuellement un angle de 45 à 90 degrés l'une par rapport à l'autre, la direction du grain de la première couche et la direction du grain de la deuxième couche étant éventuellement sensiblement perpendiculaires l'une à l'autre.
 7. Raccord selon l'une quelconque des revendications précédentes, dans lequel la première et la deuxième couche (21, 22) sont chacune formées d'une étoffe de type tricot chaîne, les étoffes de type tricot chaîne formant la première et la deuxième couche comprenant éventuellement un côté brillant et un côté mat, le côté brillant des étoffes de type tricot chaîne étant agencé face à face au niveau de l'interface de glissement (25), et les étoffes de type tricot chaîne étant orientées de façon que les sens machine de fabrication des étoffes de type tricot chaîne sont perpendiculaires l'une à l'autre.
 8. Raccord selon l'une quelconque des revendications
- précédentes, dans lequel la première et la deuxième couche (21, 22) sont raccordées l'une à l'autre au niveau d'une région du raccord entourant l'interface de glissement (25), la première et la deuxième couche pouvant éventuellement être raccordées l'une à l'autre au niveau d'une région périphérique du raccord et l'interface de glissement étant prévue dans une région centrale du raccord, la première et la deuxième couche pouvant éventuellement être raccordées par une couche adhésive, la couche adhésive pouvant éventuellement être constituée d'un adhésif thermofusible.
9. Raccord selon l'une quelconque des revendications précédentes, ledit raccord (20) ayant une forme sensiblement circulaire, le raccord ayant éventuellement un diamètre inférieur à 50 mm.
 10. Dispositif comprenant :
 une couche intérieure (15),
 une couche extérieure (3), et
 le raccord (20) selon l'une quelconque des revendications précédentes, raccordé à la couche intérieure et à la couche extérieure (15, 3) afin de permettre un glissement relatif entre la couche intérieure et la couche extérieure (15, 3) au niveau d'une interface de glissement supplémentaire, en réaction à un choc subi par le dispositif.
 11. Dispositif selon la revendication 10, dans lequel le premier moyen de raccordement (23) est raccordé à la première couche (21) du raccord (20) et à la couche extérieure (3) du dispositif, le premier moyen de raccordement comprenant un matériau auto-agrippant, et le deuxième moyen de raccordement (24) étant raccordé à la deuxième couche (22) du raccord et à la couche intérieure (15) du dispositif, le deuxième moyen de raccordement comprenant du ruban adhésif double face.
 12. Dispositif selon l'une quelconque des revendications 10 et 11, ledit dispositif étant un casque (1).
 13. Dispositif selon la revendication 12, dans lequel la couche extérieure (3) est une couche d'absorption d'énergie et la couche intérieure (15) est un support de tête conçu pour fixer le casque sur la tête d'un utilisateur.
 14. Dispositif selon la revendication 12, dans lequel la couche extérieure est une couche à faible frottement (4) située radialement vers l'intérieur d'une couche d'absorption d'énergie (3) du casque (1) et la couche intérieure (15) est un support de tête conçu pour fixer le casque sur la tête d'un utilisateur.

15. Dispositif selon l'une des revendications 13 et 14, dans lequel le support de tête comprend un rembourrage de confort.

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Fig. 1

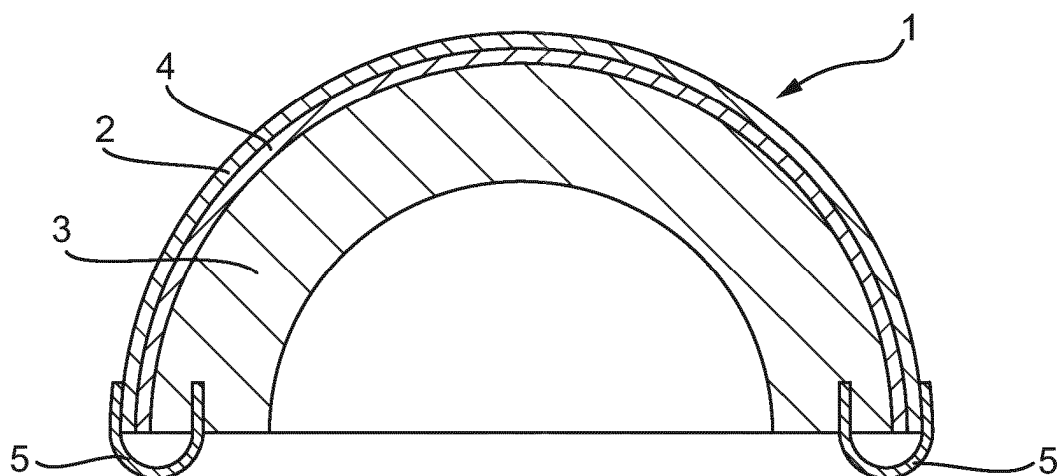


Fig. 2

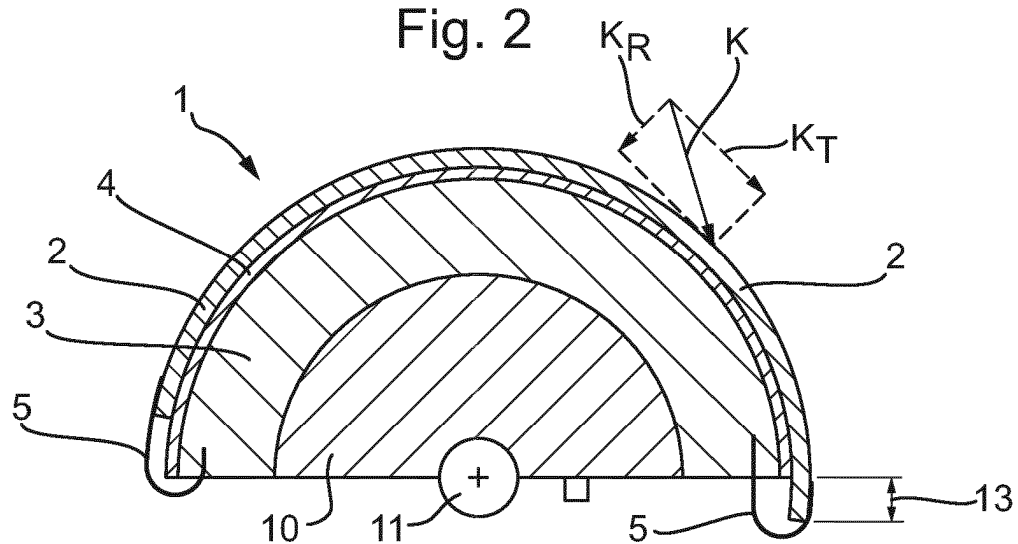


Fig. 3A

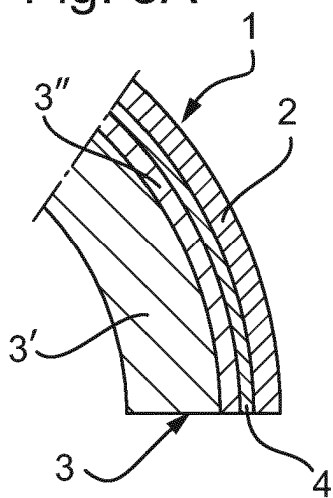


Fig. 3B

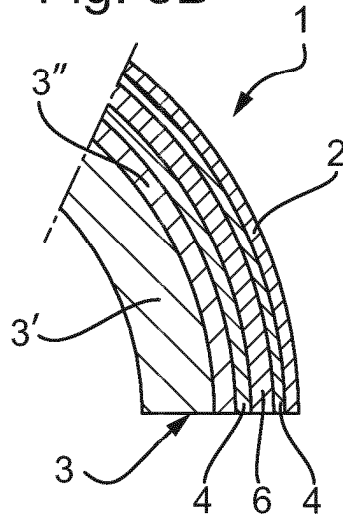


Fig. 3C

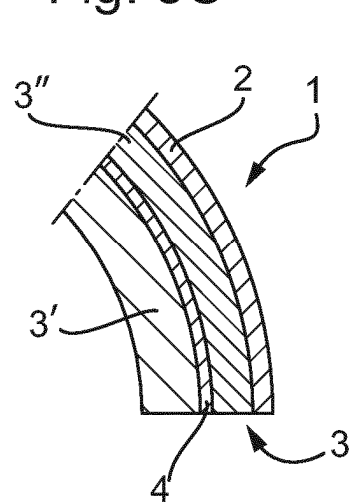


Fig. 4

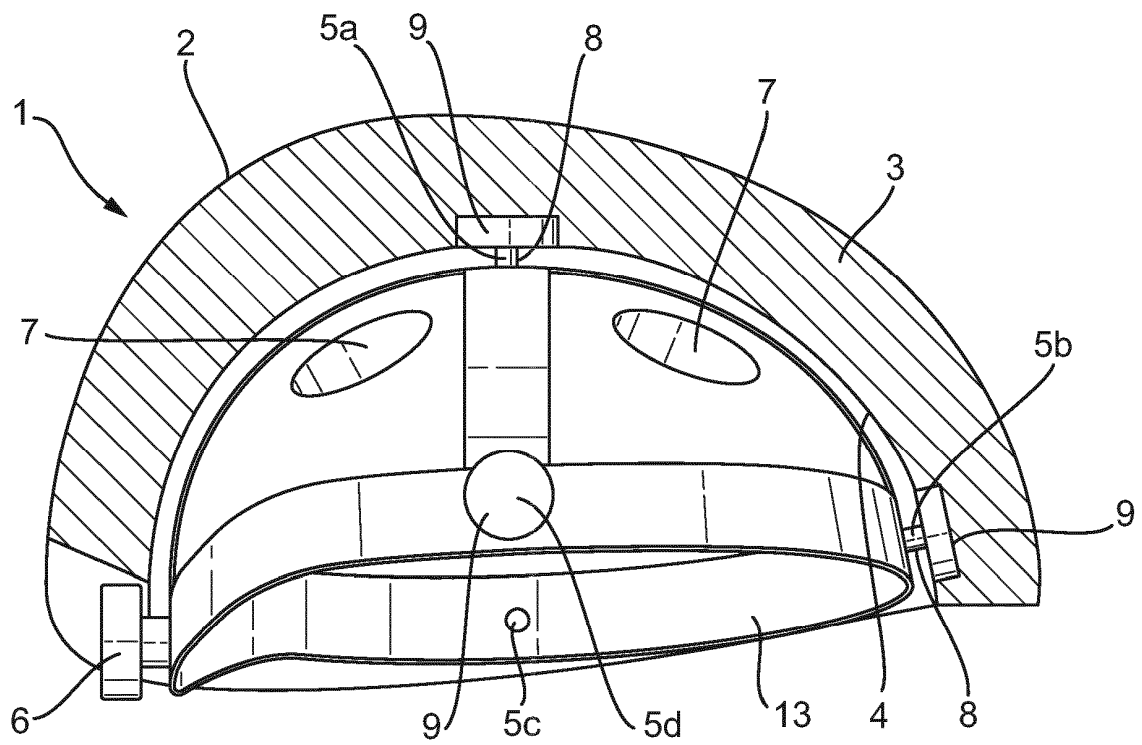


Fig. 5

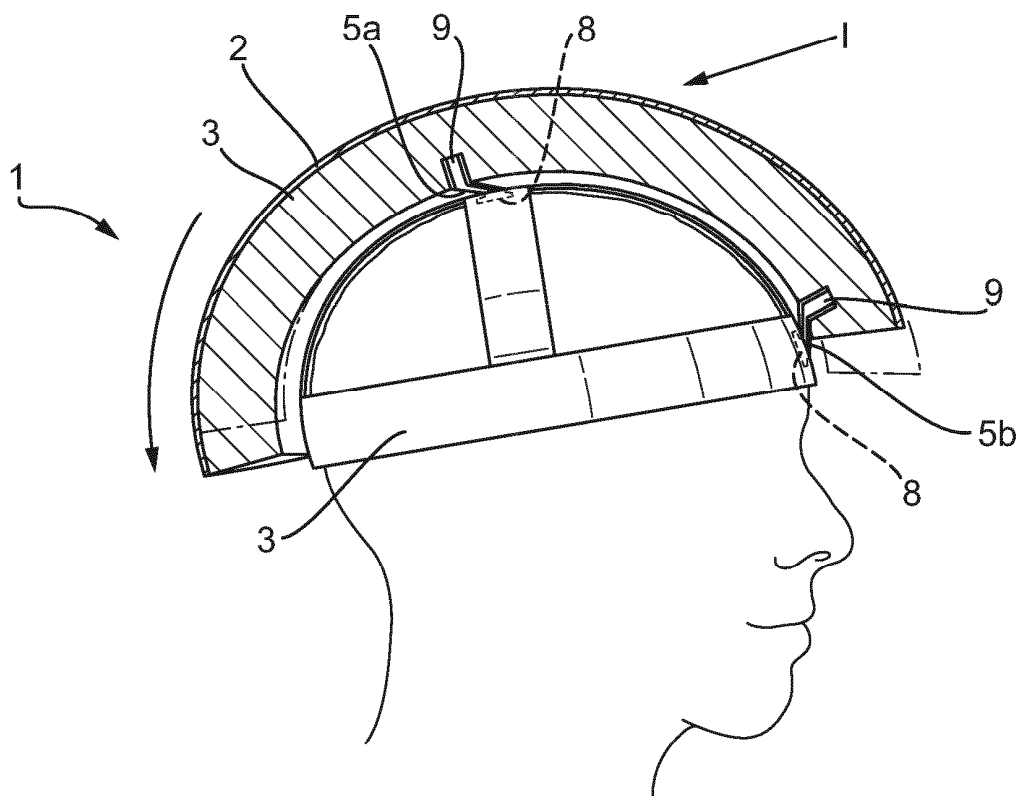


Fig. 6

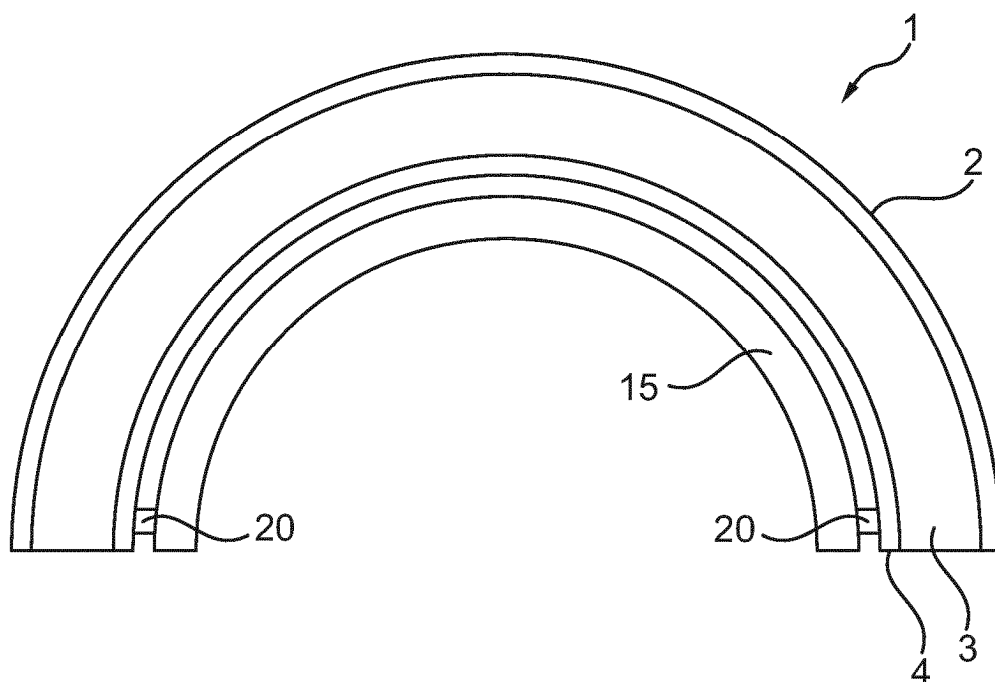


Fig. 7

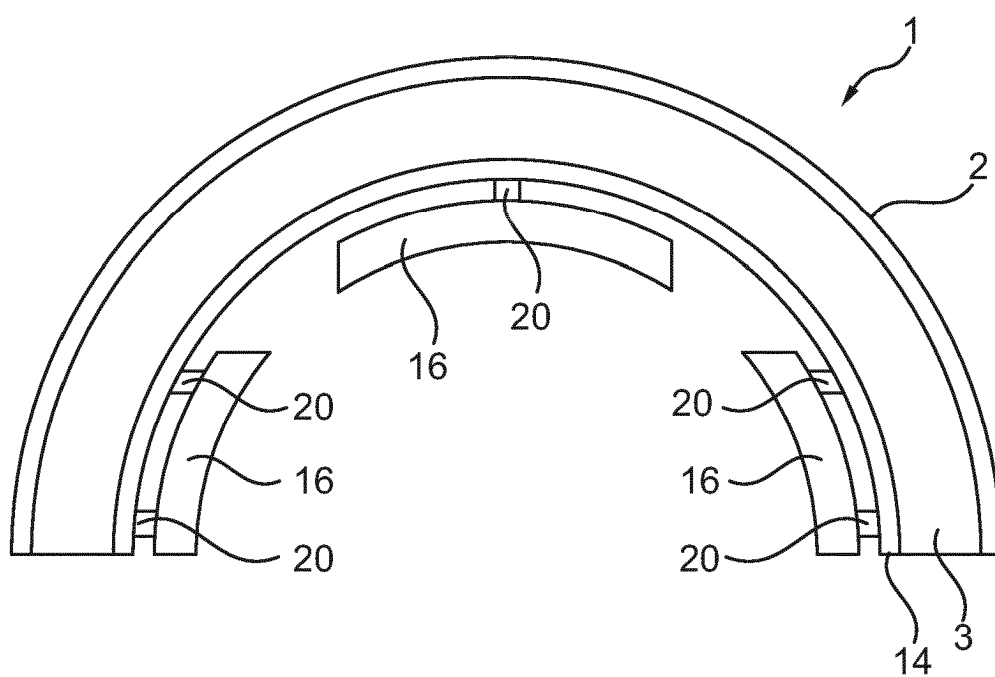


Fig. 8

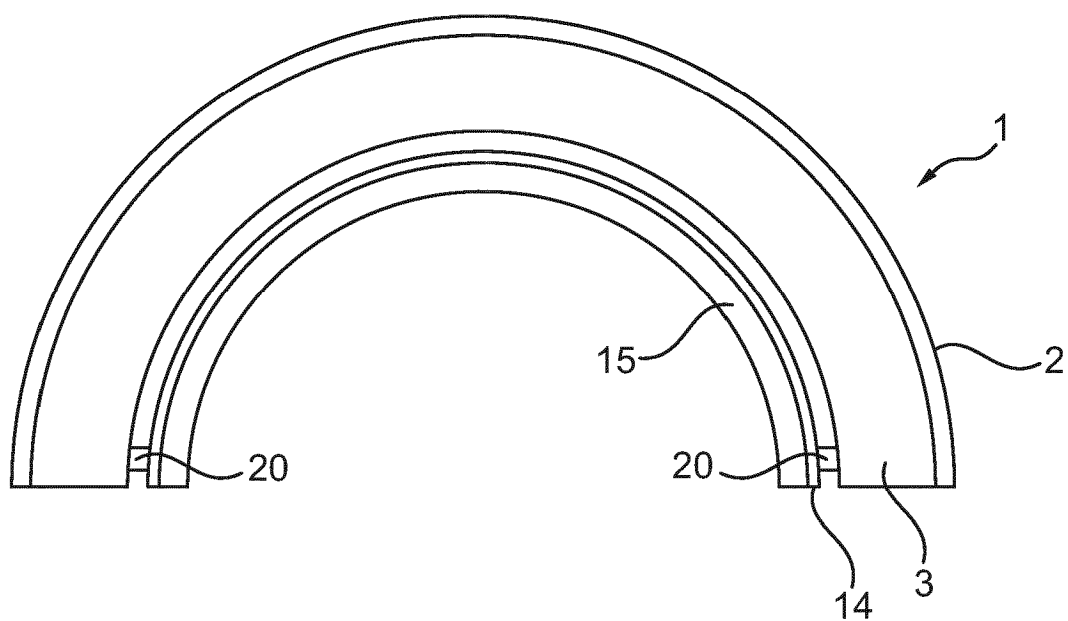


Fig. 9

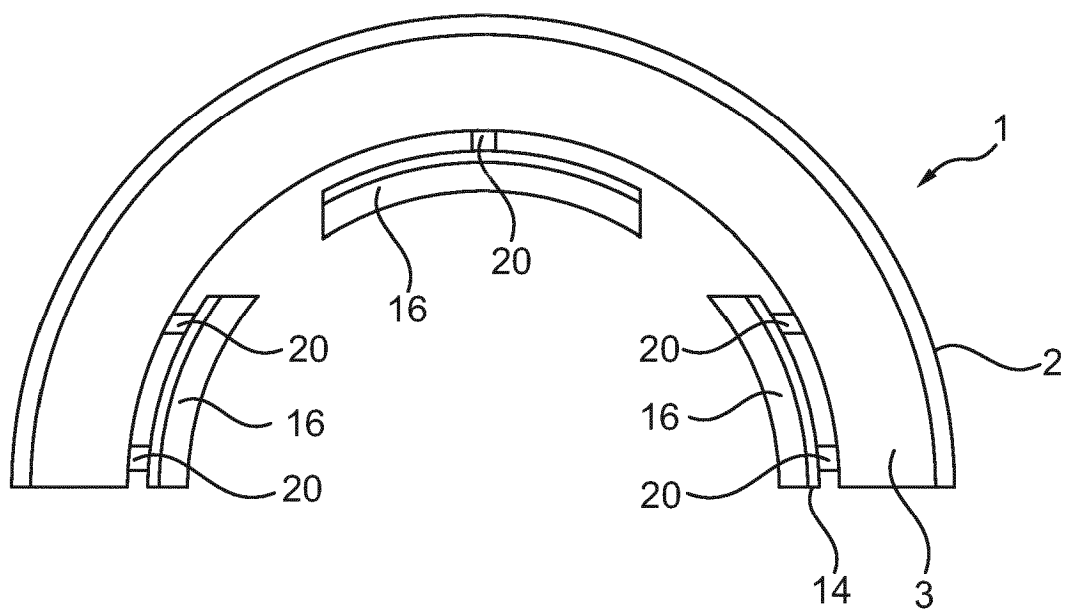


Fig. 10

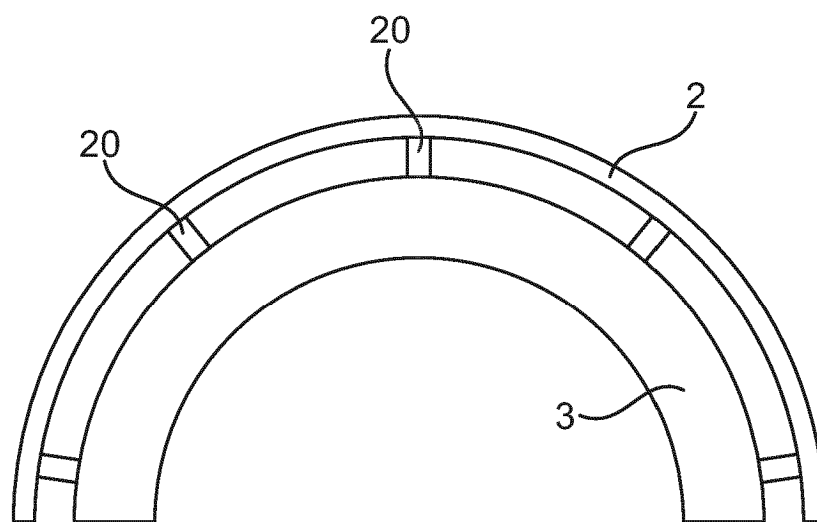


Fig. 11

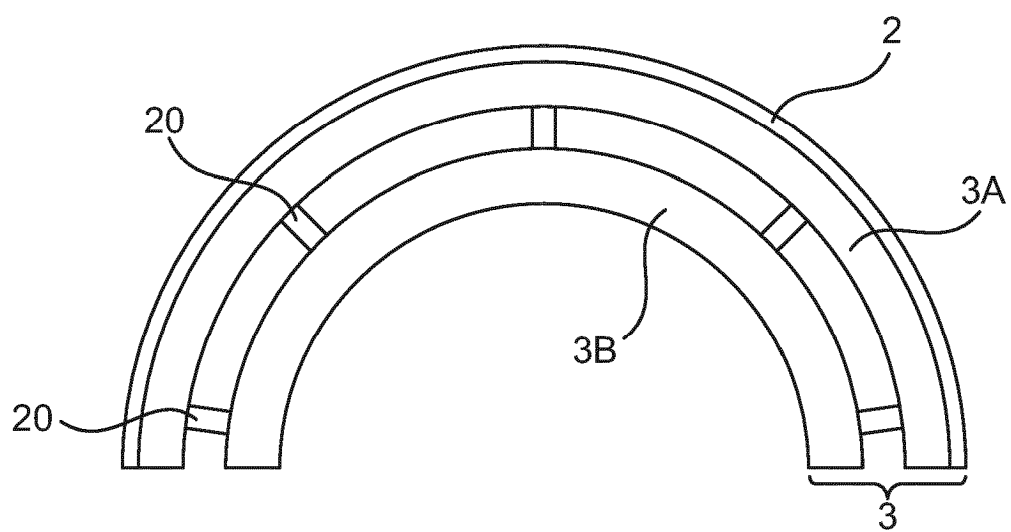


Fig. 12

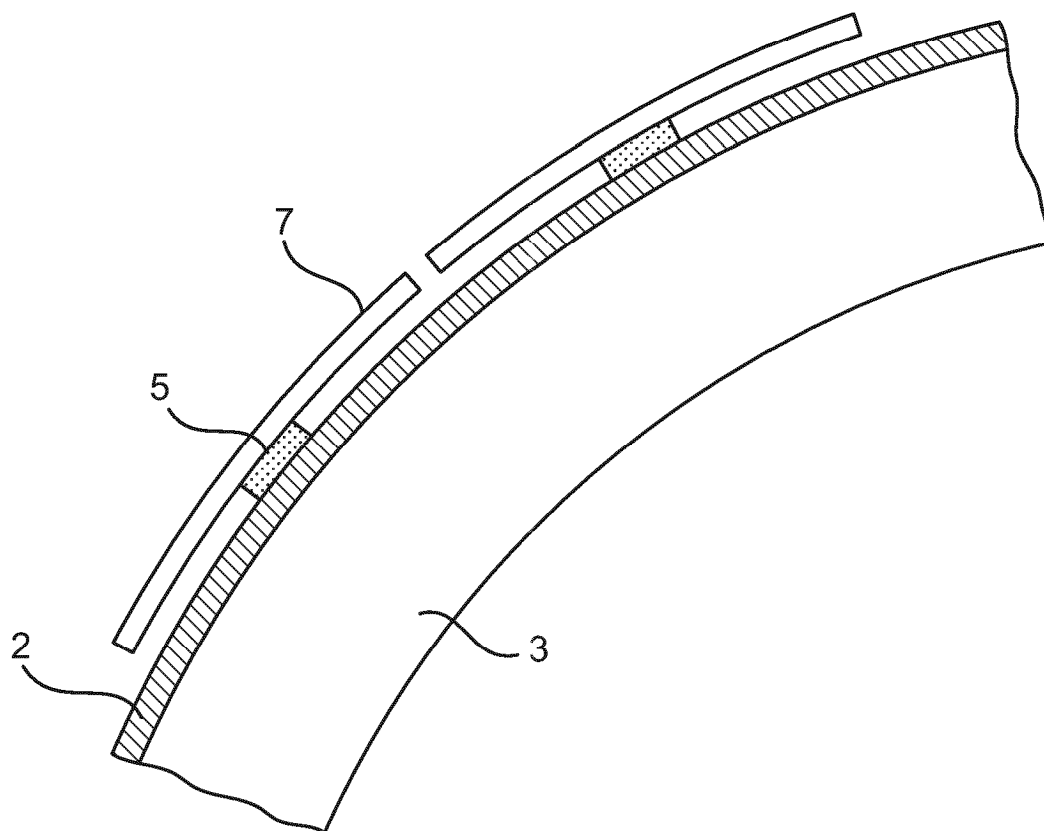


Fig. 13

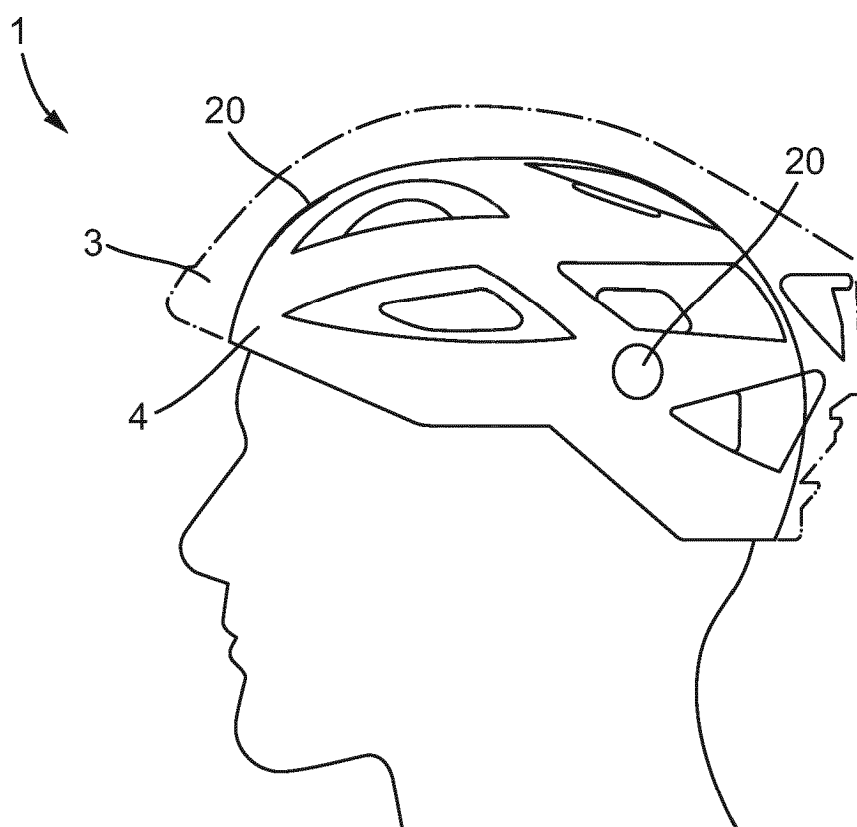


Fig. 14

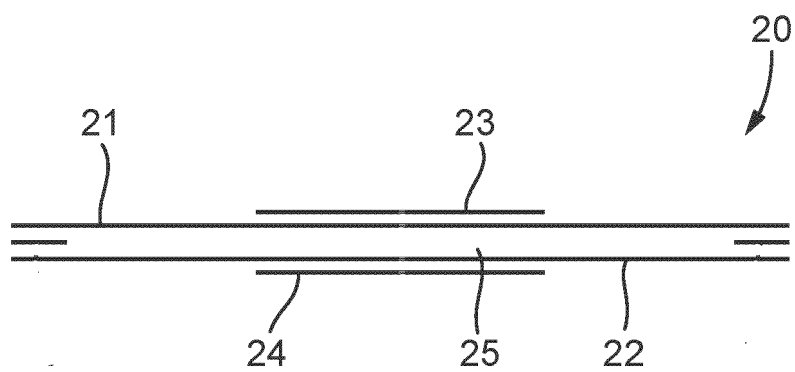


Fig. 15

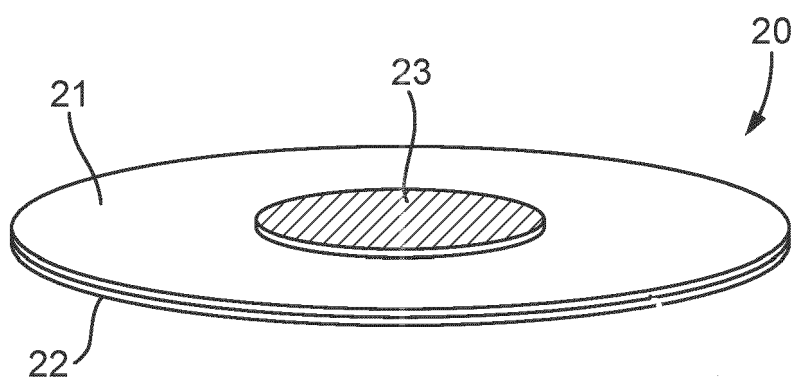
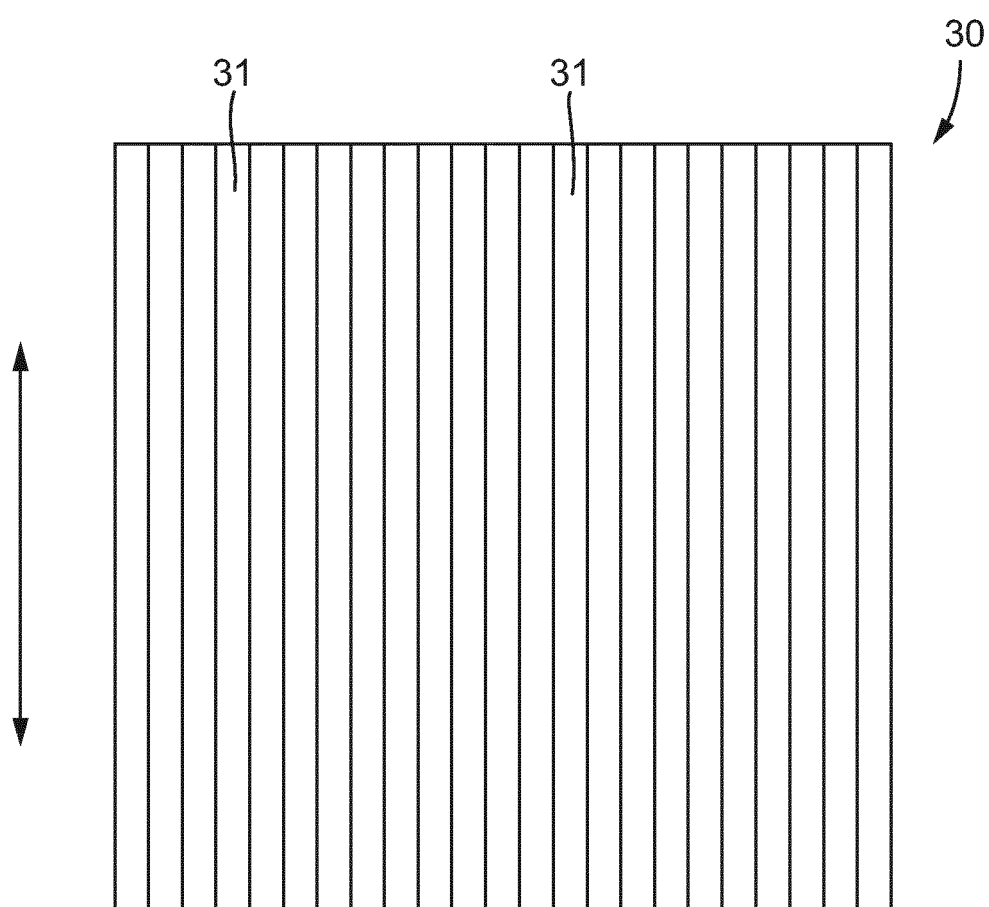


Fig. 16



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2001045526 A [0004] [0008]
- WO 201139224 A [0004]
- WO 201139224 A [0008] [0028]
- WO 2020078913 A1 [0009]
- WO 0145526 A [0014]