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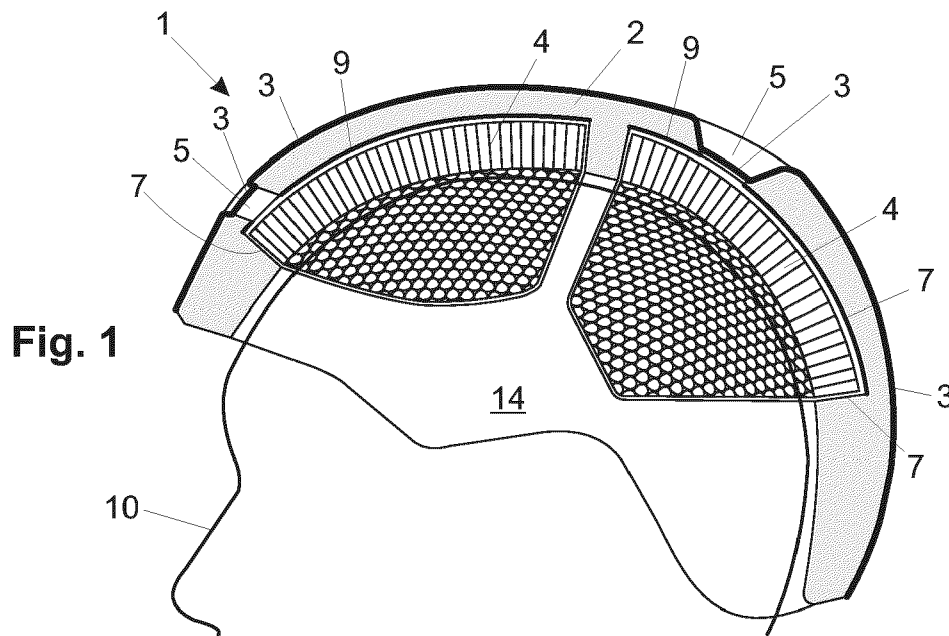
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(54) **HELMET**

(57) Helmet (1) comprising a foam liner (2) having at least one through hole (5) crossing the foam liner (2) along its thickness; a shell (3) covering at least in part the outside of the foam liner (2); at least one cellular energy-absorbing insert (4) comprising a plurality of interconnected open cells (8) that are configured to absorb energy by plastic deformation in response to a compressive

load crushing the cellular energy-absorbing insert (4); wherein the cellular energy-absorbing insert (4) is arranged inside the foam liner (2); wherein the at least one through hole (5) lies in correspondence of said cellular energy-absorbing insert (4); and wherein the at least one through hole (5) is closed from outside.



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Description

TECHNICAL FIELD

[0001] The present invention relates to the field of helmets with cellular energy-absorbing structures. In particular, the present invention relates to helmets using layered structures. Even more particularly, the present invention relates to helmets having parts able to move relative to each other for attenuating the negative effects on the wearer's head caused by an oblique impact.

BACKGROUND ART

[0002] Historically, the oldest helmets were without vents. With the evolution of manufacturing processes, the helmets acquired vents for ventilating the head of the wearer.

[0003] Modern helmets, in particular sport helmets, comprise a liner made of a polymeric foam that is covered and protected by a shell. The shell is in-moulded with or attached to the foam liner. The foam liner is moulded inside complex moulds. These complex moulds allow to provide complex geometries to the foam liner and to create vents for ventilating the head of the wearer.

[0004] Since these complex moulds are very expensive it is preferable to reduce the versions of helmets that a helmet manufacturer needs to realize.

[0005] Moreover, not all types of helmets require a ventilation system. For example, certain kinds of helmets for winter sports do not require vents because they are used in cold environments.

[0006] It is thus desirable that a same foam liner could be used on helmets with or without ventilation systems.

[0007] The document US10736373 for example describes a helmet having an outer liner with vents and one or more cellular inserts confined inside cavities of the outer liner. Each vent is aligned with a corresponding cavity for improving the ventilation of the head. In this helmet, the cellular inserts lie under corresponding vents and consequently the cellular inserts are exposed to ruptures if a sharp element enters in a vent. Indeed, the cellular insert is prevalently empty and it is not able to efficiently prevent the penetration of a sharp element.

[0008] This problem is partially solved by the helmet of document EP3130243B1, which comprises a plurality of small holes distributed all over the outer shell. Despite these small holes prevent the entrance of sharp elements in the helmet, they can easily become blocked up. Moreover, a ventilation always occurs, because the small holes are always opened.

[0009] Apart from the ventilation, another important task of current helmets, in particular sport helmets, is to reduce torque to brain mass during an impact. Certain known helmets provide an outer layer that is able to move with respect to an inner layer, creating a small degree of freedom that reduces rotational acceleration of head during an oblique impact. In this manner the outer layer

tends to rotate under the oblique impact, and the skull is not dragged in rotation. An example in this sense is provided by the helmet described in the document US10834987B1. In the helmet of this solution, the polymer foam liner has no vents, therefore air does not enter inside the helmet, but the same foam liner cannot be used for another helmet that needs ventilation. In this case, the manufacturer will be obliged to use a different mould that is shaped so as to create vents in the foam liner.

SUMMARY

[0010] Said and other drawbacks of the state of the art are now solved by a helmet comprising a foam liner having at least one through hole crossing the foam liner along its thickness; a shell covering at least in part the outside of the foam liner; at least one cellular energy-absorbing insert comprising a plurality of interconnected open cells that are configured to absorb energy by plastic deformation in response to a compressive load crushing the cellular energy-absorbing insert. The cellular energy-absorbing insert is arranged inside the foam liner. The at least one through hole lies in correspondence of said cellular energy-absorbing insert. The at least one through hole is closed from outside. In this way, despite the foam liner is perforated with pass-through holes, the air does enter inside the helmet. Moreover, being the foam liner perforated, the same foam liner can be used for a different helmet that needs ventilation, without the need of an additional mould for realizing it. Therefore, the same foam liner can be used both for ventilated and not-ventilated helmets. In addition, being the through holes closed from outside, debris cannot enter and accumulate inside the holes. Furthermore, being the through holes closed, sharp objects cannot penetrate into the holes, and the helmet is safer.

[0011] In particular, the at least one through hole can be closed by the shell. In addition, the shell can entirely cover and span across the at least one through hole. In this manner, it's enough to change to shell, to obtain a ventilated or a not-ventilated helmet.

[0012] Preferably, the shell can be attached, in a direct manner, to the foam liner. The shell is in direct contact with the foam liner and is attached to it in an irreversible manner, thus it is firmly connected to the foam liner.

[0013] Alternatively to the solution in which a shell closes the through holes of the foam liner, the helmet can comprise at least one patch that is arranged between the foam liner and the shell and that is configured to close the at least one through hole. In this manner, the patch acts as a shield that prevents to air and sharp objects to enter inside the through hole/s.

[0014] Preferably, the patch can be clamped between the shell and the foam liner, in order to remain firmly in position when the helmet is used.

[0015] In particular, the patch can be a continuous non-porous sheet, a fabric, or a mesh. In the first case, the entrance of air inside the helmet via the through holes is

prevented. In the latter two cases, depending on how the mesh is wide or thick, the airflow entering in the through hole/s can be adjusted.

[0016] Advantageously the foam liner can be made of a polymeric foam. Preferably the polymer is made of EPS or EPP. This material makes the foam liner easy to be realized and cheaper.

[0017] In particular, the foam liner can comprise at least one recess configured to receive and contain the at least one cellular energy-absorbing insert. In this manner, the cellular insert cannot leak from the helmet and the helmet remains more compact.

[0018] Preferably the shape of the at least one recess can be complementary to the shape of the corresponding cellular energy-absorbing insert. In this manner, the cellular insert remains fit snug in the recess and can be removed from it only if it is in-plane compressed.

[0019] Advantageously, said at least one through hole can open into the at least one recess. In this manner, the foam liner is ready to be used in a ventilated helmet even if it comprises one or more recesses.

[0020] In addition, the helmet can comprise a sliding layer arranged between the foam liner and the cellular energy-absorbing insert. This sliding layer is configured to facilitate sliding of cellular energy-absorbing insert with respect to the foam liner. In substance, the sliding layer prevents the cellular insert sticking into the soft material of the foam liner, allowing the cellular insert to slide over the sliding layer in case of an oblique impact to the helmet. If an oblique impact hits the shell, for example during a crash, the shell transmits the torque to the foam liner, while the sliding layer allows to transmit only a reduced amount of this torque to the cellular insert and thus to the wearer's head.

[0021] Preferably, the sliding layer can close the at least one through hole from inside. In this manner, during an oblique impact the cellular insert does not stick in the through hole and spans across it.

[0022] The foam liner can comprise one or more vents lying outside a perimeter of said cellular energy-absorbing insert so as to directly ventilate a wearer's head without crossing the cellular energy-absorbing insert. These vents fall outside the area of the foam liner occupied by the cellular insert/s. In this way, a certain amount of air enters inside the helmet without passing through the cells of the cellular insert.

[0023] In this case, the shell comprises aperture/s in correspondence of said one or more vents and/or said at least one through hole of the foam liner. In the former case, the aperture admits air inside the vent and thus inside the helmet, in the latter case the aperture is used when the helmet comprises at least one patch arranged between the foam liner and the shell.

[0024] Preferably, said one or more vents can be arranged in the front and/or back portions of the helmet. In this manner, when the helmet is used and the user advances forwards, the air enters from the front vents and exits from the back vents or from the cavity that

accommodates the user's head.

[0025] These and other advantages will be better understood thanks to the following description of different embodiments of said invention given as non-limitative examples thereof, making reference to the annexed drawings.

DRAWINGS DESCRIPTION

[0026] In the drawings:

Fig. 1 shows a schematic cross-sectional view of a helmet according to a first embodiment of the present invention;

Fig. 2 shows a schematic axonometric view of a helmet according to the first embodiment of the present invention;

Fig. 3 shows a schematic cross-sectional view of a further version of a helmet according to a first embodiment of the present invention;

Fig. 4 shows a schematic cross-sectional view of a helmet according to a second embodiment of the present invention;

Fig. 5 shows a schematic cross-sectional view of a further version of a helmet according to the second embodiment of the present invention;

Fig. 6 shows a schematic axonometric view of a helmet according to the second embodiment of the present invention;

Fig. 7 shows a schematic cross-sectional view of a helmet according to a third embodiment of the present invention;

Fig. 8 shows a schematic axonometric view of the helmet according to the third embodiment of the present invention;

Fig. 9 shows the helmet of Fig. 1 during an impact;

Fig. 10 shows the helmet of Fig. 5 during an impact;

Fig. 11 shows a partial schematic cross-sectional view of the foam liner and cellular energy-absorbing insert of the helmets during an impact;

Fig. 12 shows a schematic cross-sectional view of a helmet according to a fourth embodiment of the present invention;

Fig. 13 shows a schematic axonometric view of the helmet according to the fourth embodiment of the present invention.

DETAILED DESCRIPTION

[0027] The following description of one or more embodiments of the invention refers to the annexed drawings. The same reference numbers indicate equal or similar parts. The object of the protection is defined by the annexed claims. Technical details, structures or characteristics of the solutions here-below described can be combined with each other in any suitable way.

[0028] With the reference number 1 is represented a helmet according to the present invention. In particular,

Figs. 1-3 and 9 represent a first embodiment of the helmet according to the present invention, Figs. 4-6, 10 represent a second embodiment of the helmet according to the present invention, Figs. 7, 8 represent a third embodiment of the helmet according to the present invention, and Figs. 12, 13 represent a fourth embodiment of the helmet according to the present invention.

[0029] In the present description the term "cellular energy-absorbing insert" can be abbreviated with "cellular insert".

[0030] The helmet 1 of first embodiment comprises a foam liner 2, a shell 3, and at least one cellular energy-absorbing insert 4.

[0031] The foam liner 2 is a liner made of foam material, like EPP (Expanded Polypropylene) or EPS (Expanded Polystyrene).

[0032] The shell 3 is a thin layer, preferably made of a polymeric material such as PC (polycarbonate), PE (polyethylene), ABS (acrylonitrile butadiene styrene). Depending on the material, the shell can be thermo-moulded or thermo-formed or injection-moulded.

[0033] The shell 3 is directly attached to the foam liner 2 and it is, at least in part, in direct contact with it. The shell 3 covers, at least in part, the outer side of the foam liner 2.

[0034] The cellular insert 4 comprises an array of energy-absorbing open-cells 8. These open-cells 8 are connected to each other via their sidewalls 13, as schematically depicted in Fig. 11.

[0035] The cells 8 are open at their ends so that each open-cell 8 realizes a tube through which the air can flow. The tubular shape of the cell 8 can be defined by a single-piece sidewall 13 or by a multi-pieces sidewall 13. The open-cell 8 can have a circular cross-section as represented in Figs. 1, 4, 7 and 9. Alternatively, the open-cell 8 can have an arrowhead cross-section as represented in Figs. 3, 5, 10, 12. In a further alternative (not shown), the cross-section of the open-cells 8 can be a square, a hexagon, a non-uniform hexagon, a re-entrant hexagon, a chiral truss, a diamond, or a triangle.

[0036] The open-cells 8 of said array can be welded to each other via their sidewalls 13. Alternatively, the cells 8 can be bonded by means of adhesive layers interposed between adjacent sidewalls 13. This kind of adhesive can be a thermo-adhesive material, thus an adhesive that at room temperature is solid and becomes liquid above 80-100°C. Otherwise, the adhesive could also be a reactive adhesive or a pressure sensitive adhesive.

[0037] When the open-cells 8 have a circular cross-section, the outer diameter of the circular cross-section can range between 2,5 and 8 mm, and the wall thickness of said open-cells 9 can range between 0,05 and 0,2 mm.

[0038] The array of energy-absorbing open-cells 8 is configured to absorb energy through a plastic deformation of the sidewalls 13 in response to out-of-plane compression, wherein "plastic deformation" means that the sidewalls 13 crumple irreversibly. In this way, a large amount of energy is absorbed by the plastic deformation of the sidewalls. Alternatively, the array of energy-ab-

sorbing cells 8 can absorb energy through an elastic deformation of the sidewalls 13 of the open-cells 8. In the latter case, the deformation is almost completely reversible and the sidewalls 13 come back a shape similar or equal to the original one, when the compression ends.

[0039] The foam liner 2 comprises one or more through holes 5 that cross the foam liner 2 from outer side to inner side along its thickness.

[0040] On the inner side of the foam liner 2 can be accommodated the head 10 of the wearer, while on the outer side of the foam liner 2 is arranged the shell 3, as already described.

[0041] Normally through holes on the foam liner are used to ventilate the inside of the helmet and thus the user's head 10. In the helmet according to the present invention, the ventilation is reduced, limited or eliminated, because the present helmet requires a very limited or null ventilation. This kind of helmet is particularly useful for winter sport, thus on environments that are cold or very cold.

[0042] In order to limit or prevent the ventilation through these through holes 5, the holes 5 are closed from outside, as here-below described in detail with reference to the first and second embodiments.

[0043] In the helmet, the through hole 5 lies in correspondence of the cellular insert 4. Since each through hole 5 is closed, any cellular insert 4 does not receive an airflow from the through holes/s 5, and air cannot flow through them.

[0044] In the first embodiment, the shell 3 is continuous and closes the through hole/s 5.

[0045] In particular, the shell 3 entirely covers and spans across the through hole 5, as shown in Figs. 1, 2, 3, 9, 12, 13.

[0046] The advantage of having a foam liner 2 with through hole/s 5 and a continuous shell 3 that covers/closes them is that the same foam liner 2 can be employed even with a shell comprising vents. In this manner, the helmet manufacturer can mould only one type of foam liner and use it for multiple scopes. It's enough to change the outer shell 3 to obtain a ventilated helmet instead of a not-ventilated one.

[0047] When the shell 3 is an independent element, that is created separately with respect to the foam liner 2, e.g. when it is thermoformed or thermo-moulded, the shell 3 can be realized with apertures or without aperture. In the former case, the shell 3 will be employed on a ventilated helmet, in the latter case, the shell 3 will be employed in a not ventilated helmet or in a helmet having a very limited ventilation, like in the present invention. In this manner, using the same foam liner 2 having through holes 5 and a shell with apertures or a shell 3 without apertures, it's possible to obtain two different types of helmet, saving manufacturing costs.

[0048] In certain versions, the helmet of the present invention can comprise vent/s 11, as shown in Figs. 3, 5, 6, 7, 8, 10, 12 and 13. Through the vent/s 11 the air can

enter/exit in/from the cavity 14 configured to receive the wearer's head 10. The optional vents 11 of the helmet 1 are small and allow only a limited air exchange through them.

[0049] In any case, the eventual vent/s 11 is/are arranged outside the perimeter of the cellular insert 4, thus outside the perimeter of the face of the cellular insert 4 that faces the foam liner 2. Substantially, any vent 11 does not open on a position of the inner side of the foam liner 2 over which the cellular insert 4 is arranged, leaving the cellular insert 4 invisible from outside.

[0050] The one or more vents 11 directly ventilate the wearer's head 10, fluidly connecting the outside to the cavity 14 inside the helmet 1.

[0051] Preferably, the one or more vents 11 are provided in a front portion and a back portion of the helmet 1, as shown in Figs. 3, 5, 6, 7, 8, 10, 12 and 13, for facilitating the entrance and exit of air when the user moves forward, e.g. on skis or on a bike.

[0052] As depicted in Figs. 1, 3, 4, 5, 7, 9, 10, 12 the foam liner 2 comprises at least one recess 7 in which the at least one cellular insert 4 is arranged. The shape of the recess 7 is complementary or substantially complementary to the shape of the cellular insert 4. In this way, the cellular insert 4 fits the recess 7 and does not come out from it.

[0053] In particular, the recess 7 is conformed so that the bottom of the recess 7 is larger than its top, thus the aperture of the recess 7. In this manner, the cellular insert 4 once that is inserted in the recess 7, thanks to a light in-plane compression of the cellular insert 4, remains locked in the recess 7. Despite this locking, the cellular insert 4 can slide inside the recess 7 in case of an in-plane deformation of the cellular insert 4.

[0054] In order to facilitate this sliding a sliding layer 9 can be arranged between the foam liner and the cellular insert 4 for facilitating the relative movements of the cellular insert 4 with respect to the recess 7 of the foam liner 2. The sliding layer 9 can be a coating of a polymeric material that is sprayed over the inner side of the foam liner 2, in particular over the bottom of the recess/es 7. Alternatively, the sliding layer 9 can be a thin layer of a low friction material, like polyamide, PC (polycarbonate) or PTFE (Poly Tetra Fluoro Ethylene).

[0055] If the sliding layer 9 is a thin layer attached to the inner side of the foam liner 2, in particular to the bottom of the recess/es 7, the thin layer can span across the inner aperture of the through hole/s 5 closing it/them from inside. In this manner, the inner surface of the foam liner 2, or the bottom surface of the recess 7, is smooth and the cellular insert 4 can slide over it without jamming in case it is in-plane compressed against the sidewall of the recess 7 during an oblique impact of the helmet 1. Indeed, since the through hole 5 opens into one recess 7, the inner rim of the through hole 5 could represent an edge against which the cellular insert 4 can jam during an oblique impact, vanishing the positive effect provided by the sliding layer 9.

[0056] It's useful to underline that the relative tangential movement of the foam liner 2 with respect to the cellular insert 4, which remains substantially fixed to the head 10, reduce rotational acceleration and consequently injuries to brain during an oblique impact. Indeed, when an oblique impact occurs a force F, shown in Figs. 9, 10 and 11, applies a torque to the shell 3 and the foam liner 2. Since the helmet 1 is locked to the wearer's head 10 through a retaining system (not shown), the rotation of the shell 3 and foam liner 2 tends to be transferred to the wearer's head 10 causing an acceleration of brain mass and consequent injuries to the wearer. For mitigating this effect, the sliding layer 9 facilitated the relative sliding of the foam liner 2 with respect to the cellular insert 4 during an oblique impact and the tangential component of the force F provided by the oblique impact is transferred to the wearer's head only minimally.

[0057] Alternatively to a continuous shell 3 that closes the through holes 5, the helmet 1 of the second embodiment can comprise a shell 3 with apertures 12. Some apertures 12 lie in front and in correspondence of respective through holes 5. Some other apertures 12 can lie in front of respective vents 11, if the helmet 1 has vents 11.

[0058] Behind the aperture 12, thus between the shell 3 and the foam liner 2, a patch 6 can be arranged, as shown in Figs. 4, 5, 6, 7, 8, 10, 12, 13. The patch 6 lies above the foam liner 2, thus over the outer face of the foam liner 2, and below the shell 3. The patch 6 is preferably clamped between the shell 3 and the foam liner 2, as shown in Figs. 4, 5, 6, 7, 8, 10, 12, 13.

[0059] In the second embodiment, the patch 6 is a continuous non-porous sheet 6', as shown in Figs. 4, 5, 6, 10, 12, 13. In this case, the air cannot cross the patch 6 and cannot enter in the underlying hole 5.

[0060] The patch 6 can be attached to the foam liner 2 and then the shell 3 with aperture/s 12 attached to the foam liner 2.

[0061] In particular version of the second embodiment, the continuous patch 6' can be made of a transparent material that allows to see the underlying components, for example the through hole/s 5 and the cellular insert/s 4.

[0062] In a further particular version of the second embodiment, the continuous patch 6' can comprise micro-holes for admitting only a limited amount of air through it.

[0063] In the third embodiment, the patch 6 is a piece of fabric or a mesh 6", e.g. a plastic or metallic mesh. In this way, a small amount of air can cross the patch 6 and reach the through hole 5. Figs. 7, 8 show a helmet 1 with some pieces of a mesh that cover respective through holes 5. Depending on the weave, the permeability of the mesh can increase or decrease.

[0064] Even when the helmet 1 comprises a patch 6, a sharp element cannot penetrate inside the through hole 5, in particular if the patch 6 is continuous non-porous sheet 6' or a mesh 6".

[0065] The fourth embodiment, shown in Figs. 12 and

13, is a combination of first and second/third embodiment. The helmet 1 comprises certain through holes 5 that are covered by the shell 3 like in the first embodiment, and certain other through holes 5 that are covered by patch/es 6. Substantially, this helmet 1 is a hybrid version between that of first embodiment and that of the second/third embodiment. In this embodiment, the patch 6 can be a continuous non-porous sheet 6', like in the second embodiment or a fabric/mesh 6" like in the third embodiment. Preferably, the non-porous sheet 6' can be a transparent sheet that allows to see the cellular insert 4 inside the helmet 1.

[0066] The helmet of this fourth embodiment, as depicted in Figs 12 and 13, can also comprise one or more vents 11 arranged in front and/or in the back portion of the helmet 1 for allowing a perspiration between the inner cavity 14 and the outside environment.

[0067] Alternatively to small and discrete patches 6, like those shown in Figs. 4, 5, 6, 7, 8, 10, 12, 13, a single thin liner can be arranged between the shell 3 and the foam liner 2 and attached to one or both of them.

[0068] Concluding, the invention so conceived is susceptible to many modifications and variations all of which fall within the scope of the inventive concept, furthermore all features can be substituted to technically equivalent alternatives. Practically, the quantities can be varied depending on the specific technical requirements. Finally, all features of previously described embodiments can be combined in any way, so as to obtain other embodiments that are not herein described for reasons of practicality and clarity.

Legend of reference signs:

[0069]

- | | | |
|----|----------------------------------|--|
| 1 | helmet | |
| 2 | foam liner | |
| 3 | shell | |
| 4 | cellular energy-absorbing insert | |
| 5 | through hole (of the foam liner) | |
| 6 | patch | |
| 6' | continuous non-porous sheet | |
| 6" | mesh | |
| 7 | recess | |
| 8 | cell | |
| 9 | sliding layer | |
| 10 | wearer's head | |
| 11 | vent | |
| 12 | aperture (of the shell) | |
| 13 | sidewall (of the cell) | |
| 14 | cavity | |

Claims

1. Helmet (1) comprising:
 - a foam liner (2) having at least one through hole

(5) crossing the foam liner (2) along its thickness;

- a shell (3) covering at least in part the outside of the foam liner (2);

- at least one cellular energy-absorbing insert (4) comprising a plurality of interconnected open cells (8) that are configured to absorb energy by plastic deformation in response to a compressive load crushing the cellular energy-absorbing insert (4);

wherein the cellular energy-absorbing insert (4) is arranged inside the foam liner (2);

wherein the at least one through hole (5) lies in correspondence of said cellular energy-absorbing insert (4); and

wherein the at least one through hole (5) is closed from outside.

2. Helmet (1) according to claim 1, wherein the at least one through hole (5) is closed by the shell (3).

3. Helmet (1) according to claim 2, wherein the shell (3) entirely covers and spans across the at least one through hole (5).

4. Helmet (1) according to claim 2 or 3, wherein the shell (3) is attached, in a direct manner, to the foam liner (2).

5. Helmet (1) according to any one of preceding claims, further comprising at least one patch (6), wherein the at least one patch (6) is arranged between the foam liner (2) and the shell (3), and is configured to close the at least one through hole (5).

6. Helmet (1) according to claim 5, wherein the patch (6) is clamped between the shell (3) and the foam liner (2).

7. Helmet (1) according to claim 5 or 6, wherein the patch (6) comprises a continuous non-porous sheet (6'), a fabric or a mesh (6").

8. Helmet (1) according to any one of preceding claims, wherein the foam liner (2) is made of a polymer foam like EPS or EPP.

9. Helmet (1) according to any one of preceding claims, wherein the foam liner (2) comprises at least one recess (7) configured to receive and contain the at least one cellular energy-absorbing insert (4), preferably the shape of the at least one recess (7) is complementary to the shape of the corresponding cellular energy-absorbing insert (4).

10. Helmet (1) according to claim 9, wherein the at least one through hole (5) opens into the at least one recess (7).

11. Helmet (1) according to any one of preceding claims, further comprising a sliding layer (9) arranged between the foam liner (2) and the cellular energy-absorbing insert (4) and configured to facilitate sliding of cellular energy-absorbing insert (4) with respect to the foam liner (2). 5
12. Helmet (1) according to claim 11, wherein the sliding layer (9) closes the at least one through hole (5) from inside. 10
13. Helmet (1) according to any one of preceding claims, wherein the foam liner (2) further comprises one or more vents (11) lying outside a perimeter of said cellular energy-absorbing insert (4) so as to directly ventilate a wearer's head (10) without crossing the cellular energy-absorbing insert (4). 15
14. Helmet (1) according to claim 13, wherein the shell (3) comprises aperture/s (12) in correspondence of said one or more vents (11) and/or said at least one through hole (5) of the foam liner (2). 20
15. Helmet (1) according to claim 13 or 14, wherein said one or more vents (11) are arranged in the front and/or back portions of the helmet (1). 25

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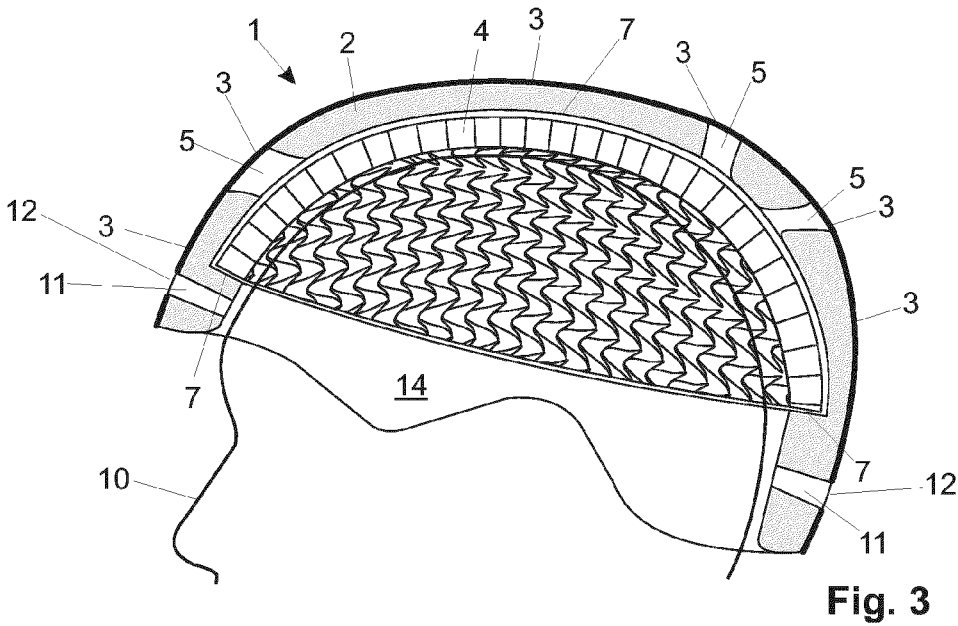
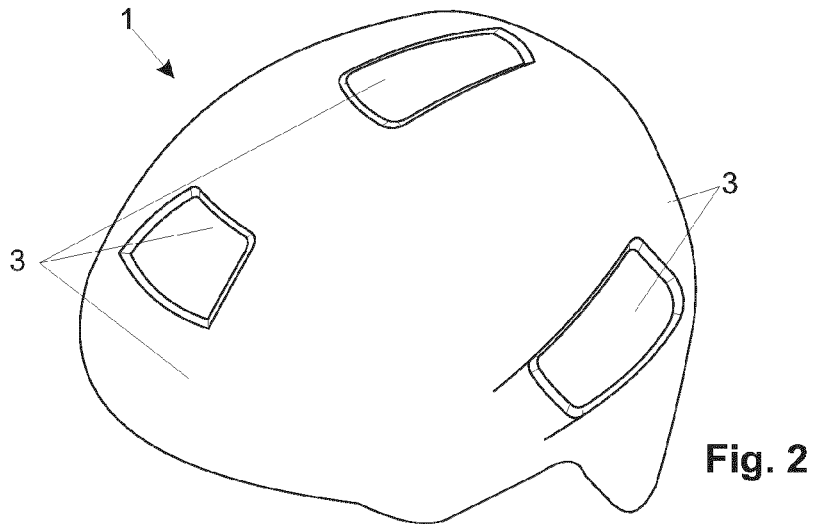
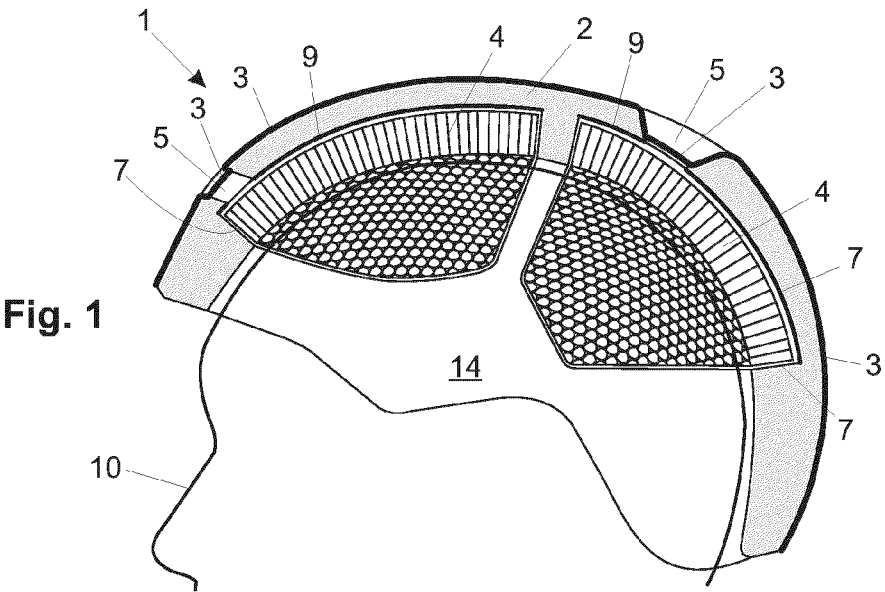
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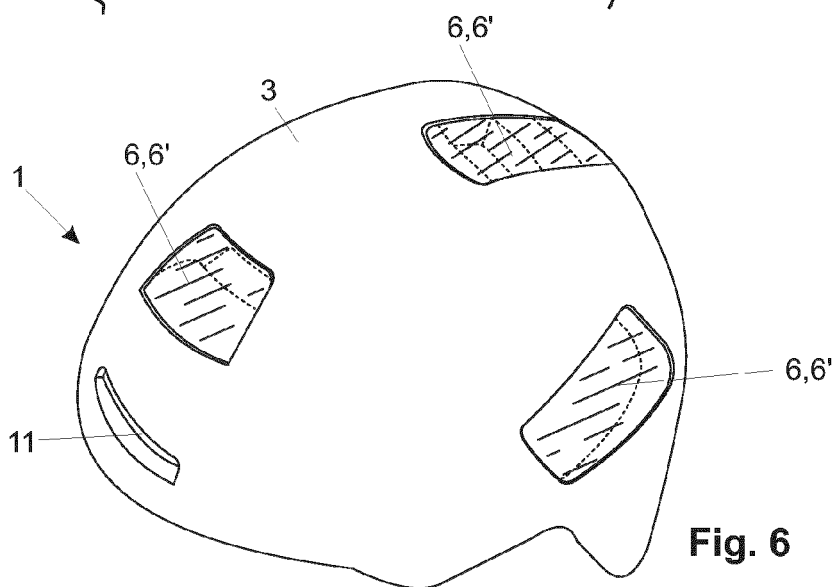
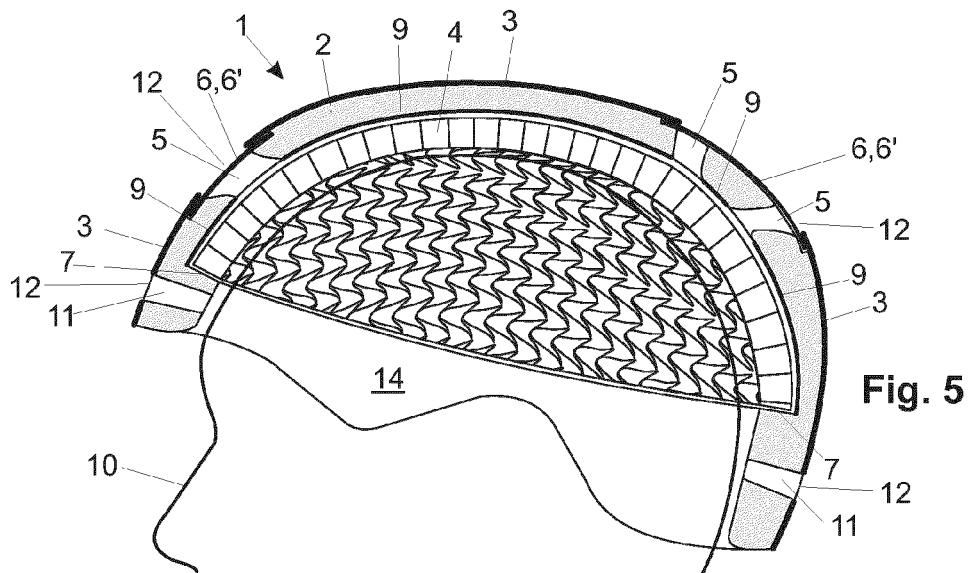
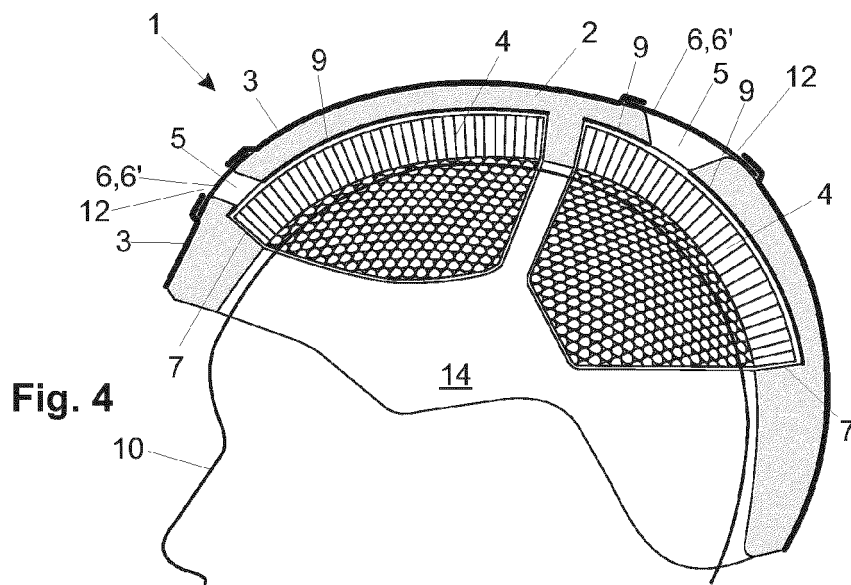
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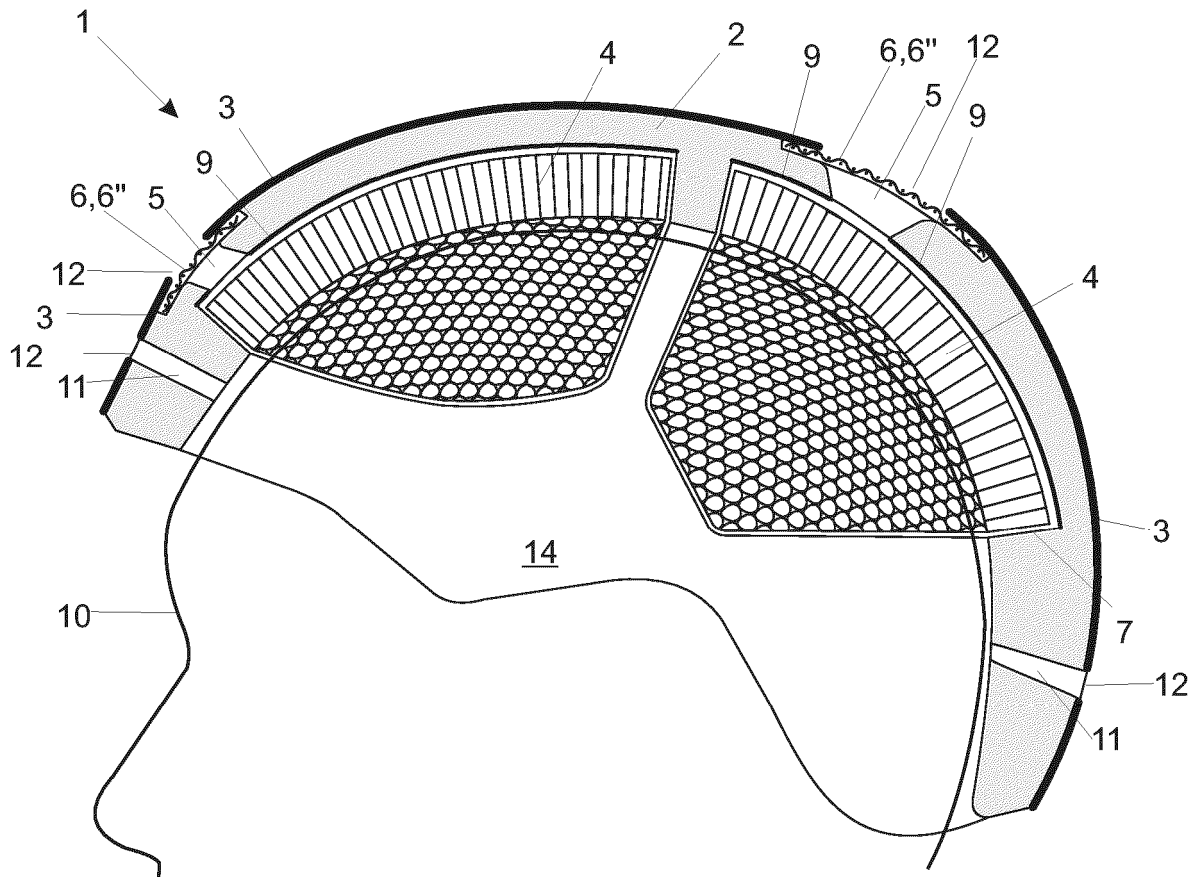


Fig. 7

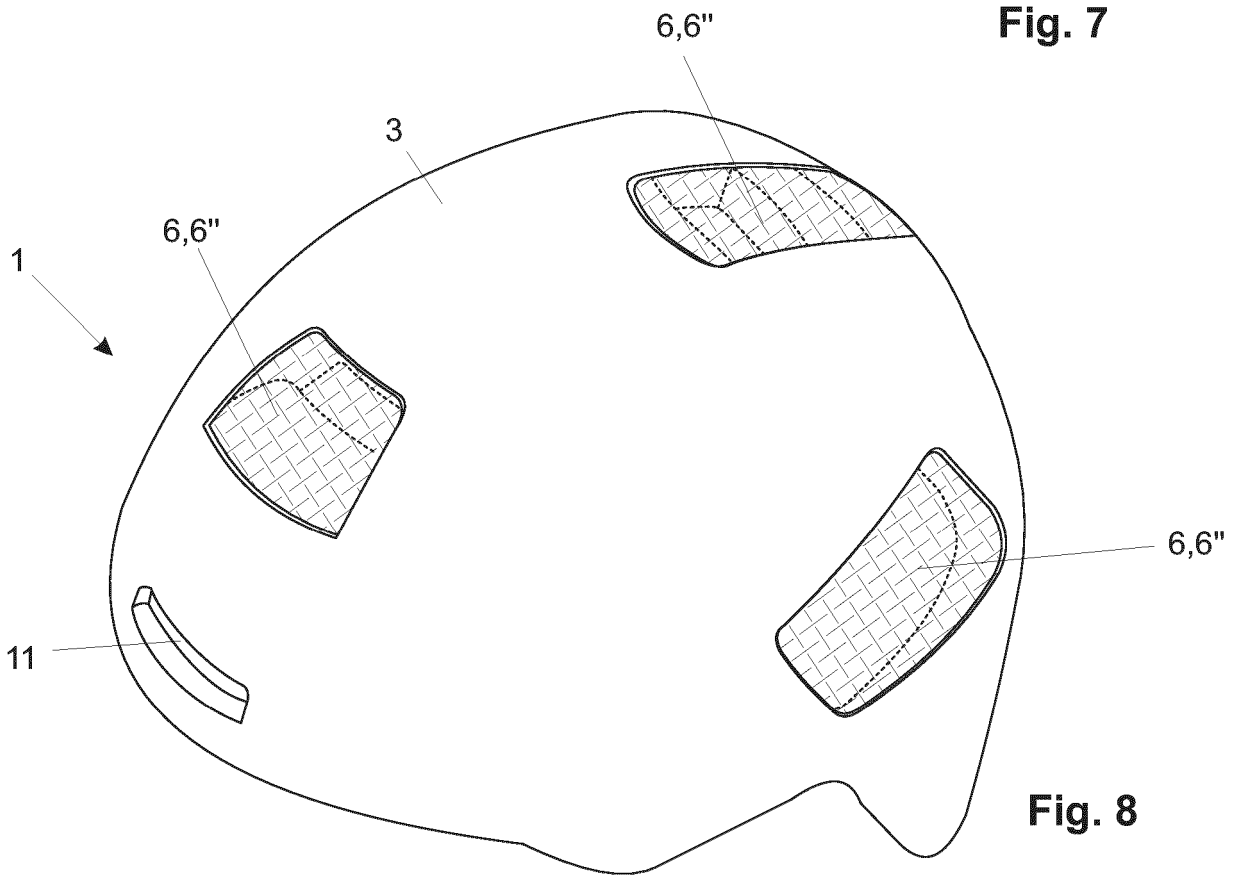


Fig. 8

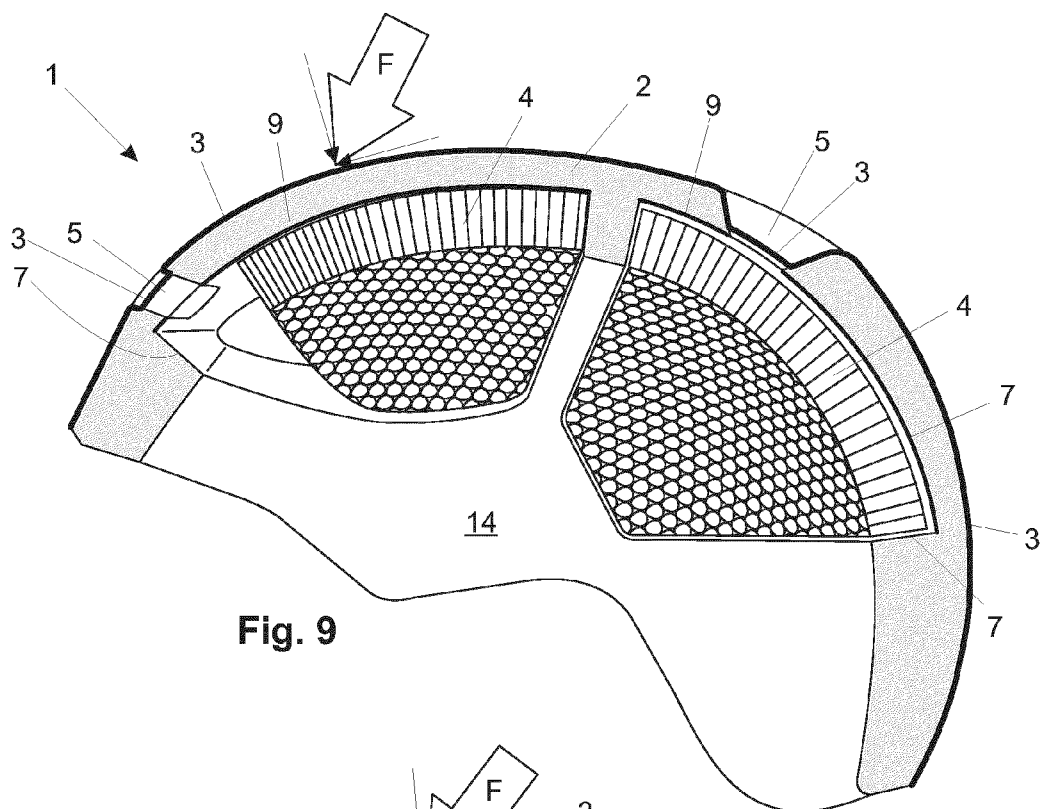


Fig. 9

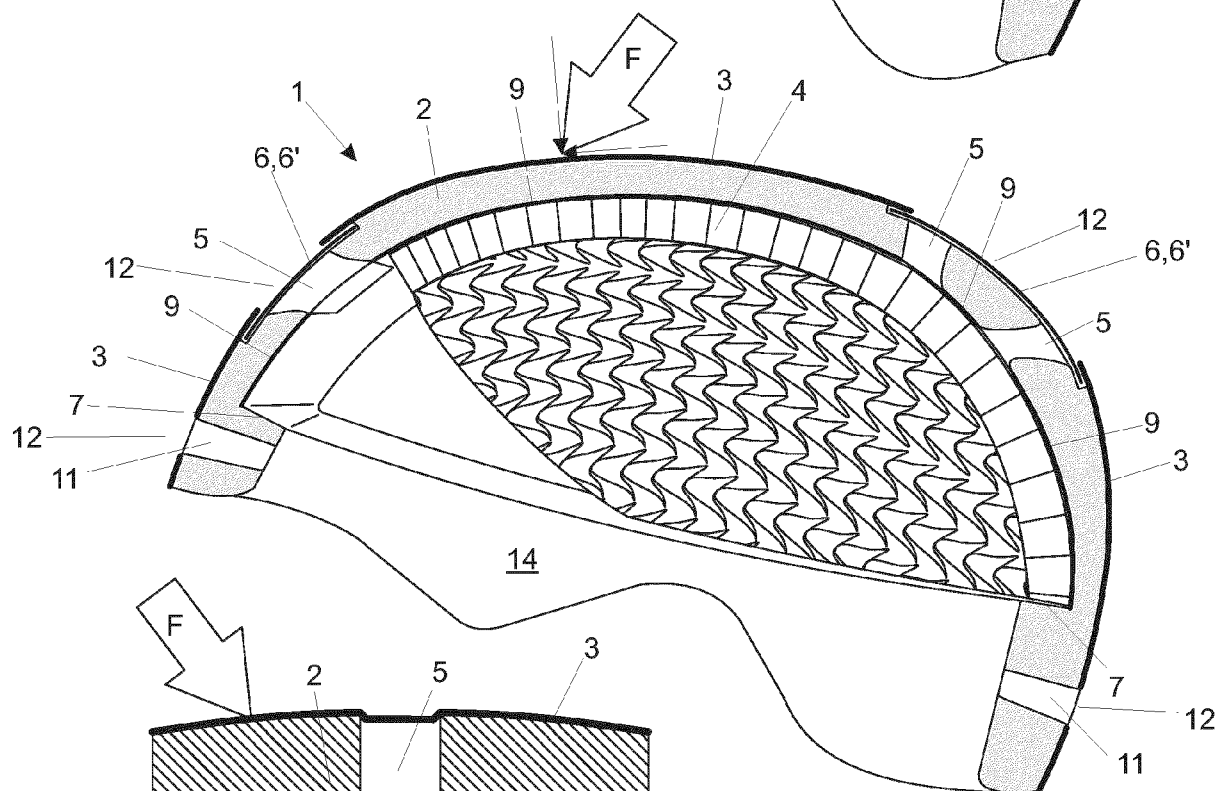


Fig. 10

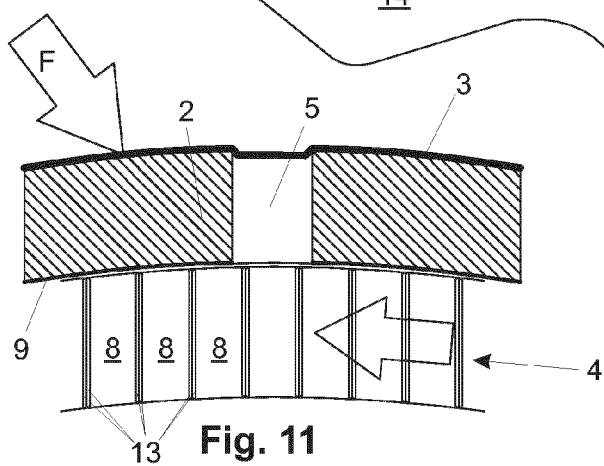
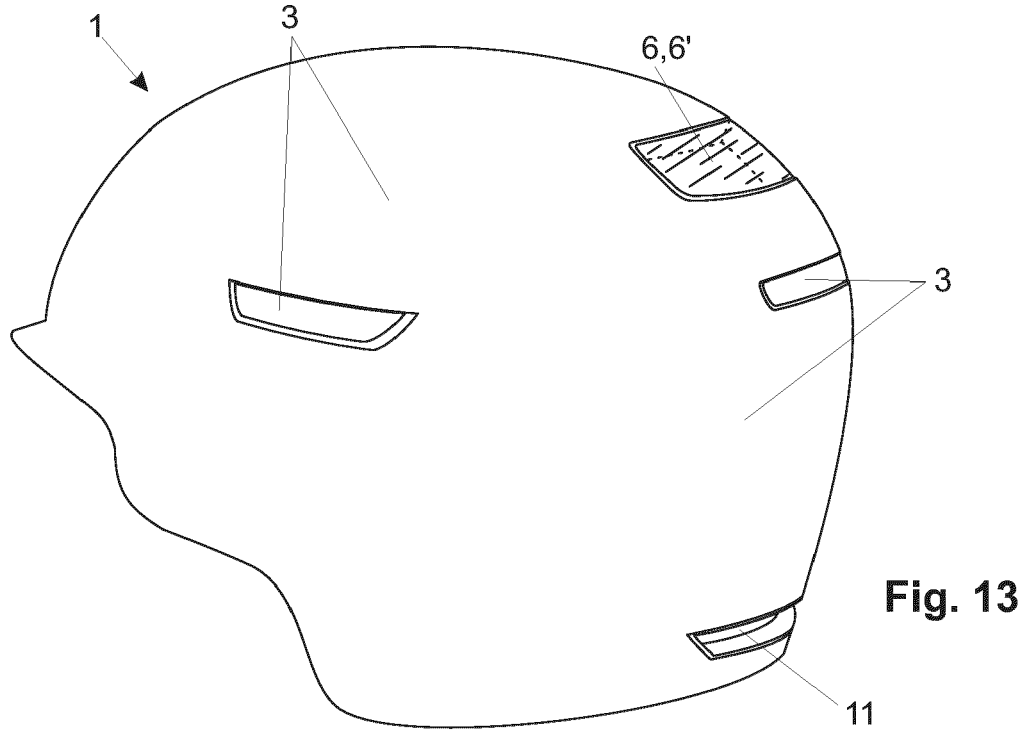
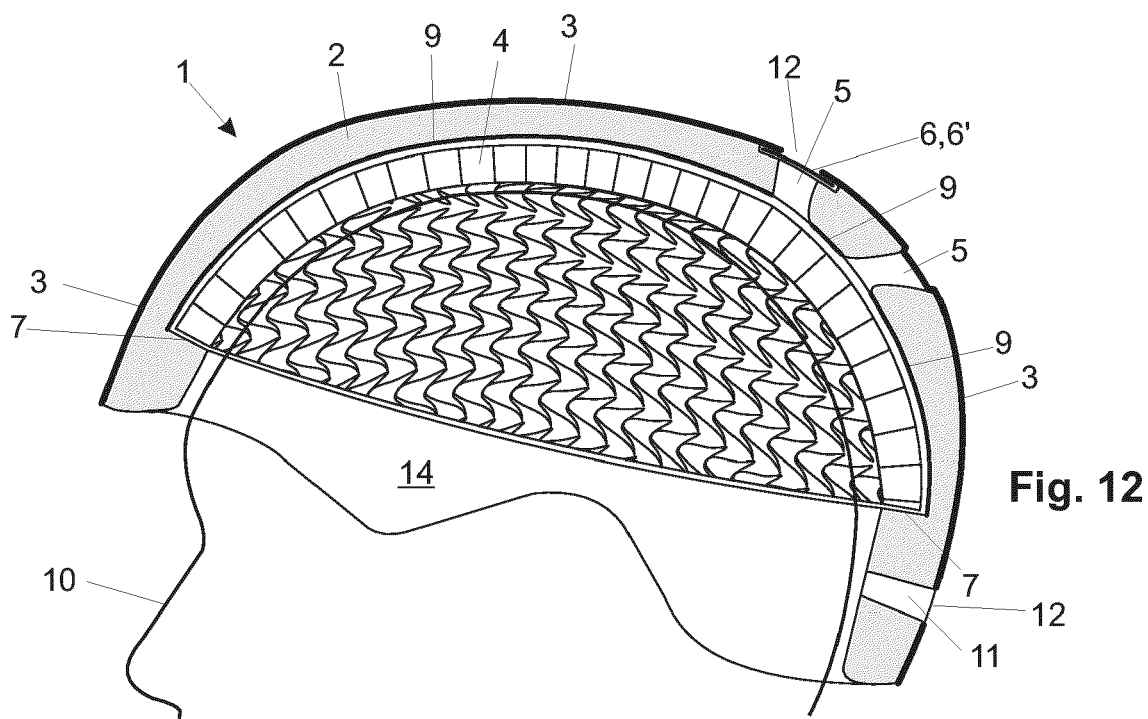


Fig. 11





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