US010517346B2

(12) **United States Patent**
Suddaby

(10) **Patent No.: US 10,517,346 B2**
(45) **Date of Patent: *Dec. 31, 2019**

(54) **HELMET WITH MULTIPLE PROTECTIVE ZONES**

(71) Applicant: **Loubert S. Suddaby**, Orchard Park, NY (US)

(72) Inventor: **Loubert S. Suddaby**, Orchard Park, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 263 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/602,678**

(22) Filed: **May 23, 2017**

(65) **Prior Publication Data**

US 2017/0251744 A1 Sep. 7, 2017

Related U.S. Application Data

(63) Continuation of application No. 13/841,076, filed on Mar. 15, 2013, now Pat. No. 9,795,178, which is a continuation-in-part of application No. 13/412,782, filed on Mar. 6, 2012, now abandoned.

(51) **Int. Cl.**

A42B 3/12	(2006.01)
A42B 3/06	(2006.01)
A42B 3/32	(2006.01)

(52) **U.S. Cl.**

CPC ***A42B 3/121*** (2013.01); ***A42B 3/064*** (2013.01); ***A42B 3/124*** (2013.01); ***A42B 3/326*** (2013.01)

(58) **Field of Classification Search**

CPC A42B 3/121; A42B 3/064; A42B 3/124; A42B 3/322; A42B 3/326

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,194,903	A	3/1940	Holstein
2,861,272	A	11/1958	Stuart et al.
3,089,144	A	5/1963	Cherup
3,107,356	A	10/1963	Pestronk et al.
3,167,069	A	1/1965	Lobelle
3,600,714	A	8/1971	Cade et al.
3,616,463	A	11/1971	Theodore et al.
3,668,704	A	6/1972	Conroy et al.
3,872,511	A	3/1975	Nichols

(Continued)

FOREIGN PATENT DOCUMENTS

CN	201094314	8/2008
DE	19544375	3/1997

(Continued)

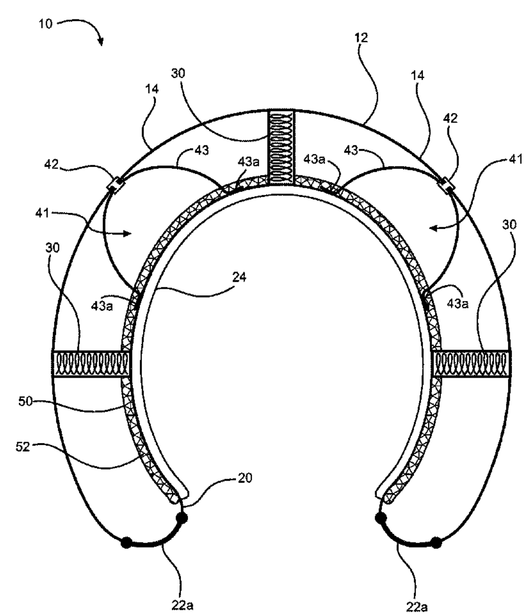
Primary Examiner — Sally Haden

(74) *Attorney, Agent, or Firm* — Simpson & Simpson, PLLC

(57) **ABSTRACT**

A protective helmet, including a hard outer shell, a hard inner shell slidingly connected to, and spaced apart from, the outer shell, and a leaf spring including a center portion, a first end, and a second end, the leaf spring anchored only at the center portion onto the hard outer shell, the first end unattached to, and in sliding contact with the hard inner shell, and the second end unattached to, and in sliding contact with the hard inner shell. In a neutral position, the first end is spaced from the second end by a first distance, and when a force strikes the helmet, the first end is spaced from the second end by a second distance, the second distance being different from the first distance.

18 Claims, 23 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

3,875,275 A 4/1975 Lemelson
3,946,441 A 3/1976 Johnson
4,023,209 A 5/1977 Frieder, Jr. et al.
4,075,717 A 2/1978 Lemelson
4,307,471 A * 12/1981 Lovell A42B 3/065 2/411
4,586,200 A 5/1986 Poon
4,903,346 A 2/1990 Reddemann et al.
5,101,517 A 4/1992 Douglas
5,181,279 A 1/1993 Ross
5,204,998 A * 4/1993 Liu F16F 1/3732 2/411
5,263,202 A 11/1993 Siberell
5,319,808 A 6/1994 Bishop et al.
5,815,846 A 10/1998 Calonge
5,950,244 A 9/1999 Fournier et al.
5,956,777 A 9/1999 Ponovich
6,138,283 A 10/2000 Kress
6,604,246 B1 8/2003 Obreja
6,658,671 B1 12/2003 Von Holst et al.
6,817,039 B1 11/2004 Grilliot et al.
8,176,574 B2 5/2012 Bryant et al.
2008/0229488 A1 9/2008 Kim
2010/0000009 A1* 1/2010 Morgan A42B 3/124 2/414
2012/0198604 A1 8/2012 Weber et al.
2012/0233745 A1 9/2012 Veazie
2012/0297526 A1 11/2012 Leon
2013/0061371 A1 3/2013 Phipps et al.
2014/0173810 A1 6/2014 Suddaby

FOREIGN PATENT DOCUMENTS

EP 0048442 3/1982
JP 2001295129 10/2001
WO WO 2010-151631 12/2010
WO 2011090381 7/2011

* cited by examiner

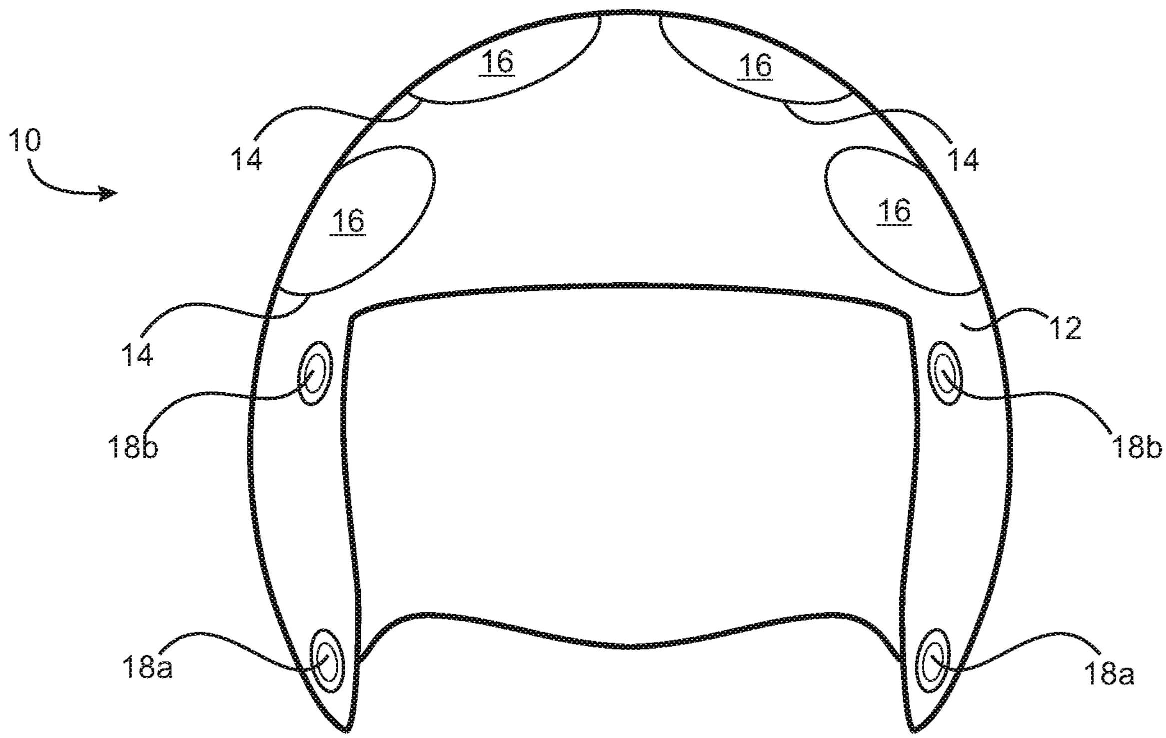

10
16
16
14
14
16
16
14
12
18b
18b
18a
18a

Fig. 1

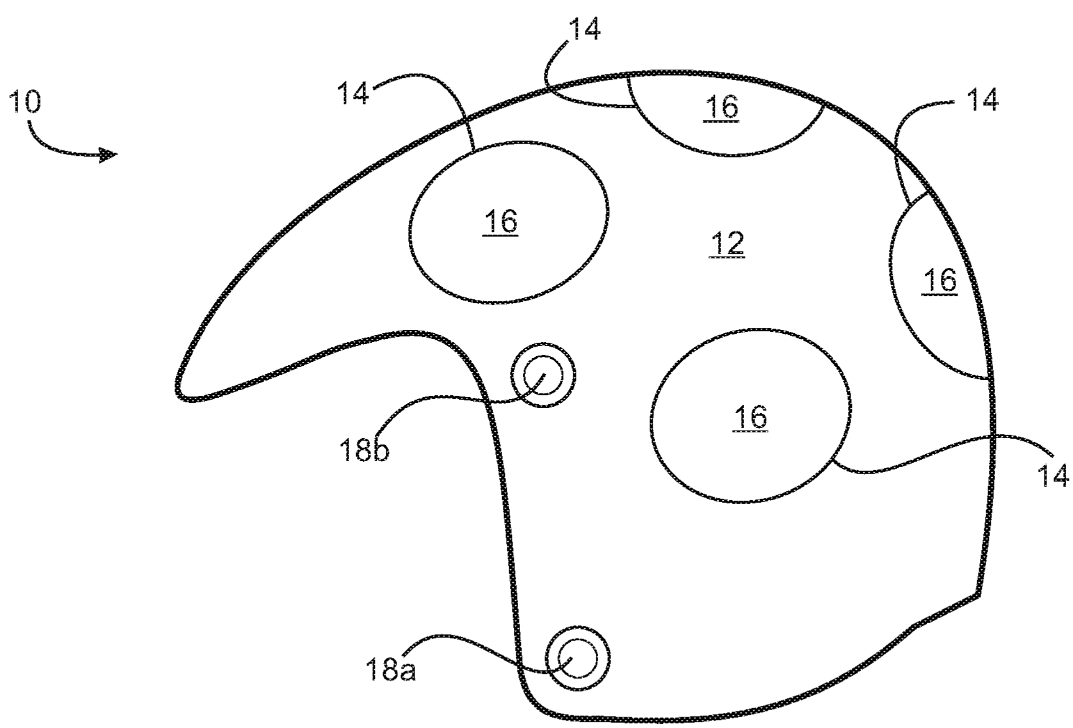

14
14
14
10
16
16
12
16
18b
16
14
18a

Fig. 2

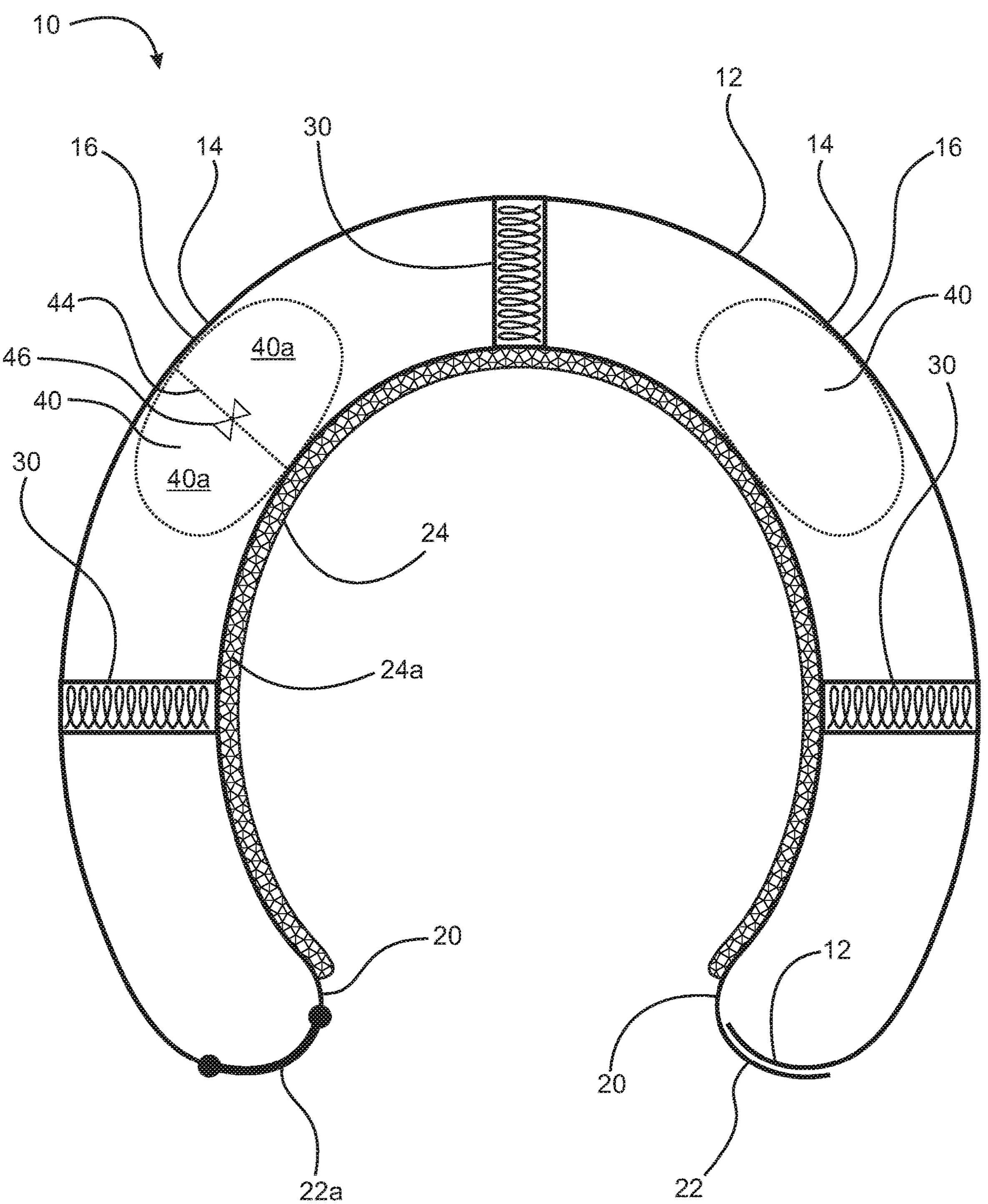


Fig. 3A

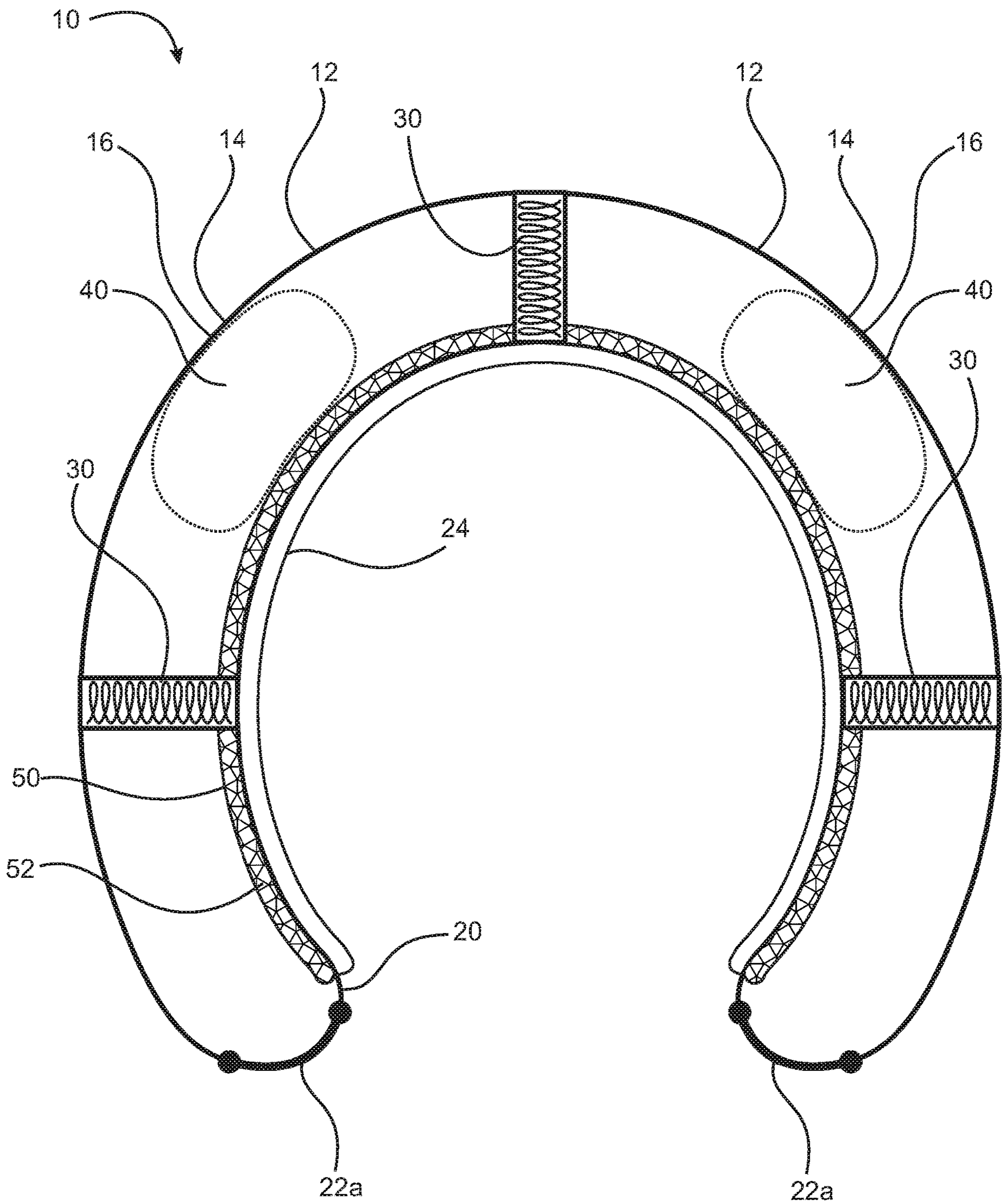


Fig. 3B

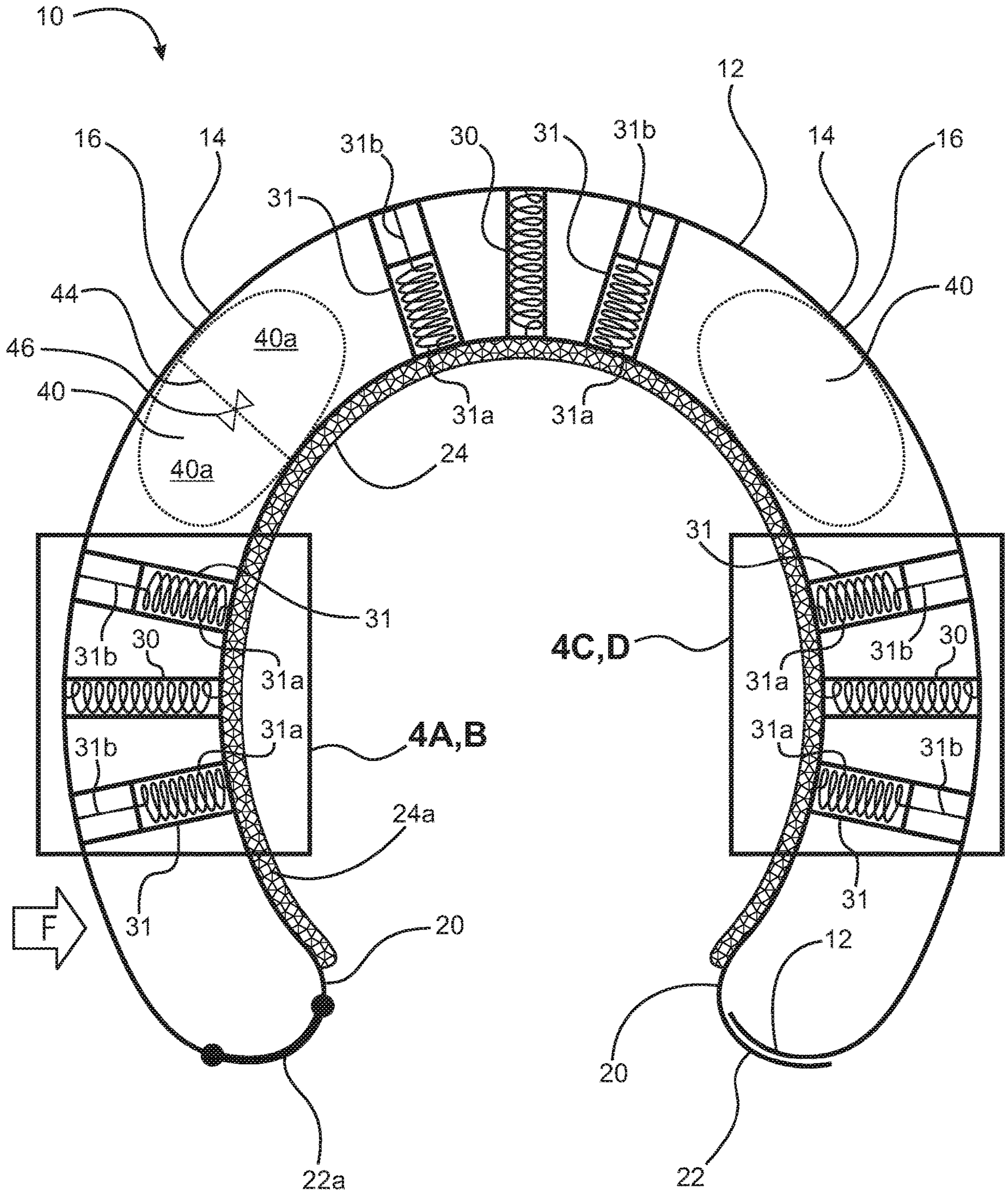

10
12
16
14
31b
30
31
31b
14
16
31
44
40a
40
46
40
40a
31a
31a
24
31
31
31b
30
31a
4C,D
31b
30
31a
31b
31a
4A,B
31a
31b
24a
31
31
F
20
12
20
22a
22

Fig. 3C

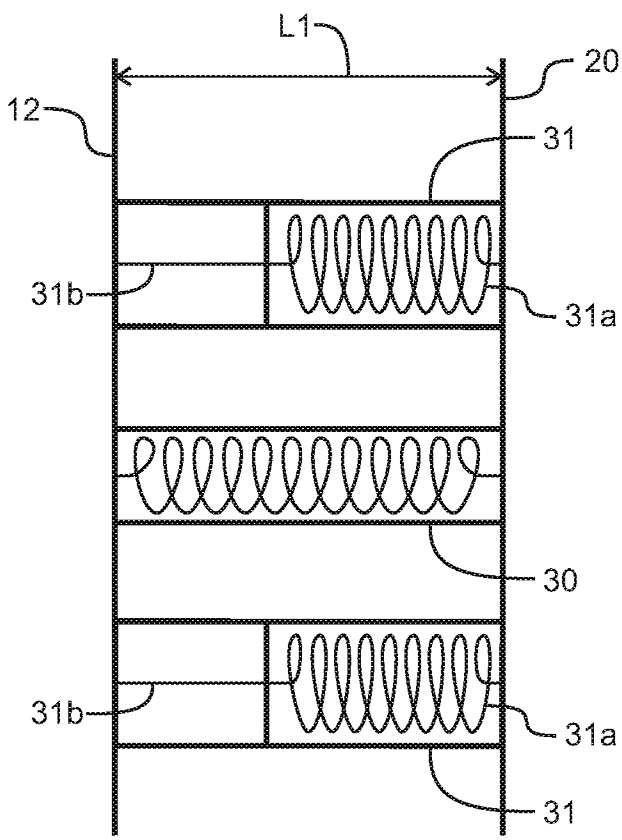


Fig. 4A

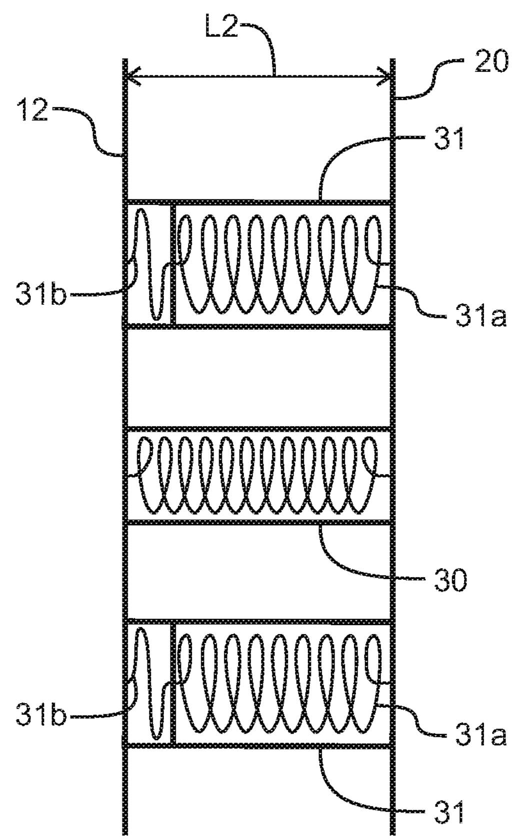


Fig. 4B

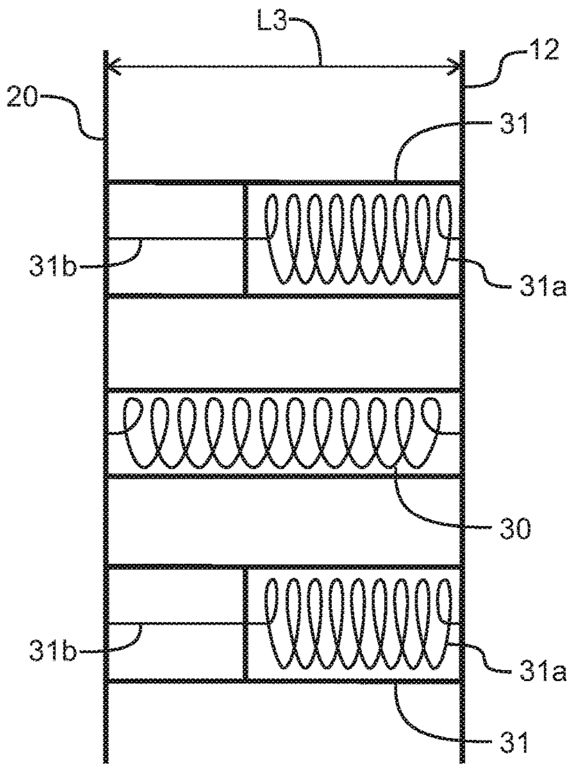


Fig. 4C

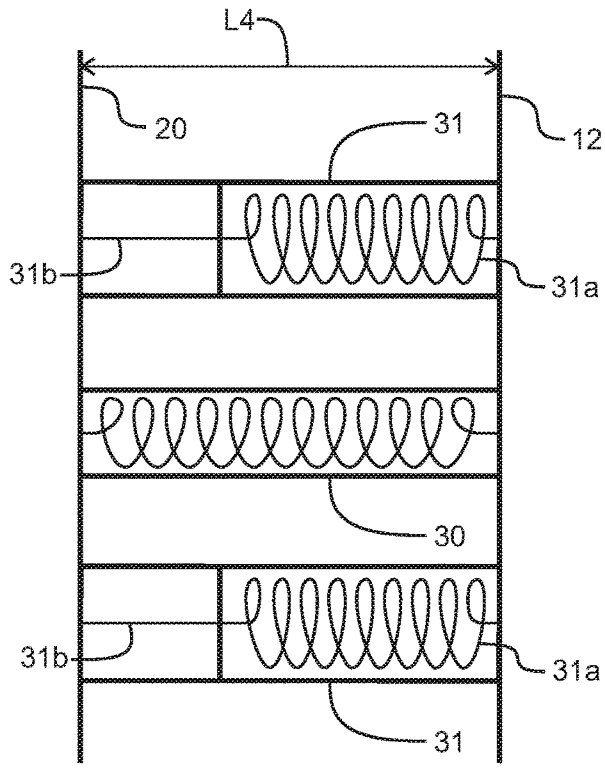


Fig. 4D

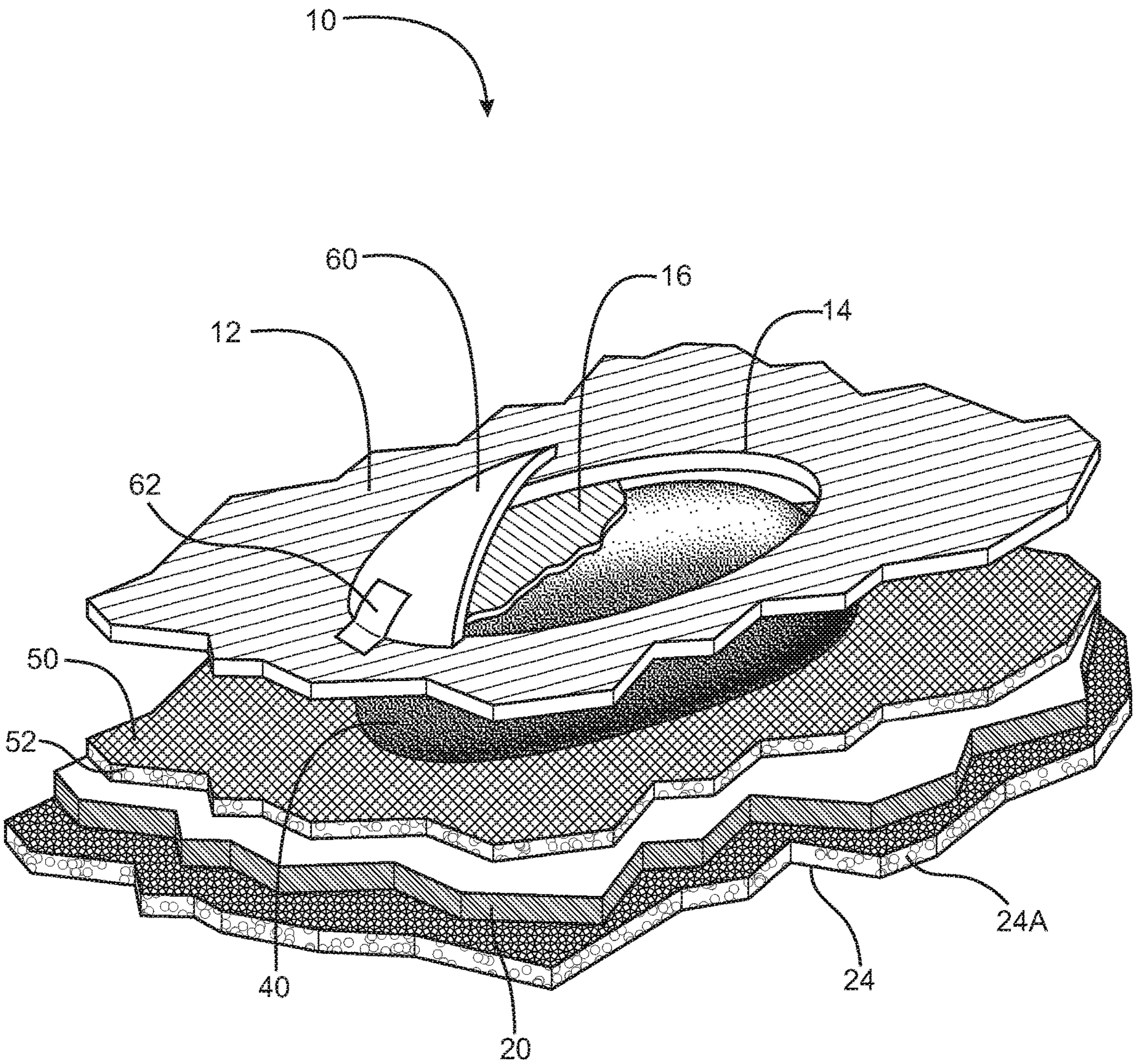


Fig. 5A

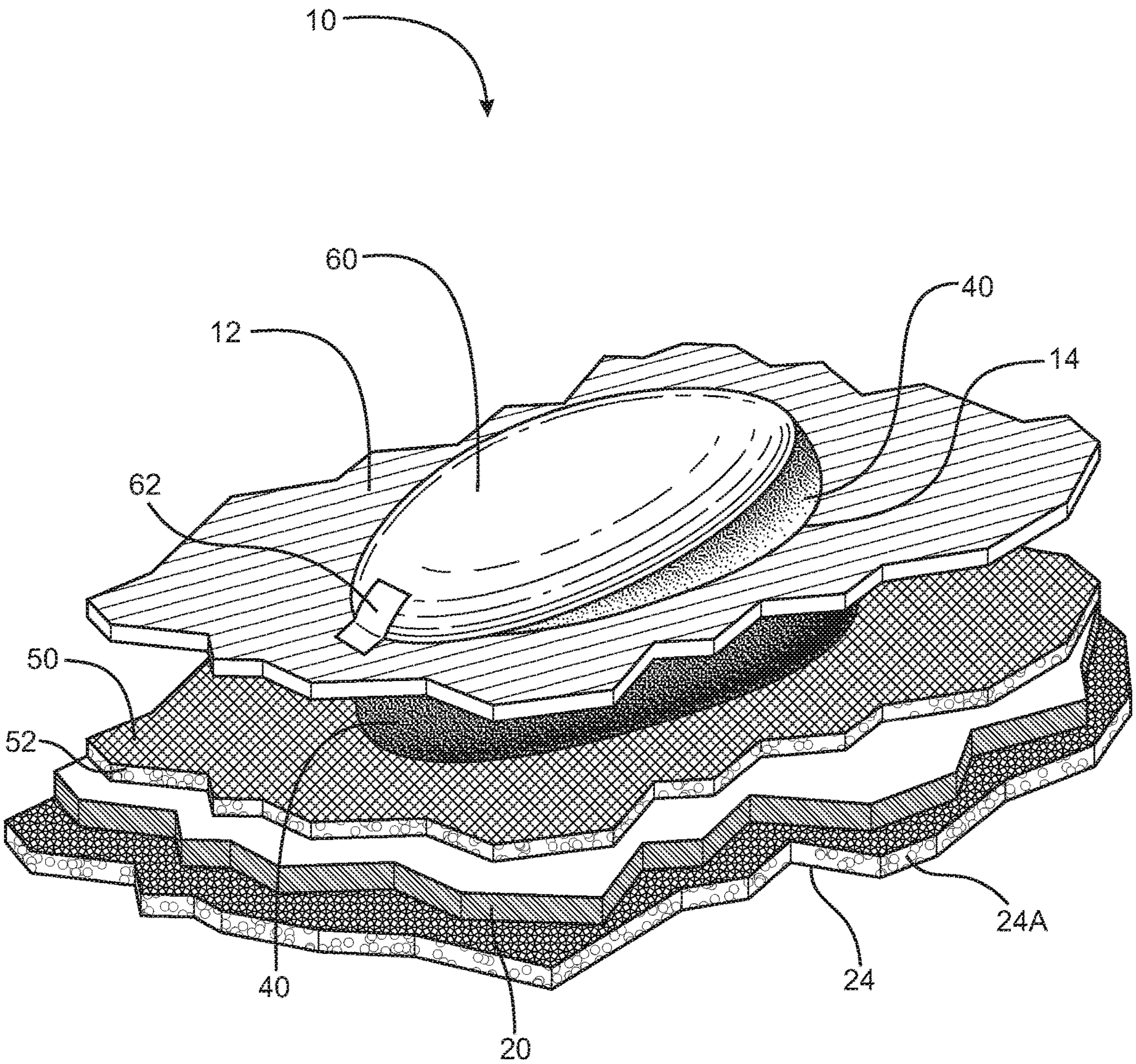


Fig. 5B

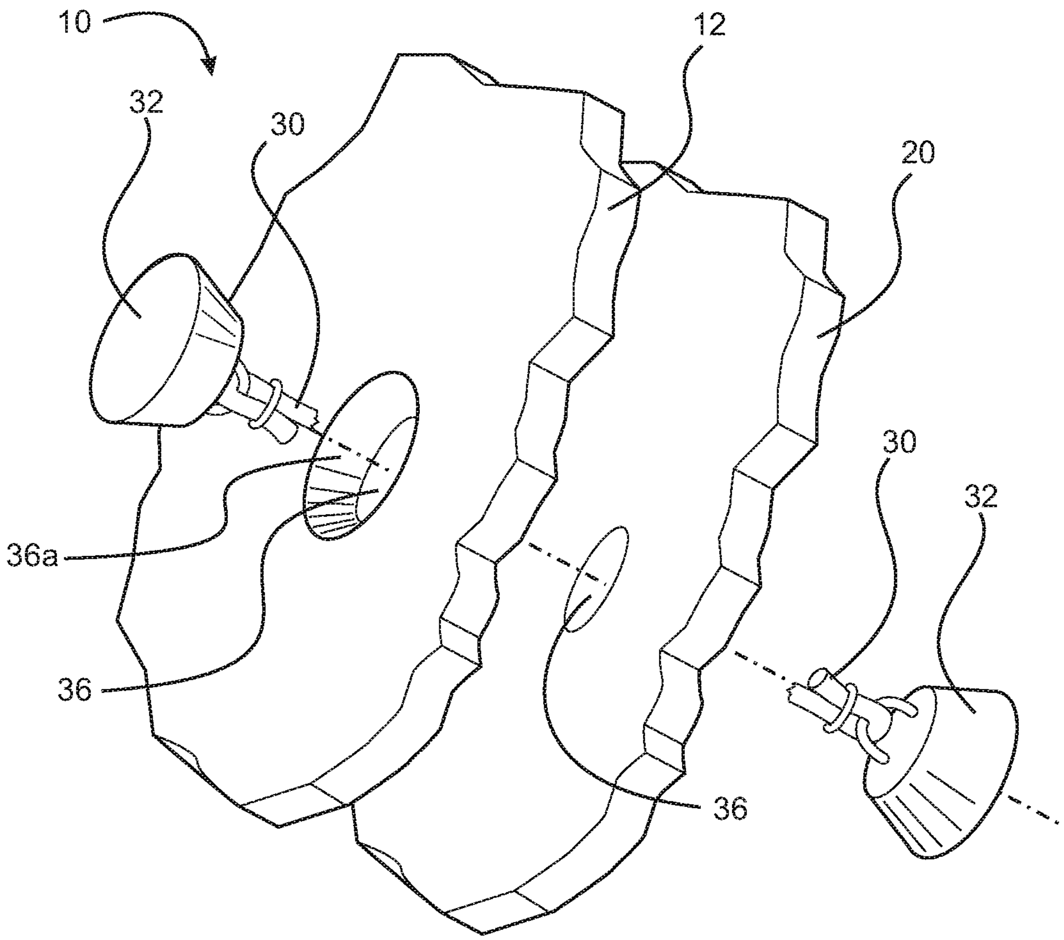


Fig. 6A

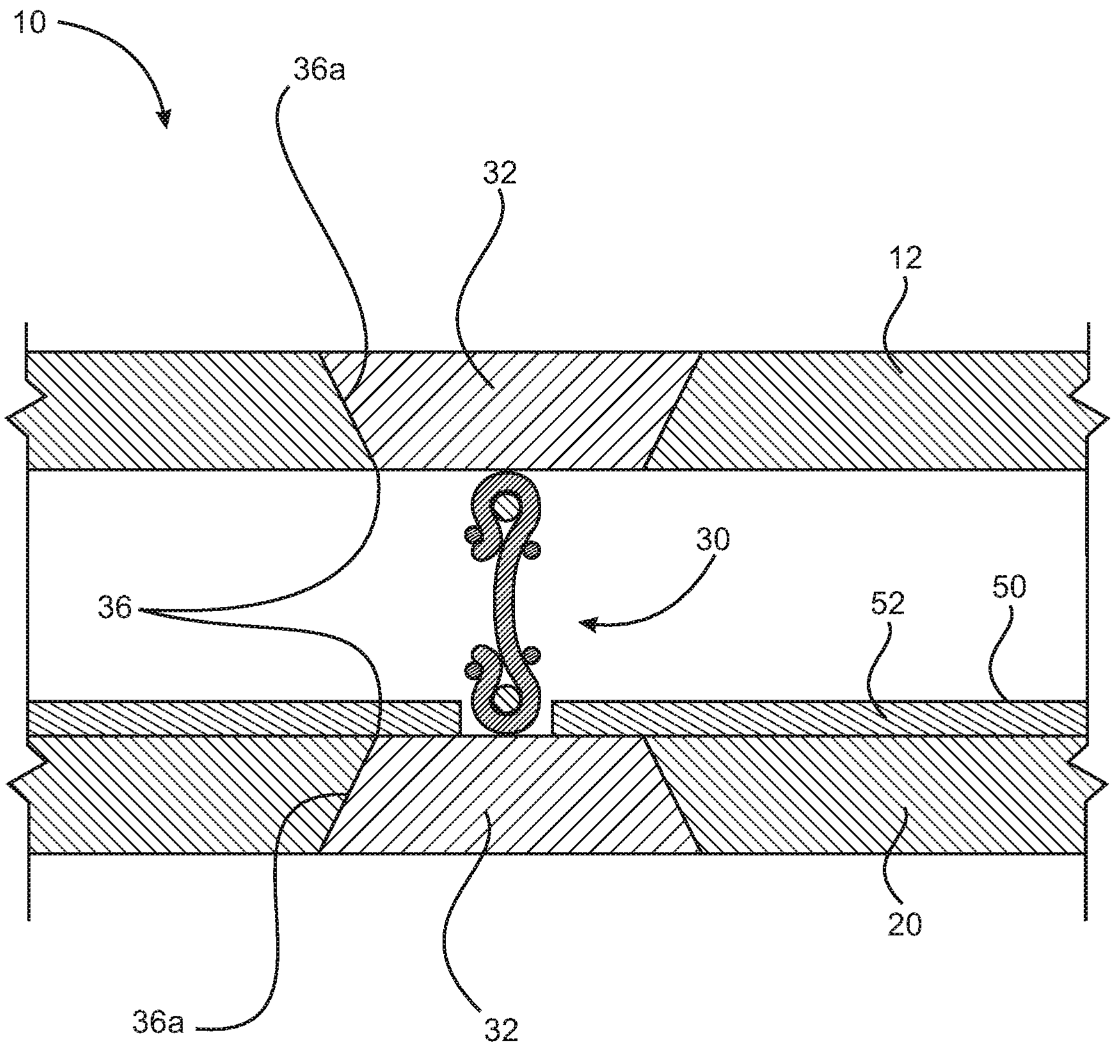
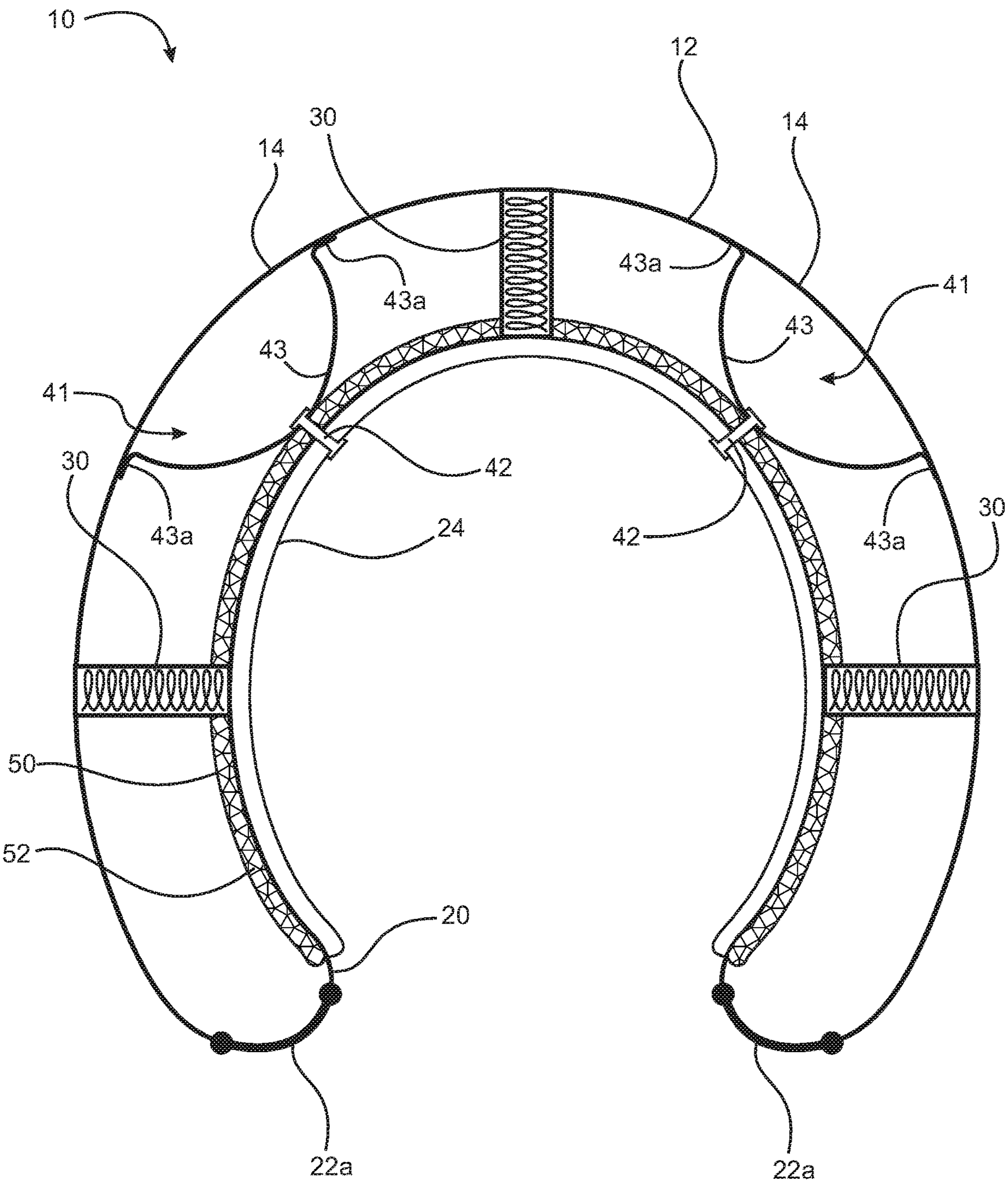


Fig. 6B



10
12
30
14
14
43a
43a
41
43
43
41
42
30
43a
42
24
43a
30
50
52
20
22a
22a

Fig. 7

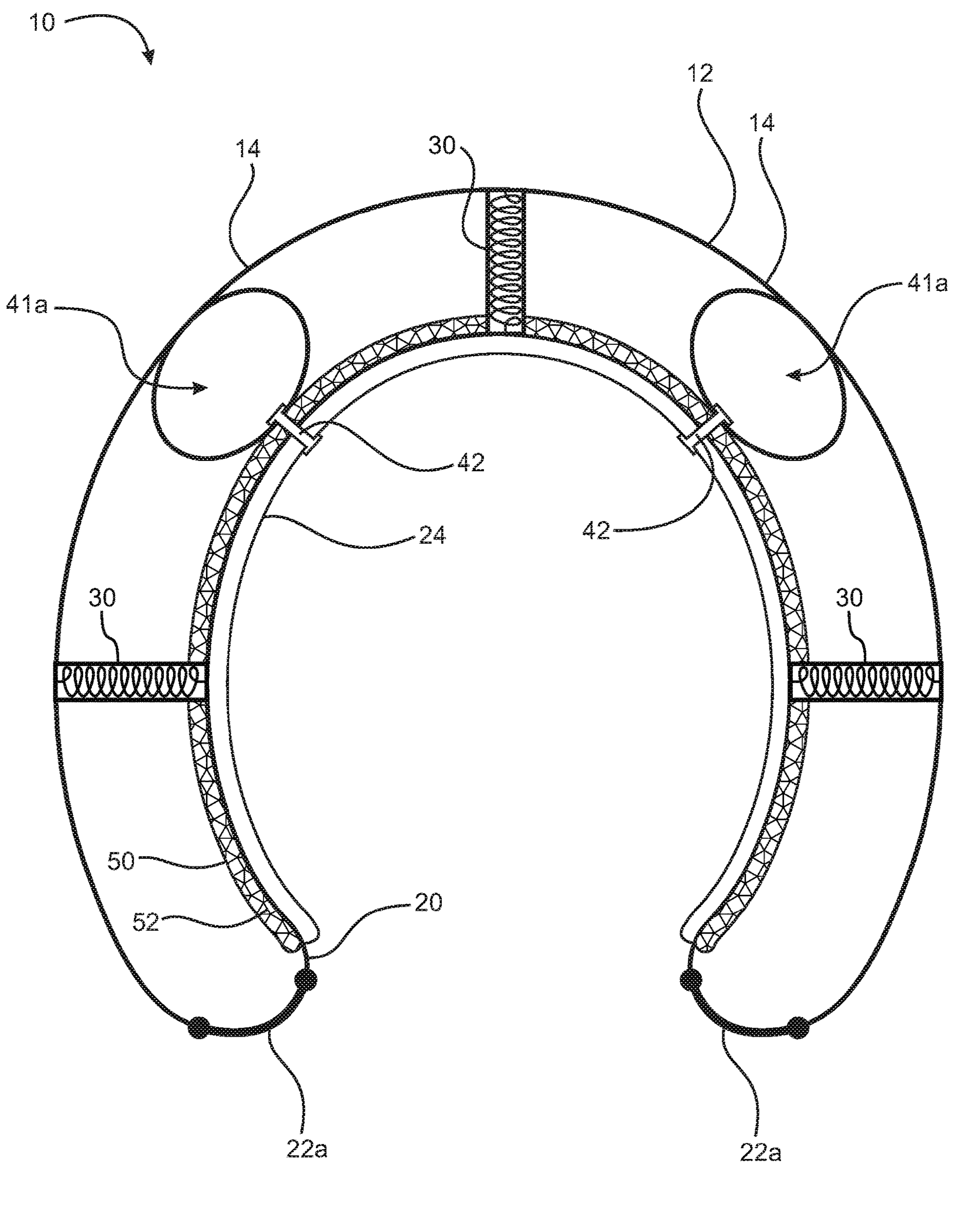


Fig. 7A

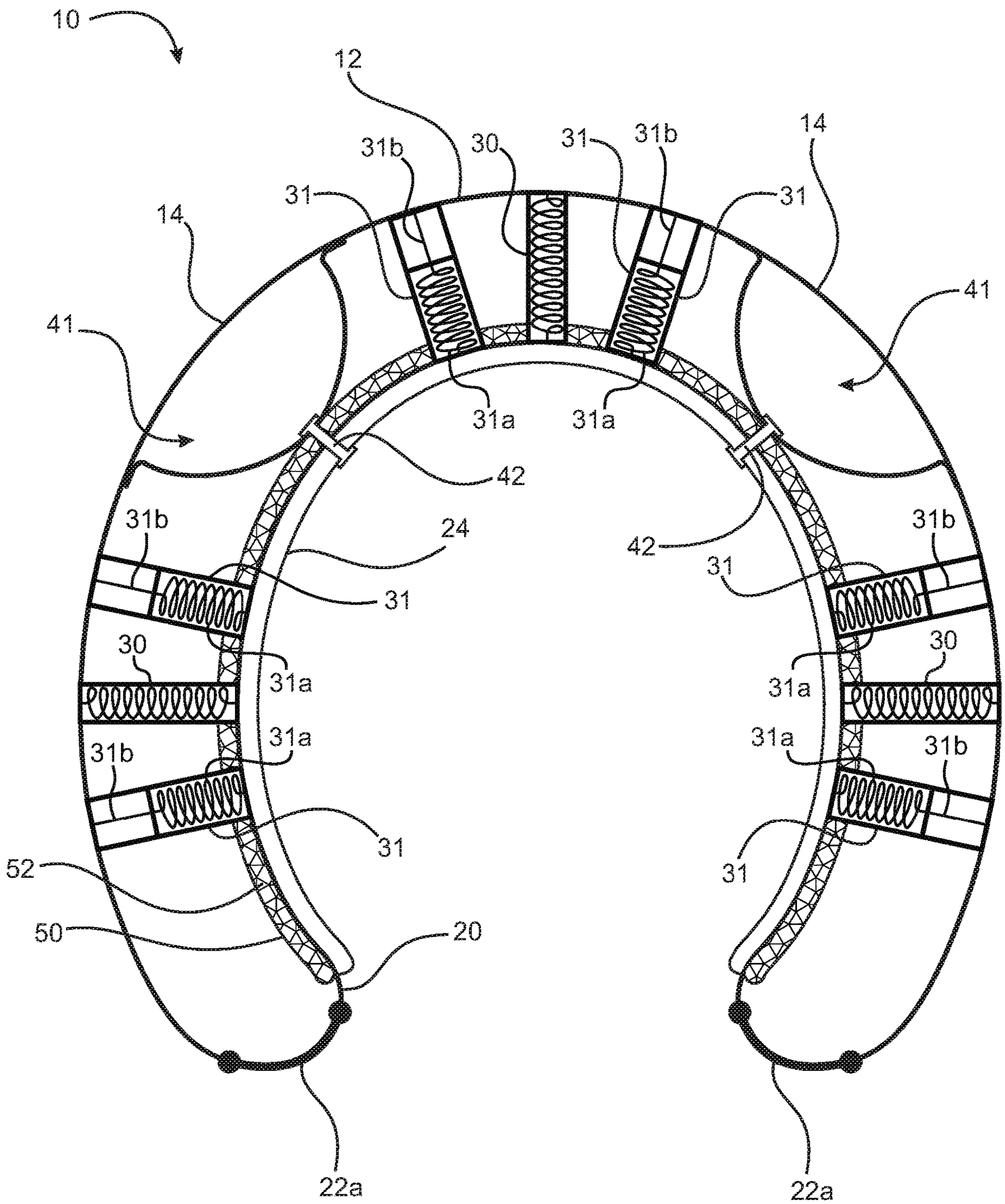


Fig. 8

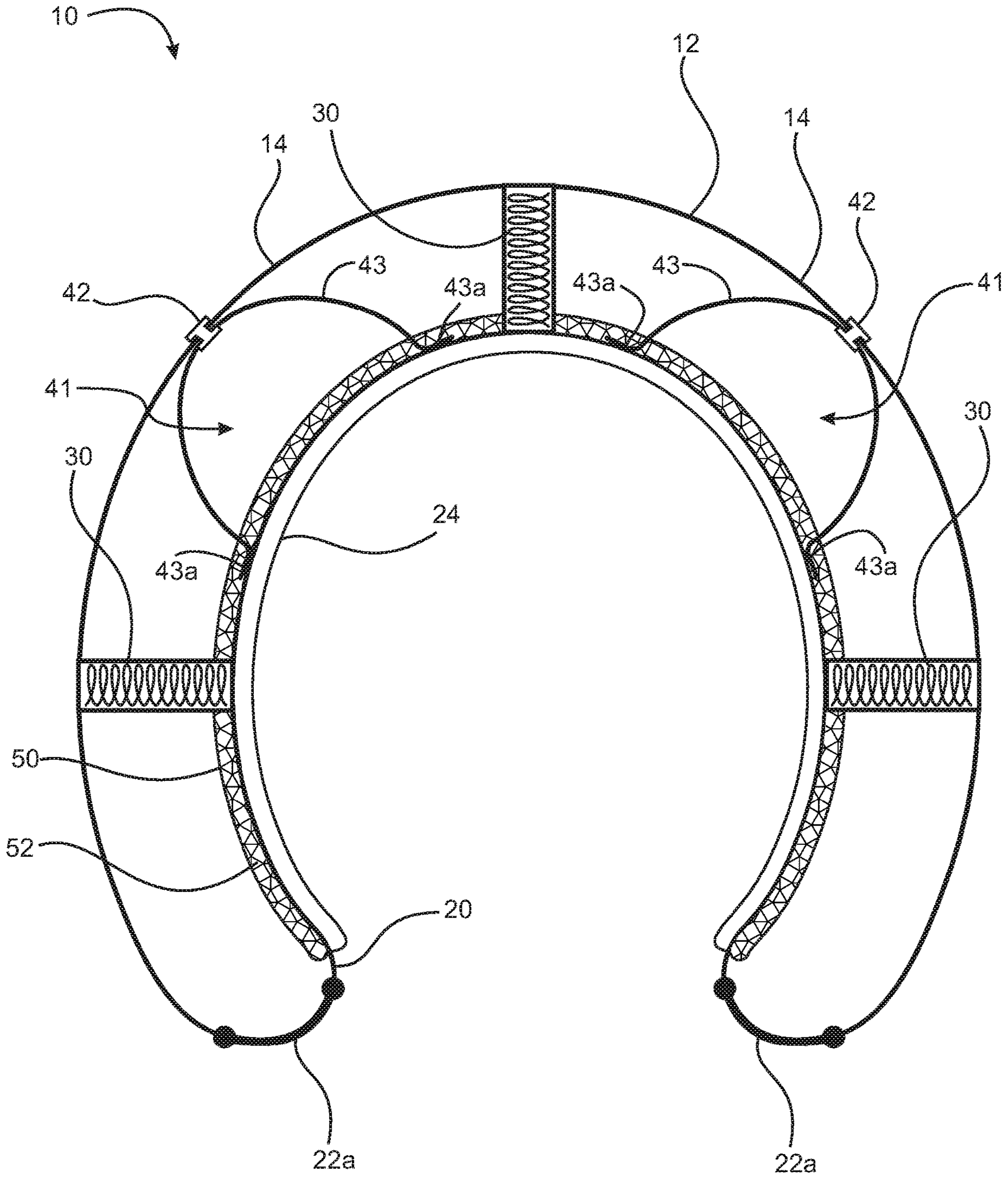

10
12
30
14
14
14
42
43
43a
43a
43
42
41
41
30
30
24
43a
43a
50
52
20
22a
22a

Fig. 9

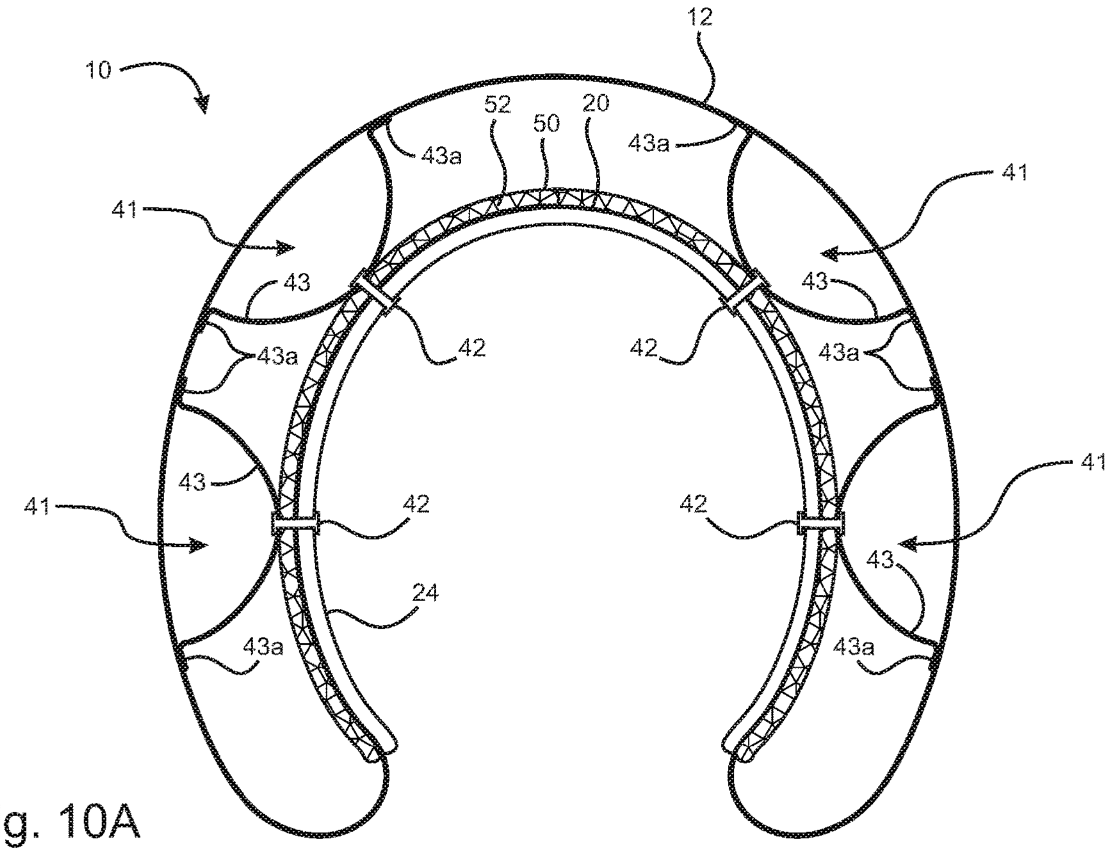


Fig. 10A

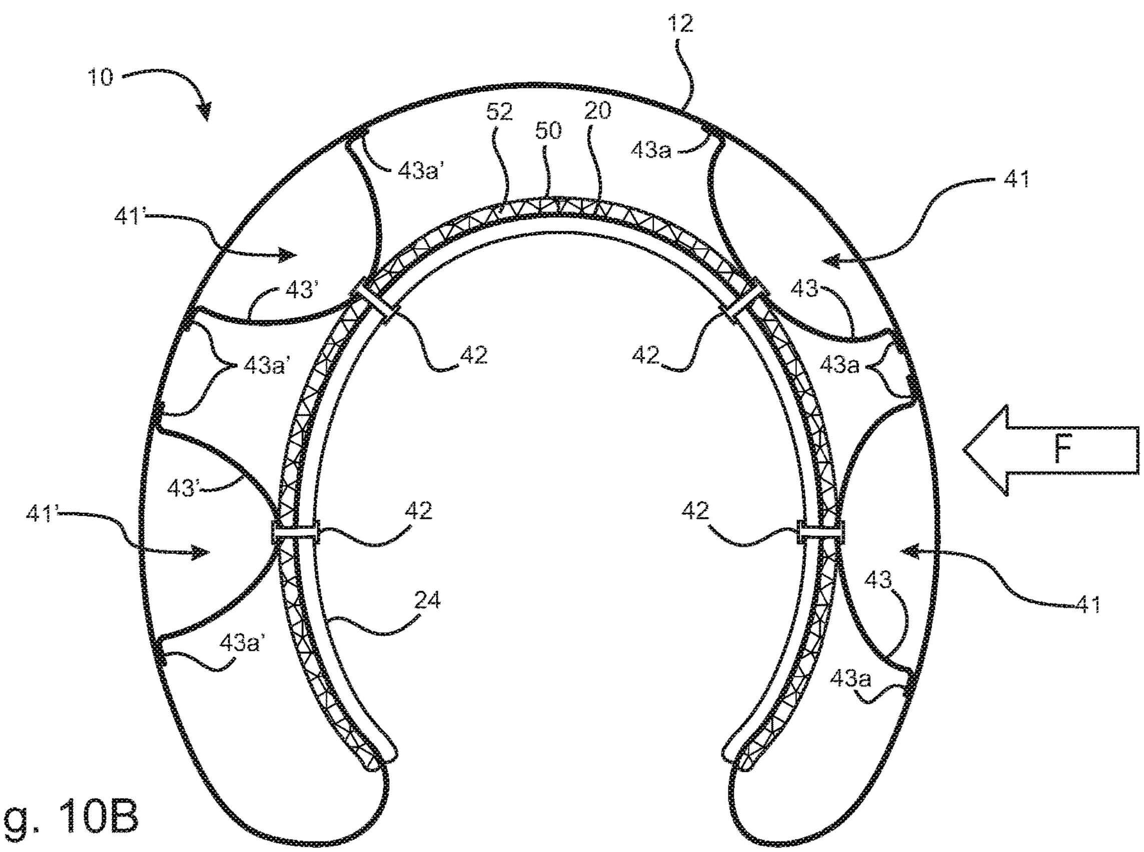


Fig. 10B

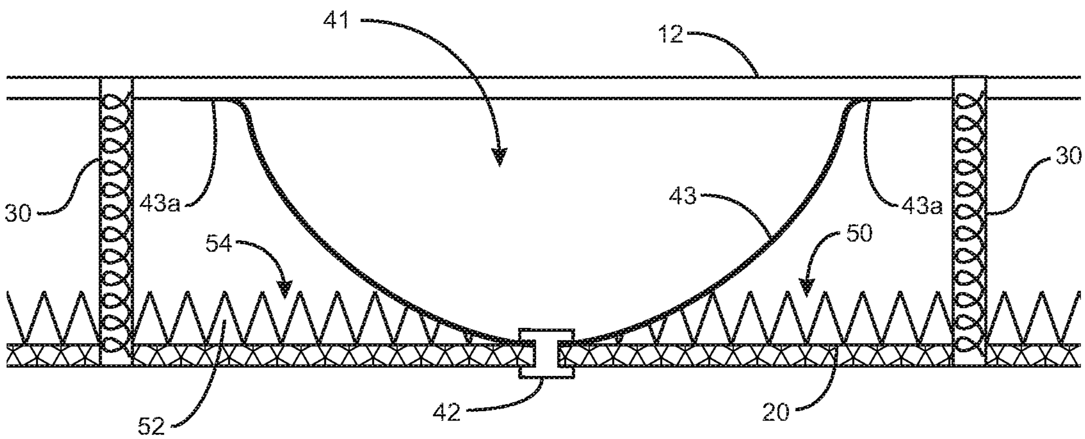


Fig. 11

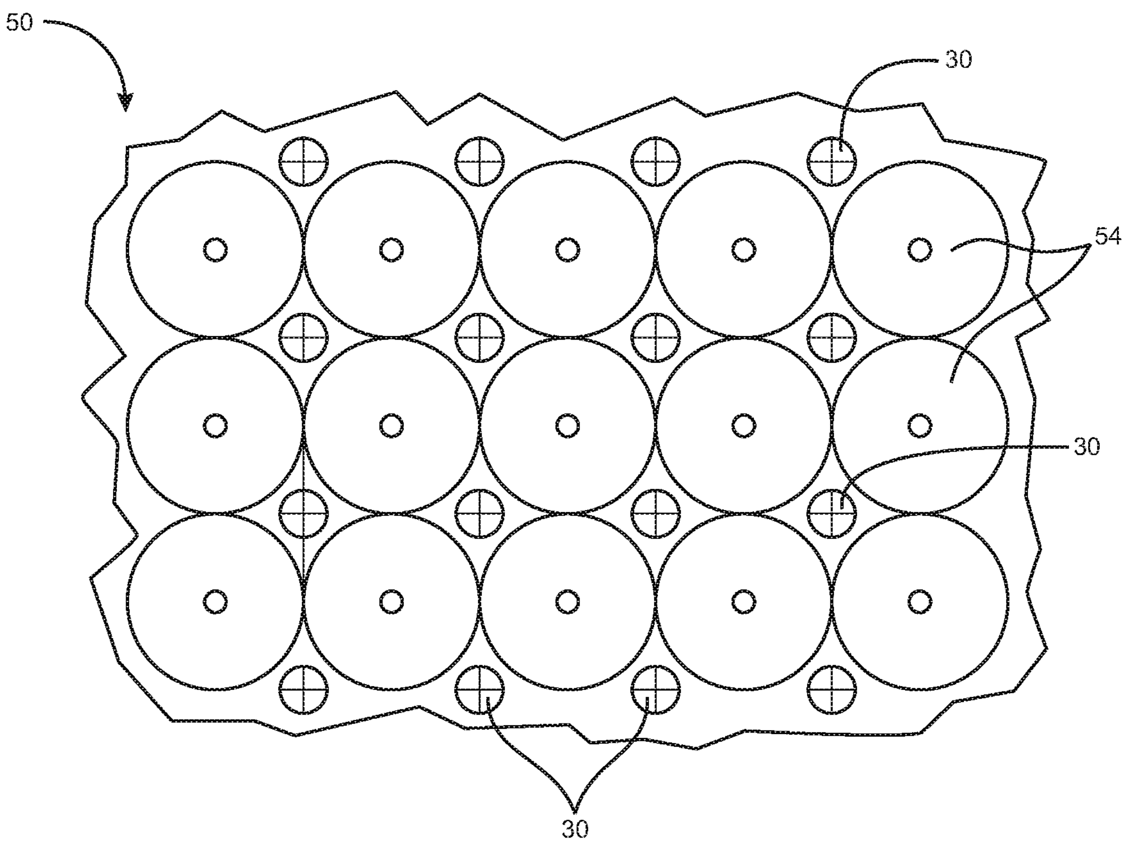


Fig. 12

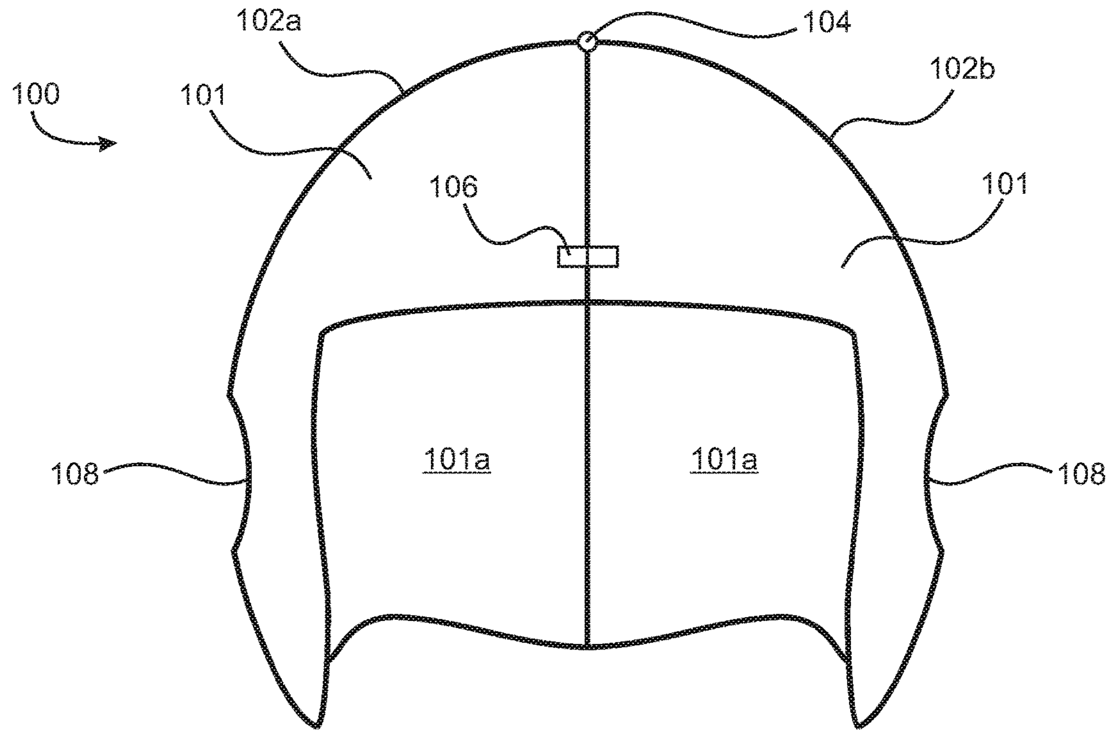


Fig. 13A

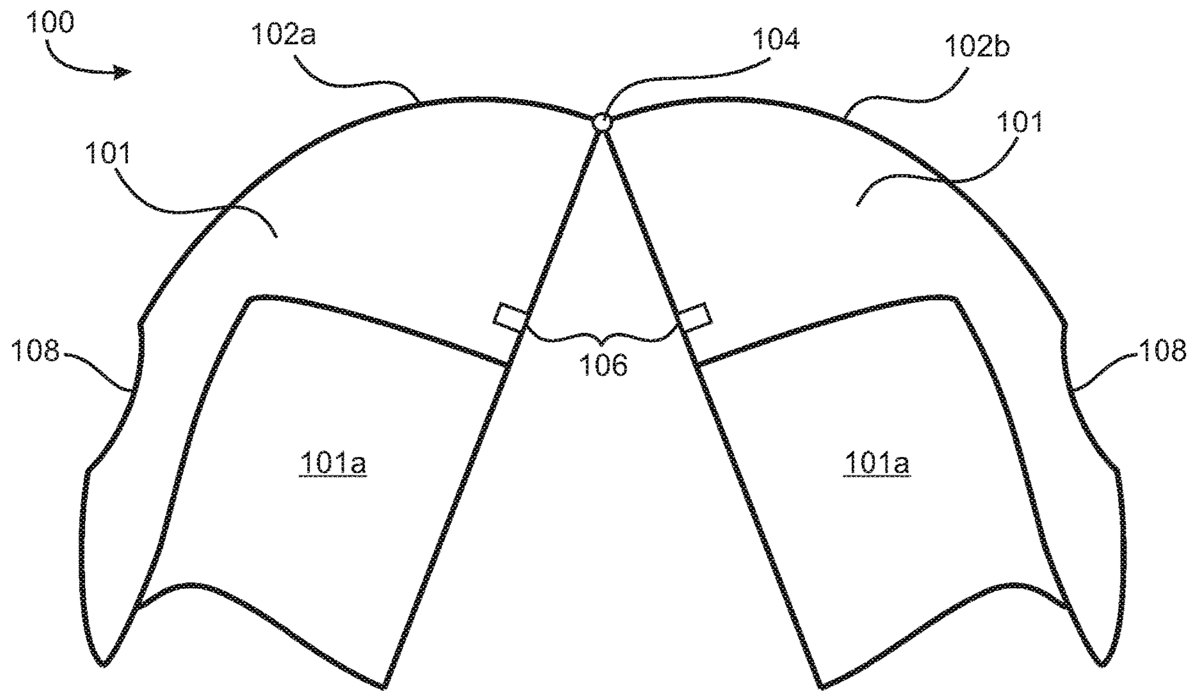


Fig. 13B

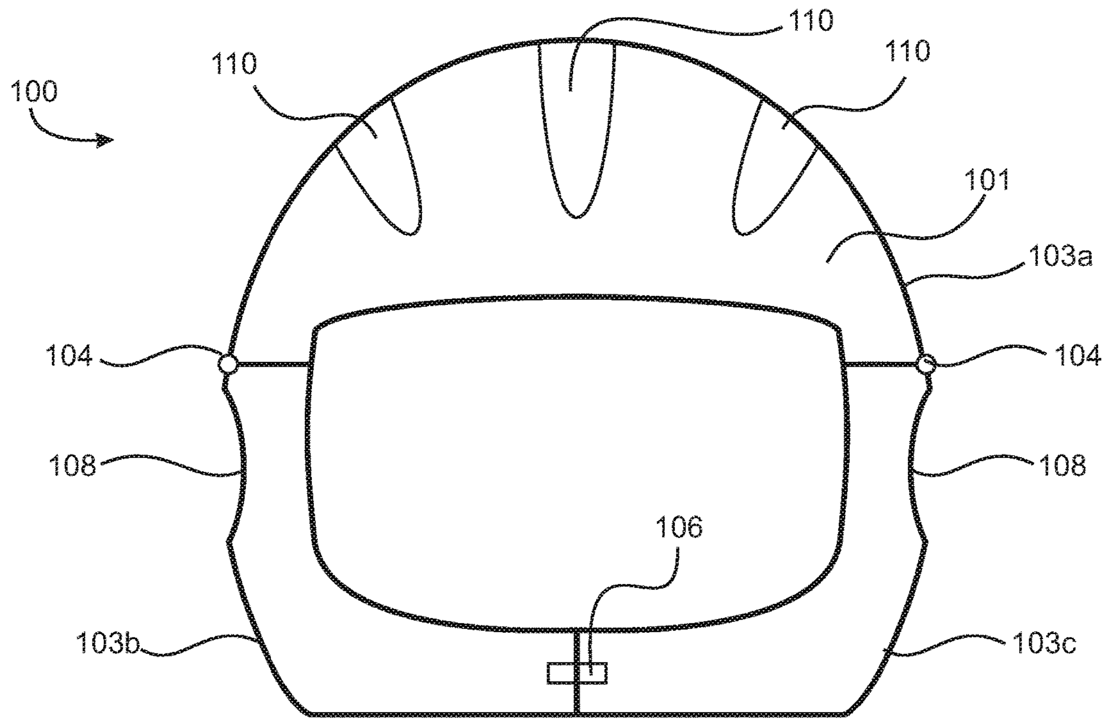


Fig. 14A

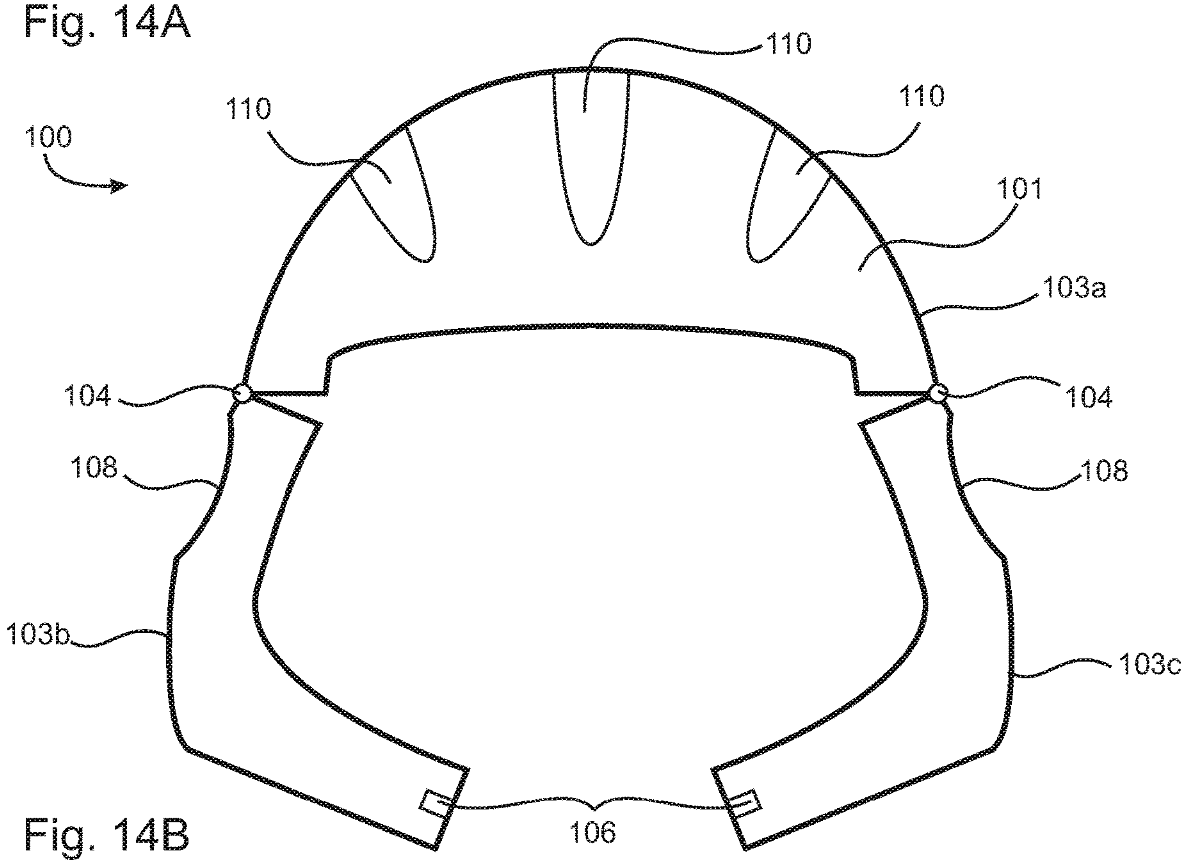


Fig. 14B

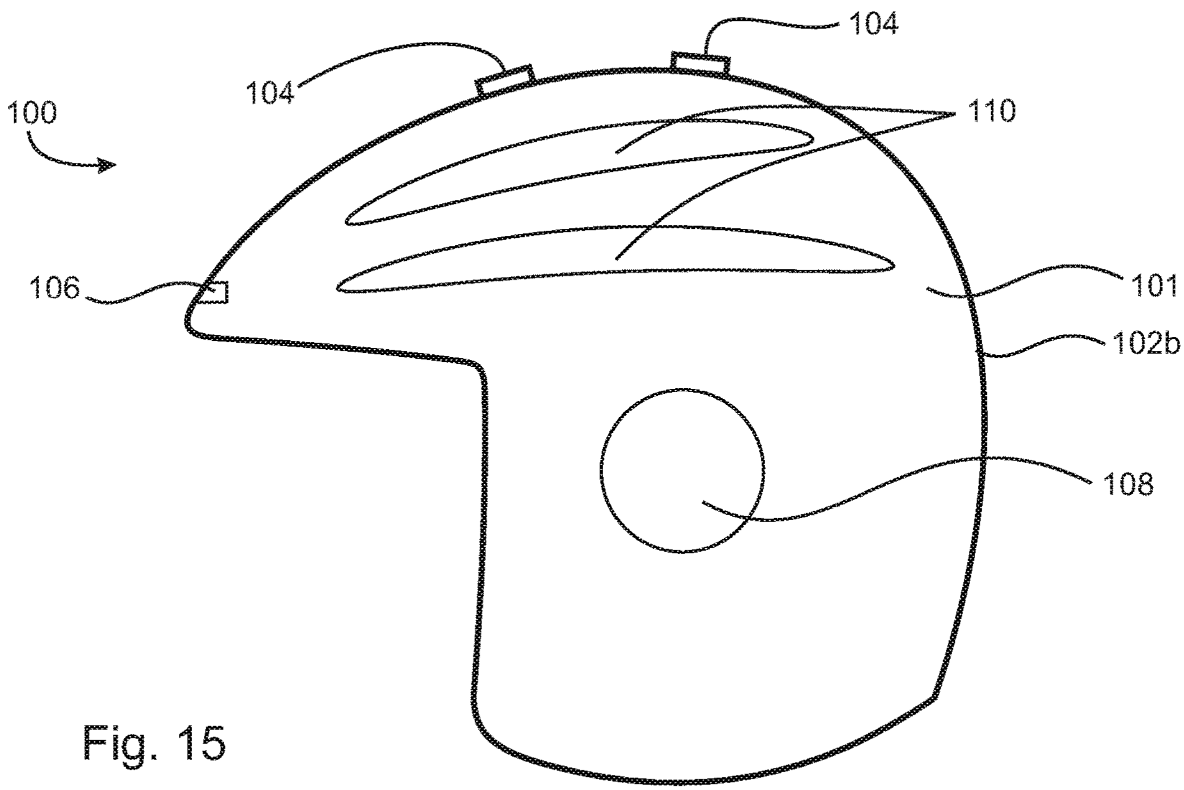

100
104
104
110
106
101
102b
108

Fig. 15

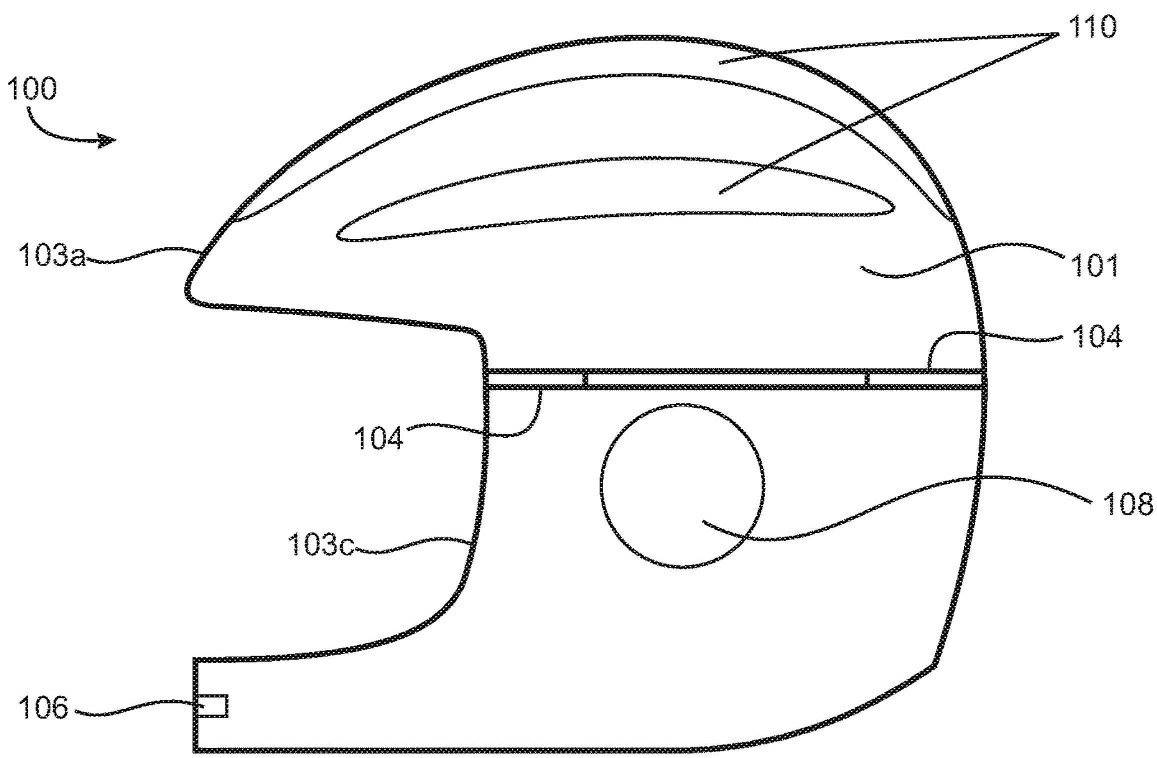

100
110
103a
101
104
104
108
103c
106

Fig. 16

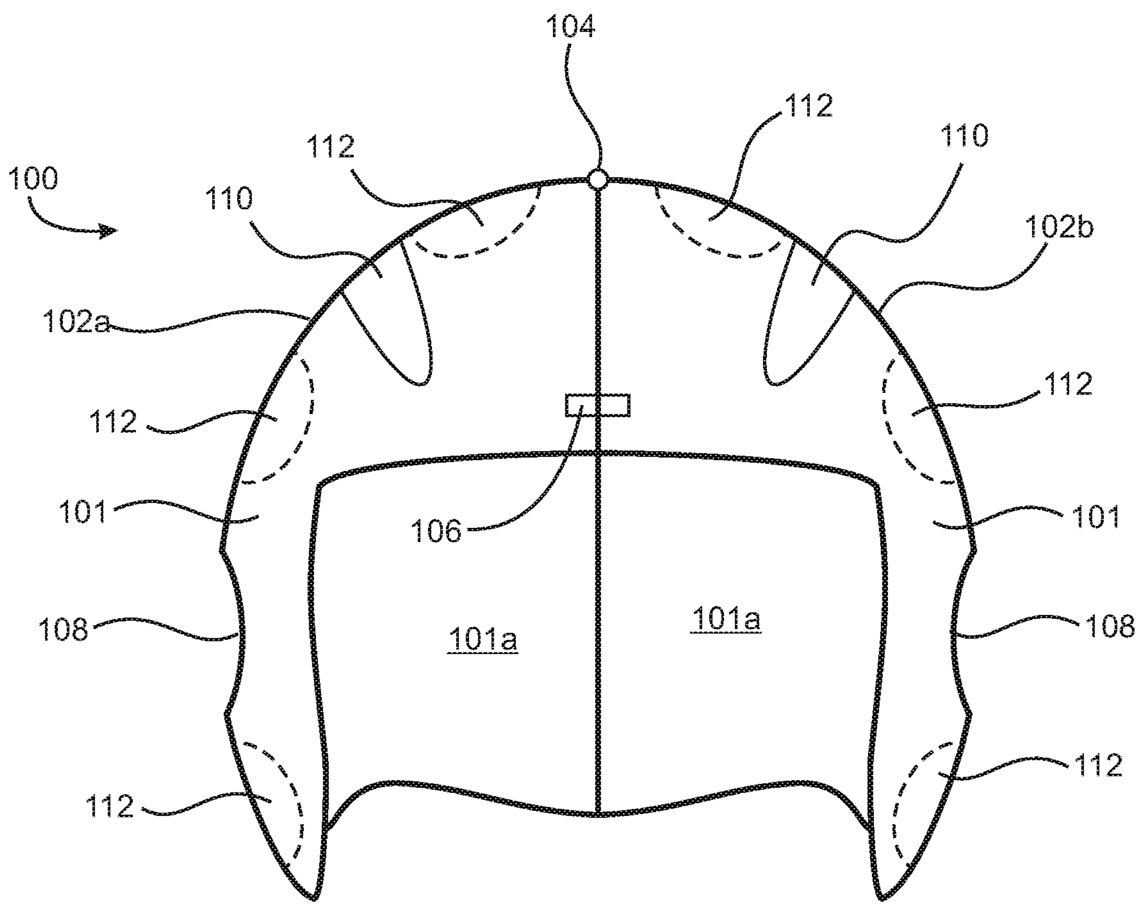

104
112
110
102b
100
112
110
102a
112
112
101
106
101
101a
101a
108
108
112
112

Fig. 17

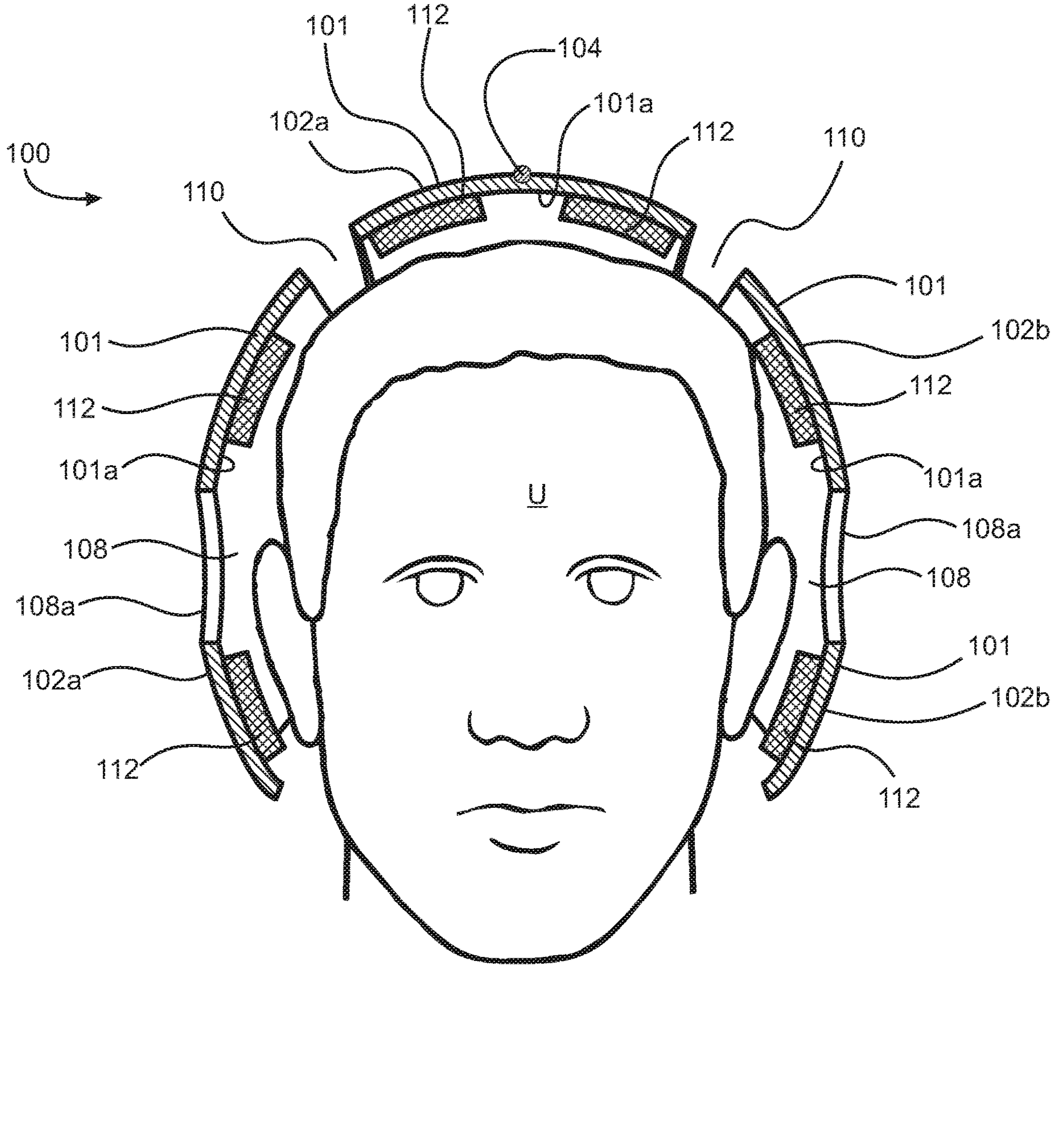

100
110
101
112
102a
104
101a
112
110
101
102b
112
101a
108a
108
101
102b
112
101
112
101a
108
108a
102a
112
U

Fig. 17A

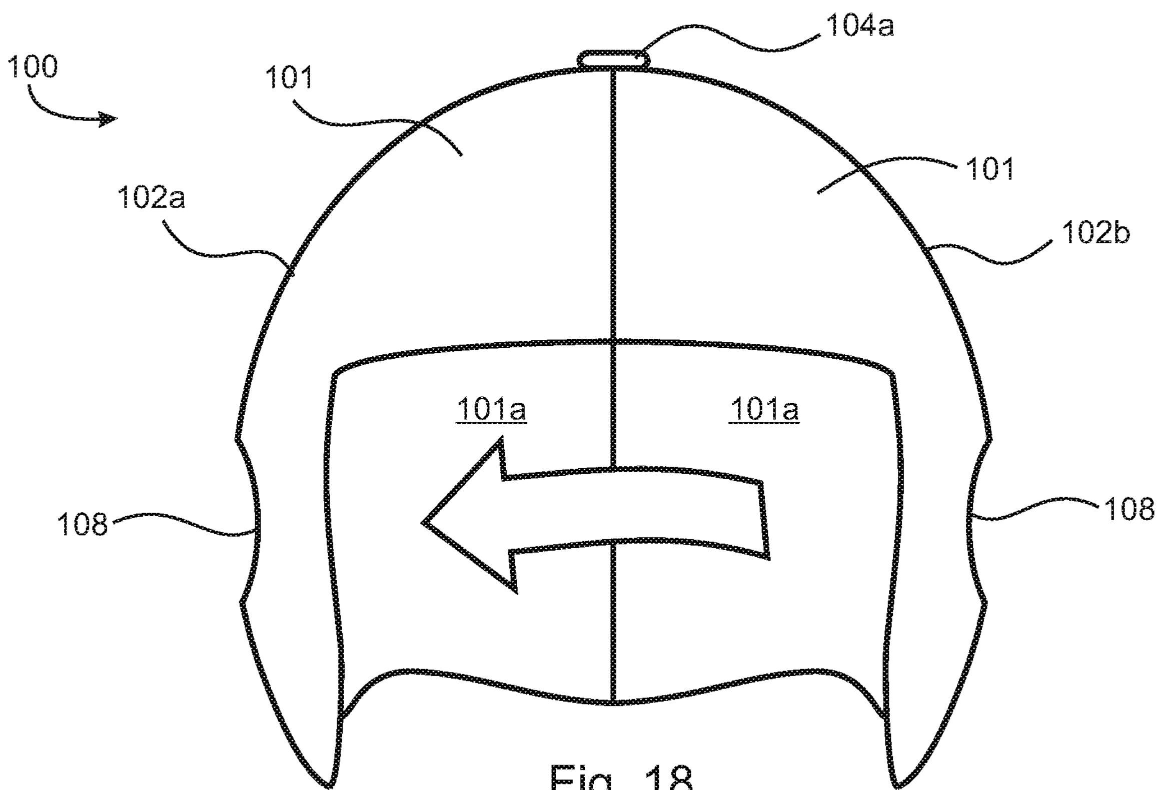


Fig. 18

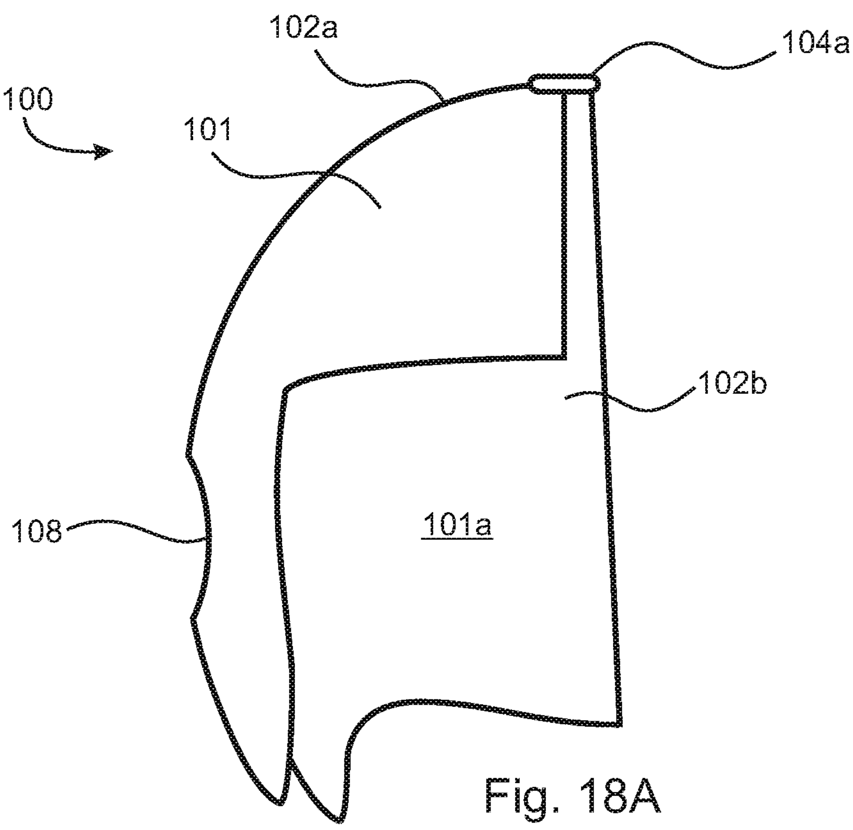


Fig. 18A

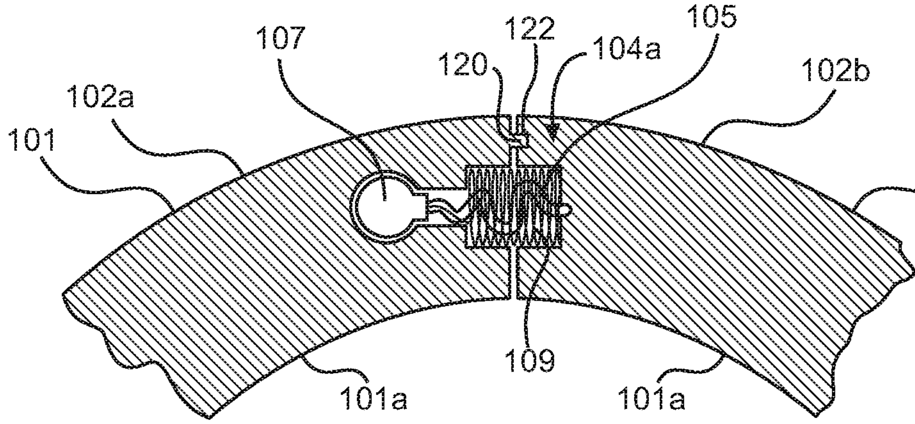


Fig. 19A

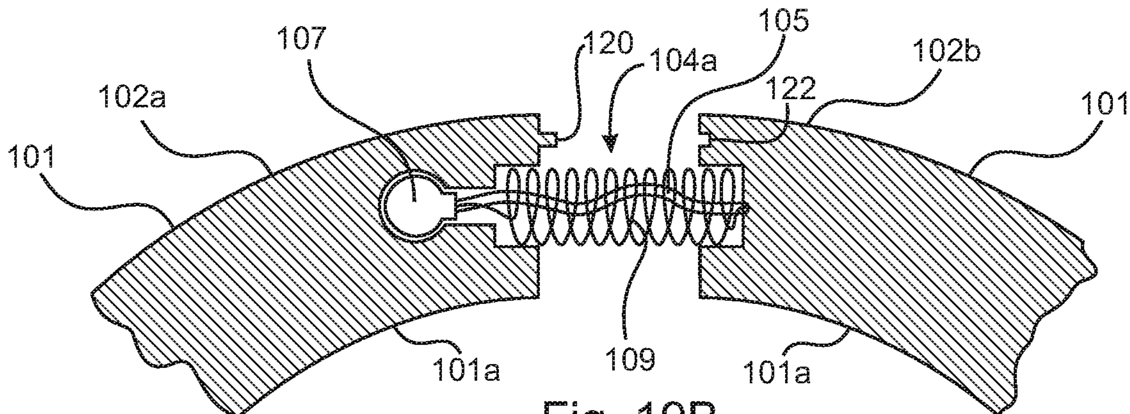


Fig. 19B

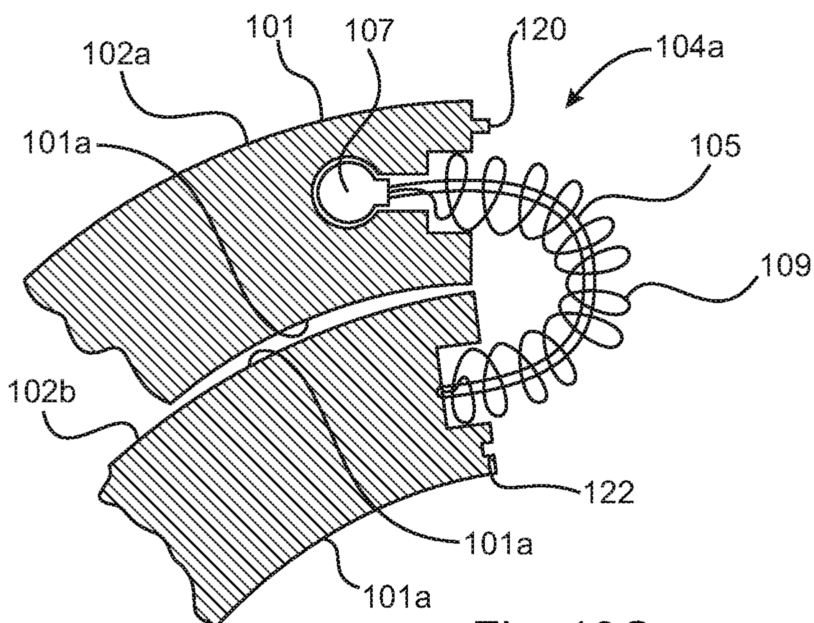


Fig. 19C

HELMET WITH MULTIPLE PROTECTIVE ZONES

This application is filed under 35 U.S.C. § 120 as a continuation patent application of U.S. patent application Ser. No. 13/841,076, filed Mar. 15, 2013, which application is a continuation-in-part patent application of U.S. patent application Ser. No. 13/412,782, filed Mar. 6, 2012, the contents of which are hereby incorporated herein by reference in their entirety.

FIELD

The present disclosure relates generally to protective headgear, more particularly to sports or workplace protective headgear, and still more particularly, to protective headgear designed to prevent or reduce head injury caused by linear or rotational forces.

BACKGROUND

The human brain is an exceedingly delicate structure protected by a series of envelopes to shield it from injury. The innermost layer, the pia mater, covers the surface of the brain. The human brain is an exceedingly delicate structure protected by a series of envelopes to protect it from injury. The innermost layer, the pia mater, covers the surface of the brain. The arachnoid layer, adjacent to the pia mater, is a spidery web-like membrane that acts like a waterproof membrane. Finally, the dura mater, a tough leather-like layer, covers the arachnoid layer and adheres to the bones of the skull.

While this structure protects against penetrating trauma, the softer inner layers absorb only a small amount of energy before linear forces applied to the head are transmitted to the brain. When an object strikes a human head, both the object and the human head are moving independently and often in different angles thus, angular forces, as well as linear forces, are almost always involved in head injuries. Many surgeons in the field believe the angular or rotational forces applied to the brain are more hazardous than direct linear forces due to the twisting or shear forces they apply to the white matter tracts and the brain stem.

One type of brain injury that occurs frequently is the mild traumatic brain injury (MTBI), more commonly known as a concussion. Such injury occurs in many settings, such as, construction worksites, manufacturing sites, and athletic endeavors and is particularly problematic in contact sports. While at one time a concussion was viewed as a trivial and reversible brain injury, it has become apparent that repetitive concussions, even without loss of consciousness, are serious deleterious events that contribute to debilitating irreversible diseases, such as dementia and neuro-degenerative diseases including Parkinson's disease, chronic traumatic encephalopathy (CTE), and dementia pugilistica.

U.S. Pat. No. 5,815,846 (Calonge) describes a helmet with fluid filled chambers that dissipate force by squeezing fluid into adjacent equalization pockets when external force is applied. In such a scenario, energy is dissipated only through viscous friction as fluid is restrictively transferred from one pocket to another. Energy dissipation in this scenario is inversely proportional to the size of the hole between the full pocket and the empty pocket. That is to say, the smaller the hole, the greater the energy drop. The problem with this design is that, as the size of the hole is decreased and the energy dissipation increases, the time to dissipate the energy also increases. Because fluid filled chambers react hydraulically, energy transfer is in essence instantaneous. Hence, in the Calonge design, substantial energy is transferred to the brain before viscous fluid can be displaced negating a large portion of the protective function provided by the fluid filled chambers. Viscous friction is too slow an energy dissipating modification to adequately mitigate concussive force. If one were to displace water from a squeeze bottle one can get an idea as to the function of time and force required to displace any fluid when the size of the exit hole is varied. The smaller the transit hole, the greater the force required and the longer the time required for any given force to displace fluid.

U.S. Pat. No. 6,658,671 (Hoist) describes a helmet with inner and outer shells and a sliding layer. The sliding layer allows for the displacement of the outer shell relative to the inner shell to help dissipate some of the angular force during a collision applied to the helmet. However, the force dissipation is confined to the outer shell of the helmet. In addition, the Holst helmet provides no mechanism for returning the two shells to the resting position relative to each other. A similar shortcoming is shown in the helmets described in U.S. Pat. No. 5,956,777 (Popovich) and European patent publication EP 0048442 (Kalman et al.).

German Patent DE 19544375 (Zhan) describes a construction helmet that includes apertures in the hard outer shell that allows the expansion of cushion material through the apertures to dispel some of the force of a collision. However, because the inner liner rests against a user's head, some force is directed toward rather than away from the head.

U.S. Patent Application Publication No. 2012/0198604 (Weber et al.) describes a safety helmet for protecting the human head against repetitive impacts as well as moderate and severe impacts to reduce the likelihood of brain injury caused by both translational and rotational forces. The helmet includes isolation dampers that act to separate an outer liner from an inner liner. Gaps are provided between the ends of the outer liner and the inner liner to provide space to enable the outer liner to move without contacting the inner liner upon impact.

Clearly, to prevent traumatic brain injury, not only must penetrating objects be stopped, but any force, angular or linear, imparted to the exterior of the helmet must also be prevented from simply being transmitted to the enclosed skull and brain. The helmet must not merely play a passive role in dampening such external forces, but must play an active role in dissipating both linear and angular momentum imparted such that they have little or no deleterious effect on the delicate brain.

To afford maximum protection from linear and angular forces, the outer shell of a helmet mitigating such force must be capable of movement independent from the inner shell of the helmet which covers and encloses the skull and brain, such that any force vector or vectors can be allayed prior to the force getting to the brain.

To attain these objectives in a helmet design, the inner component (shell) and the outer component (shell or shells) must be capable of appreciable degrees of movement independent of each other. Additionally, the momentum imparted to the outer shell should both be directed away from and/or around the underlying inner shell and brain and sufficiently dissipated or stored so as to negate deleterious effects.

Therefore, there is a need for a protective helmet that mitigates these deleterious consequences of repetitive traumatic brain injury.

SUMMARY

According to aspects illustrated herein, there is provided a protective helmet, comprising a hard outer shell, a hard inner shell slidingly connected to, and spaced apart from, the outer shell, and a leaf spring comprising a center portion, a first end, and a second end, the leaf spring anchored only at the center portion onto the hard outer shell, the first end unattached to, and in sliding contact with the hard inner shell, and the second end unattached to, and in sliding contact with the hard inner shell. In a neutral position, the first end is spaced from the second end by a first distance, and when a force strikes the helmet, the first end is spaced from the second end by a second distance, the second distance being different from the first distance.

According to aspects illustrated herein, there is provided a protective helmet, comprising a hard outer shell, a hard inner shell slidingly connected to, and spaced apart from, the hard outer shell, and a leaf spring comprising a center portion, the leaf spring anchored only at the center portion to the hard outer shell, a first end unattached to, and in direct sliding contact with, the hard inner shell, and a second end, unattached to, and in direct sliding contact with, the hard inner shell, wherein in a neutral position, the first end is spaced from the second end by a first distance, and when a force strikes the helmet, the first end is spaced from the second end by a second distance, the second distance being different from the first distance.

These and other objects, features, and advantages of the present disclosure will become readily apparent upon a review of the following detailed description of the disclosure, in view of the drawings and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments are disclosed, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, in which:

FIG. **1** is a front view of the double shell helmet ("helmet");

FIG. **2** is a side view of the helmet of FIG. **1** showing two face protection device attachments on one side of the helmet;

FIG. **3**A is a cross-sectional view of the helmet of FIG. **1** showing an inner shell and elastomeric cords connecting the two shells;

FIG. **3**B is a cross-sectional view similar to FIG. **3** depicting an alternate embodiment of the helmet including an intermediate shell enclosing cushioning pieces;

FIG. **3**C is a cross-sectional view similar to FIG. **3**A depicting an alternate embodiment of the elastomeric cords in which some of the elastomeric cords have thin and thick portions;

FIG. **4**A is an enlarged schematic view of the cords shown in FIG. **3**C in a neutral position;

FIG. **4**B is an enlarged schematic view of the cords shown in FIG. **3**C in compression;

FIG. **4**C is an enlarged schematic view of the cords shown in FIG. **3**C in a neutral position;

FIG. **4**D is an enlarged schematic view of the cords shown in FIG. **3**C in tension;

FIG. **5**A is a top perspective view of a section of the outer shell of the helmet showing an alternate embodiment including a liftable lid that protect diaphragms covering apertures in the outer shell of the helmet;

FIG. **5**B is a top perspective view of a section of the outer shell of the helmet, as shown in FIG. **5**A, depicting the liftable lid protecting the bulging fluid-filled bladder;

FIG. **6**A is an exploded view showing the attachment of the cord to both the inner shell and outer shell to enable the outer shell to float around the inner shell;

FIG. **6**B is a cross-sectional view of the completed attachment fitting with the elastomeric cord attached to two plugs and extending between the outer shell and the inner shell of the helmet;

FIG. **7** is a cross-sectional view of an alternate embodiment of the helmet including parabolic leaf springs;

FIG. **7**A is a cross-sectional view of an alternate embodiment of the helmet including elliptical leaf springs;

FIG. **8** is a cross-sectional view of the alternate embodiment of the protective helmet shown in FIG. **7** showing the leaf springs with elastomeric cords;

FIG. **9** is a cross-sectional view of the helmet illustrating leaf springs anchored on the outer shell of the helmet;

FIG. **10**A depicts schematically the parabolic leaf springs when the helmet is in a neutral state before being struck by a force;

FIG. **10**B depicts schematically how the parabolic leaf springs temporarily change their shape when absorbing a force striking the helmet;

FIG. **11** is an enlarged schematic cross-sectional view of a crumple zone in a helmet in which a leaf spring is the force absorber/deflector;

FIG. **12** is a top view of the crumple zone showing a plurality of elastomeric cords extending between the cones of a visco-elastic material;

FIG. **13**A is a front view of an articulating helmet, which is divided into at least two parts that are attached by an articulating means such as hinges or pivots;

FIG. **13**B is a front view of an articulating helmet, which is divided into two parts;

FIG. **14**A is a front view of an alternate embodiment of the articulating helmet having three articulating sections;

FIG. **14**B is a front view of the articulating helmet of FIG. **14**A;

FIG. **15** is a side view of a two-section embodiment of an articulating helmet including air vents;

FIG. **16** is a side view of a three-section embodiment of an articulating helmet showing two hinges for the articulating means;

FIG. **17** is a front view of an additional alternate embodiment of an articulating helmet including pads or cushions attached to the inner surface of the helmet;

FIG. **17**A is a front view of a user wearing an articulating helmet in a cross-sectional view demonstrating the fit of the helmet on the user;

FIG. **18** is a front view of an articulating helmet;

FIG. **18**A is a front view of the articulating helmet of FIG. **18**;

FIG. **19**A depicts an enlarged cross-sectional view of a swivel that enables two articulating sections of an articulating helmet to nest within one another;

FIG. **19**B depicts an enlarged cross-sectional view showing two articulating sections of an articulating helmet pulled apart prior to being placed into a nesting position; and,

FIG. **19**C depicts an enlarged cross-sectional view of two articulating sections in a nested position.

DETAILED DESCRIPTION

At the outset, it should be appreciated that like drawing numbers on different drawing views identify identical, or functionally similar, structural elements. It is to be understood that the claims are not limited to the disclosed aspects.

Furthermore, it is understood that this disclosure is not limited to the particular methodology, materials and modifications described and as such may, of course, vary. It is also understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to limit the scope of the claims.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this disclosure pertains. It should be understood that any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the example embodiments.

It should be appreciated that the term "substantially" is synonymous with terms such as "nearly," "very nearly," "about," "approximately," "around," "bordering on," "close to," "essentially," "in the neighborhood of," "in the vicinity of," etc., and such terms may be used interchangeably as appearing in the specification and claims. It should be appreciated that the term "proximate" is synonymous with terms such as "nearby," "close," "adjacent," "neighboring," "immediate," "adjoining," etc., and such terms may be used interchangeably as appearing in the specification and claims.

In one embodiment, the inner shell and outer shell are connected to each other by elastomeric cords that serve to limit the rotation of the outer shell on the inner shell and to dissipate energy by virtue of elastic deformation rather than passively transferring rotational force to the brain as with existing helmets. In effect, these elastomeric cords function like mini bungee cords that dissipate both angular and linear forces through a mechanism known as hysteretic damping, i.e., when elastomeric cords are deformed, internal friction causes high energy losses to occur. These elastomeric cords are of particular value in preventing so called contrecoup brain injury.

The outer shell, in turn, floats on the inner shell by virtue of one or more force absorbers or deflectors such as, for example, fluid-filled bladders, leaf springs, or sinusoidal springs, located between the inner shell and the outer shell. To maximize the instantaneous reduction or dissipation of a linear and/or angular force applied to the outer shell, the fluid-filled bladders interposed between the hard inner and outer shells may be intimately associated with, that is located under, one or more apertures in the outer shell with the apertures preferably being covered with elastomeric diaphragms and serving to dissipate energy by bulging outward against the elastomeric diaphragm whenever the outer shell is accelerated, by any force vector, toward the inner shell. Alternatively, the diaphragms could be located internally between inner and outer shells, or at the inferior border of the inner and outer shells, if it is imperative to preserve surface continuity in the outer shell. This iteration would necessitate separation between adjacent bladders to allow adequate movement of associated diaphragms.

In existing fluid-filled designs, when the outer shell of a helmet receives a linear force that accelerates it toward the inner shell, the interposed gas or fluid is compressed and displaced. Because gas and especially fluid is not readily compressible, it passes the force passively to the inner shell and hence to the skull and the brain. This is indeed the very mechanism by which existing fluid-filled helmets fail. The transfer of force is hydraulic and essentially instantaneous, negating the effectiveness of viscous fluid transfers as a means of dissipating concussive force.

Because of the elastomeric diaphragms in the present invention, any force imparted to the outer shell will transfer to the gas or liquid in the bladders, which, in turn, will instantaneously transfer the force to the external elastomeric diaphragms covering the apertures in the outer shell. The elastomeric diaphragms, in turn, will bulge out through the aperture in the outer shell, or at the inferior junction between inner and outer shells thereby dissipating the applied force through elastic deformation at the site of the diaphragm rather than passively transferring it to the padded lining of the inner shell. This process directs energy away from the brain and dissipates it via a combination of elastic deformation and tympanic resonance or oscillation. By oscillating, an elastic diaphragm employs the principle of hysteretic damping over and over, thereby maximizing the conversion of kinetic energy to low-level heat, which, in turn, is dissipated harmlessly to the surrounding air.

Furthermore, the elastomeric springs or cords that bridge the space holding the fluid-filled bladders (like the arachnoid membrane in the brain) serve to stabilize the spatial relationship of the inner and outer shells and provide additional dissipation of concussive force via the same principle of elastic deformation via the mechanism of stretching, torsion, and even compression of the elastic cords.

By combining the bridging effects of the elastic springs or cords as well as the elastomeric diaphragms strategically placed at external apertures, both linear and rotational forces can be effectively dissipated.

In an alternate embodiment, leaf springs may replace fluid-filled bladders as a force absorber/deflector. Leaf springs may be structured as a fully elliptical spring or, preferably, formed in a parabolic shape. In both forms, the leaf spring is anchored at a single point to either the outer shell or, preferably, the hard inner shell and extends into the zone between the outer shell and inner shell. The springs may have a single leaf (or arm) or comprise a plurality of arms arrayed radially around a common anchor point. Preferably, each arm tapers from a thicker center to thinner outer portions toward each end of the arm. Further, the ends of each arm may include a curve to allow the end to more easily slide on the shell opposite the anchoring shell. In contrast to the use of leaf springs in vehicles, the distal end of the spring arms are not attached to the non-anchoring or opposite shell. This allows the ends to slide on the shell to allow independent movement of each shell when the helmet is struck by rotational forces. This also enables the frictional dissipation of energy. Preferably, the distal ends contact the opposite shell in the neutral condition, that is, when the helmet is not in the process of being struck.

Adverting to the drawings, FIG. **1** is a front view of multiple protective zone helmet **10** ("helmet **10**"). The outer protective zone is formed by outer shell **12** and is preferably manufactured from rigid, impact resistant materials such as metals, plastics, polycarbonates, ceramics, composites, and similar materials well known to those having skill in the art. Outer shell **12** defines at least one and preferably a plurality of apertures **14** (or aperture **14**). Apertures **14** may be open but are preferably covered by a flexible elastomeric material in the form of diaphragms **16** (or diaphragm **16**). In a preferred embodiment, helmet **10** also includes several face protection device attachments. FIG. **1** shows face protection device attachments **18***a* and **18***b*; however, helmet **10** can have any suitable number of face protection device attachments. In a more preferred embodiment, face protection device attachments are fabricated from a flexible elastomeric material to provide flexibility to the attachment. The elastomeric material reduces the rotational pull on helmet **10** if the attached face protection device (not shown in FIG. **1**) is pulled. By "elastomeric" it is meant any of various substances resembling rubber in properties, such as resilience and flexibility. Such elastomeric materials are well known to those having skill in the art. FIG. **2** is a side view of helmet **10** showing two face protection device attachments **18***a* and **18***b* on one side of the helmet. Examples of face protection devices are visors and face masks. Such attachments can also be used for chin straps releasably attached to the helmet in a known manner.

FIG. **3**A is a cross-sectional view of helmet **10** showing the hard inner shell **20** and the elastomeric springs or cords **30** (or cords **30**) that extend through an elastomeric zone connecting the two shells. Inner shell **20** forms an anchor zone and is preferably manufactured from rigid, impact resistant materials such as metals, plastics such as polycarbonates, ceramics, composites, and similar materials well known to those having skill in the art. Inner shell **20** and outer shell **12** are slidingly connected at sliding connection **22**. By "slidingly connected" it is meant that the edges of inner shell **20** and outer shell **12**, respectively, slide against or over each other at connection **22**. In an alternate embodiment, outer shell **12** and inner shell **20** are connected by an elastomeric element, for example, a u-shaped elastomeric connector **22***a* ("connector **22***a*"). Sliding connection **22** and connector **22***a* each serve to both dissipate energy and maintain the spatial relationship between outer shell **12** and inner shell **20**.

Cords **30** are flexible cords, such as bungee cords or elastic "hold down" cords, or their equivalents, used, for example, to hold articles on car or bike carriers. This flexibility allows outer shell **12** to move or "float" relative to inner shell **20** while remaining connected to inner shell **20**. This floating capability is also enabled by the sliding connection **22** between outer shell **12** and inner shell **20**. In an alternate embodiment, sliding connection **22** may also include elastomeric connection **22***a* between outer shell **12** and inner shell **20**. Padding **24** forms an inner zone and lines the inner surface of inner shell **20** to provide a comfortable material to support helmet **10** on the user's head. In one embodiment, padding **24** may enclose loose cushioning pieces **24***a* such as STYROFOAM® beads or "peanuts," or loose oatmeal.

Also shown in FIG. **3**A is a cross-sectional view of bladders **40** (or bladder **40**) situated in the elastomeric zone between outer shell **12** and inner shell **20**. Helmet **10** includes at least one, but preferably a plurality of bladders **40**. Bladders **40** are filled with fluid, either a liquid such as water, or a gas such as helium or air. In one preferred embodiment, the fluid is helium as it is light and its use would reduce the total weight of helmet **10**. In an alternate embodiment, bladders **40** may also include compressible beads or pieces such as STYROFOAM® beads. Bladders **40** are preferably located under apertures **14** of outer shell **12** and are in contact with both inner shell **20** and outer shell **12**. Thus, when outer shell **12** is pressed in toward inner shell **20** (and thus the user's skull) during a collision, bladder **40** is squeezed and the fluid therein is compressed, similar to squeezing a balloon. Bladder **40** will bulge toward aperture **14** and displace elastomeric diaphragm **16**. This bulging-displacement action diverts the force of the blow from radially inward (i.e., toward the user's skull and brain) to radially outward (i.e., up toward the apertures) providing a new direction for the force vector. Bladders **40** may also be divided internally into compartments **40***a* by bladder wall **44** such that, if the integrity of one of compartments **40***a* is breached, another compartment will still function to dissipate linear and rotational forces. Bladders **40** may additionally comprise valve(s) **46** arranged between compartments **40***a* to control the fluid movement. In the example embodiment shown in FIG. **3**A, bladders **40** include two compartments. It should be appreciated, however, that any number of compartments suitable to control the fluid movement can be used.

FIG. **3**B is a cross-sectional view, similar to FIG. **3**A discussed above, depicting an alternate embodiment of helmet **10**. Helmet **10** shown in FIG. **3**B includes crumple zone or intermediate shell **50** located between outer shell **12** and inner shell **20**. In the embodiment shown, intermediate shell **50** is close, or adjacent, to inner shell **20**. Intermediate shell **50** encloses filler **52**. Preferably, filler **52** is a compressible material that is packed to deflect the energy of a blow and protect the skull, similar to a "crumple zone" in an automobile. Filler **52** is designed to crumple or deform, thereby absorbing the force of the collision before it reaches inner pad **24** and the braincase. In this embodiment, cords **30** extend from inner shell **20** to outer shell **12** through intermediate shell **50**. One suitable material for filler **52** is STYROFOAM® beads or "peanuts," or an equivalent material such as materials used for packing objects. Because of its "crumpling" function, intermediate shell **50** is preferably constructed with a softer or more deformable material than outer shell **12** and/or inner shell **20**. Typical fabrication material for intermediate shell **50** is a stretchable material such as latex or spandex or other similar elastomeric fabric that preferably encloses filler **52**.

FIG. **3**C is a cross-sectional view similar to FIG. **3**A depicting an alternate embodiment of helmet **10** comprising elastomeric cords **30** and **31**. Elastomeric cords **31** (or cord **31**) include thick elastomeric portions **31***a* and thin nonelastomeric portions **31***b*. In the embodiment shown, thick elastomeric portions **31***a* are connected to the outer surface of inner shell **20**, but alternatively may be connected to the inner surface of outer shell **12**. Thin nonelastomeric portions **31***b* of cords **31** are connected to the inner surface of outer shell **12**, but alternatively may be attached to the outer surface of inner shell **20**. Thin nonelastomeric portions **31***b* may comprise a single cord or multiple cords. In this exemplary embodiment, thick elastomeric portions **31***a* of cords **31** are thicker than uniform elastomeric cords **30**. For example, the diameter of elastomeric portions **31***a* is greater than the diameter of cords **30**. It should be appreciated, however, that elastomeric portions **31***a* and cords **30** may have any suitable diameter that allows cords **31** to act as a backup to prevent cords **30** from being stretched beyond their elastic limit. Also shown in FIG. **3**C is force F located to the left of helmet **10**. Force F is directed radially inward relative to helmet **10** and represents a blow to outer shell **12** as will be discussed with respect to FIGS. **4**A-D.

FIGS. **4**A-D are enlarged schematic views of cords **30** and **31** as shown in FIG. **3**C. FIGS. **4**A and **4**B are enlarged views of detail **4**A,B in FIG. **3**C. FIG. **4**A shows cords **30**, which have uniform thickness throughout their lengths, and cords **31** in the neutral position. In the neutral position, cords **30** are under slight tension while cords **31** are under no tension. In the neutral position, the distance between inner shell **20** and outer shell **12** and thus the length of cords **30** and **31** is length L1. FIG. **4**B shows cords **30** and **31** as shown in FIG. **4**A, but under maximum compression as a result of force F impacting helmet **10** (as directed in FIG. **3**C). When force F, a greater than normal force, is applied, outer shell **12** displaces radially inward relative to inner shell **20** (i.e., the radially distance between inner shell **20** and outer shell **12** decreases). In this case, significant compression occurs in elastomeric cord **30**; however, only nominal compression occurs in cord **31**. As shown, nonelastomeric portions **31***b* loosens and elastomeric portions **31***a* exhibits only nominal or no compression. In the compressed state, the distance between inner shell **20** and outer shell **12** and thus the length of cords **30** and **31** is length L**2**, which is less than length L**1**. FIGS. **4**C and **4**D are enlarged views of detail **4**C,D in FIG. **3**C. FIG. **4**C shows cords **30**, which have uniform thickness throughout their lengths, and cords **31** in the neutral position. In the neutral position, cords **30** are under slight tension while cords **31** are under no tension. In the neutral position, the distance between inner shell **20** and outer shell **12** and thus the length of cords **30** and **31** is length L**3**, which is substantially equal to L**1**. FIG. **4**D shows cords **30** and **31** as shown in FIG. **4**C, but under maximum tension as a result of force F impacting helmet **10** (as directed in FIG. **3**C). When force F is applied, outer shell **12** displaces radially outward relative to inner shell **20** (i.e., the radial distance between inner shell **20** and outer shell **12** increases). In this case, significant expansion occurs in elastomeric cord **30**, and moderate expansion occurs in cord **31**. As shown, nonelastomeric portions **31***b* are tightly drawn and elastomeric portions **31***a* are moderately expanded. Under maximal displacement of outer shell **12** relative to inner shell **20**, cords **30** may be stretched close or up to their elastic limit. However, when this occurs, nonelastomeric portion **31***b* of cord **31** engages elastomeric portion **31***a* to mitigate the large force striking helmet **10** and to prevent any loss of elasticity in cord **30**. By using cord **31** as a backup for blows struck with severe force, greater protection can be achieved even after cord **30** reaches its elastic limit and does not interfere with absorbing any rotational forces striking helmet **10**. For this reason, cords **31** preserve the integrity of the cord system of helmet **10**. In the expanded state, the distance between inner shell **20** and outer shell **12** and thus the length of cords **30** and **31** is length L**4**, which is greater than length L**1**.

FIG. **5**A is a top view of one section of outer shell **12** of helmet **10** showing an alternate embodiment in which liftable lids **60** (or lid **60**) are used to cover aperture **14** to shield diaphragm **16** and/or bladder **40** from punctures, rips, or similar incidents that may destroy their integrity. Lids **60** are attached to outer shell **12** by lid connectors **62** (or connector **62**). Lids **60** are operatively arranged to lift or raise up if a particular diaphragm **16** bulges outside of aperture **14** due to the expansion of one or more bladders **40**. Because it is liftable, lid **60** allows diaphragm **16** to freely elastically bulge through aperture **14** above the surface of outer shell **12** (i.e., radially outward from outer shell **12**) to absorb and redirect the force of a collision, and also protects diaphragm **16** from damage due to external forces. In an alternate embodiment, diaphragm **16** is not used and lid **60** directly shields and protects bladder **40**. In an example embodiment, connectors **62** are hinges. In an example embodiment, connectors **62** are flexible plastic attachments. FIG. **5**B depicts liftable lid **60** protecting bladder **40** as it bulges through aperture **14** and radially outward from outer shell **12**.

FIG. **6**A is an exploded view showing one method of attaching cord **30** to helmet **10**, such that outer shell **12** floats over inner shell **20**. Cavities **36** (or cavity **36**), preferably comprising concave sides **36***a*, are drilled or otherwise arranged in outer shell **12** and inner shell **20** such that they are aligned. Each end of cord **30** is attached to plugs **32** which are arranged in the aligned cavities **36**. In one embodiment, plugs **32** are secured in cavities **36** using a suitable adhesive known to those having ordinary skill in the art. In an alternate embodiment, plugs **32** are secured in cavities **36** with an interference fit (i.e., press fit or friction fit) or a snap fit.

FIG. **6**B is a cross-section of helmet **10** with plugs **32** secured in cavities **36**. Cord **30** is attached to two plugs **32** at either end and extends between outer shell **12** and inner shell **20**. Also shown is intermediate shell **50** enclosing filler **52**. Not shown are bladders **40**, which would be arranged between intermediate shell **50** and outer shell **12**. Persons of ordinary skill in the art will recognize that cords **31** may be attached between outer shell **12** and inner shell **20** in a similar manner.

FIG. **7** is a cross-sectional view of an alternate embodiment of helmet **10** wherein bladders **40** are replaced with force absorbers/deflectors comprising parabolic leaf springs **41** (or springs **41**). In the embodiment shown, springs **41** are fixedly secured to inner shell **20** at anchor points **42** (or anchor point **42**). Each of springs **41** comprise at least one arm **43** (or arms **43**) with two ends **43***a*, which are preferably curvedly shaped as shown. Arms **43** are preferably tapered having a thicker center portion near anchor point **42** and gradually thinning in width and/or thickness towards ends **43***a*. In addition, arms **43** may be laminated with gradually fewer applied elastic layers as distance from anchor point **42** increases. A plurality of arms **43** may be arrayed radially around, and attached to, a single anchor point **42**. As shown in FIG. **7**, arms **43** extend to crumple zone or intermediate shell **50**, if present, and anchor points **42** extend through crumple zone **50**. Leaf springs **41** may also be used in conjunction with elastomeric cords **30**. FIG. **7**A is an alternate embodiment comprising elliptical leaf springs **41***a* (or spring **41***a*) instead of parabolic leaf springs **41**. Like springs **41**, each of springs **41***a* is attached at single anchor points **42**.

FIG. **8** is a cross-section of the embodiment of helmet **10** shown in FIG. **7**, wherein leaf springs **41** are used in conjunction with both elastomeric cords **30** and cords **31**. As described above, cords **31** act as a backup to prevent cords **30** from being stretched beyond their elastic limit. Elastomeric portions **31***a* of cords **31** comprise a diameter larger than the diameter of uniform elastomeric cords **30**. As shown in FIG. **8**, the thick portions may be attached to either outer shell **12** or inner shell **20**.

FIG. **9** is a cross-sectional view of helmet **10** comprising leaf springs **41**, fixedly secured to outer shell **12**, as well as cords **30**. It should be appreciated that the embodiment of helmet **10** shown may further comprise cords **31** as shown in FIG. **8**.

FIGS. **10**A and **10**B schematically depict the action of leaf springs **41** when helmet **10** is struck by a force. In FIG. **10**A, helmet **10** is in the neutral state. In the neutral state, springs **41** are under relatively slight tension on all circumferential locations about helmet **10**. In FIG. **10**B, force F strikes helmet **10**, specifically outer shell **12**, the right hand side (i.e., radially inward relative to helmet **10**). Ends **43***a* are separated further from each other as arms **43** are pushed toward inner shell **20** (i.e., the radial distance between inner shell **20** and outer shell **12** decreases) to absorb the translational force vector created by force F. Simultaneously, ends **43***a*' of arms **43'** of springs **41'** located on the opposite side of helmet **10** move closer together as the tension on arms **43'** is reduced (i.e., the radial distance between inner shell **20** and outer shell **12** increases). After force F is exhausted, the increased tension created on the arms **43** on the right hand or contact side of helmet **10** act to return outer shell **12** radially outward toward the neutral position. The relaxed tension of arms **43'** on the noncontact side of helmet **10** allows outer shell **12** to move radially inward, closer to inner shell **20**, toward the neutral position. Although not shown in FIGS. **10**A and **10**B, it will be understood that cords **30** and/or cords **31** will act to absorb any rotational or torsional forces generated on helmet **10** by force F.

FIG. **11** is an enlarged schematic cross section of crumple zone or intermediate zone **50** in helmet **10** wherein leaf spring **41** is the force absorber/deflector. Elastomeric cords **30** extend from inner shell **20** to outer shell **12**. Crumple zone **50** is arranged circumferentially between cords **30** and comprises filler **52**. In the embodiment shown, filler **52** material is in the shape of a plurality of cones **54**. In an example embodiment, filler **52** comprises viscoelastic materials, such as, SORBOTHANE® material, or a combination of viscoelastic materials. Viscoelastic materials provide the advantage of behaving like a quasi-liquid, being readily deformed by an applied force and recovering slowly, although, in the absence of such a force, it takes up a defined shape and volume. An unusually high amount of the energy from an object dropped onto SORBOTHANE® material is absorbed. Leaf spring **41** pivotably connected to inner shell **20** by anchor point **42**, extends up through crumple zone **50**, and contacts outer shell **12**. In this embodiment, cones **54** in crumple zone **50** act to absorb a blow having much greater than normal force so that springs **41** are deflected to such a degree that outer shell **12** reaches crumple zone **50**. FIG. **12** is a top view of crumple zone **50** showing a plurality of cords **30** arranged between cones **54** comprising viscoelastic material. It should be appreciated that a helmet employing fluid-filled bladders may include a crumple zone having viscoelastic materials as a filler such as SORBOTHANE® material or STYROFOAM® peanuts.

FIGS. **13**A and **13**B are front views of articulating helmet **100** ("helmet **100**"), which is divided into at least two parts that are attached by an articulating means. By articulating, it is meant that the helmet comprises parts or sections joined by an articulating means such as hinge or pivot connections, swivels, or other devices that allow the separate parts of the helmet to be opened and closed together. Each section includes hard outer shell **101**. FIG. **13**A shows helmet **100** in the closed and locked orientation. Sections **102***a* and **102***b* are connected through articulating means **104**. In this embodiment, articulating means **104** is a hinge. It should be appreciated that any number of articulating means **104** suitable to open and close helmet **100** may be used, and that the invention is not limited to the use of one articulating means. Preferably, helmet **100** comprises one or more locks **106** (or lock **106**) to secure helmet **100** in the closed position. Helmet **100** further comprises ear apertures **108** and inner surface **101***a*. FIG. **13**B shows helmet **100** in the open orientation. Lock **106** is disengaged allowing articulating means **104** to open and separate sections **102***a* and **102***b*.

FIGS. **14**A and **14**B depict front views of an alternate embodiment of helmet **100** comprising sections **103***a*, **103***b*, and **103***c*. In this embodiment, helmet **100** includes air vents **110**, which are openings defined by helmet **100** that extend from outer surface **101** through to inner surface **101***a*. Articulating means **104** allows sections **103***b* and **103***c* to pivot with respect to section **103***a*. One or more locks **106** hold sections **103***b* and **103***c* in the closed position. It should be appreciated that air vents **110** may be arranged in helmets having any number of sections, for example, a helmet having two sections (as shown in FIGS. **13**A and **13**B). FIG. **14**B shows helmet **100** in the open position in which both articulating means **104** open to separate sections **103***b* and **103***c* from section **103***a*. FIG. **15** is a side view of the two-section embodiment of helmet **100**, as shown in FIGS. **13**A and **13**B, further comprising air vents **110** and two articulating means **104**. Similarly, FIG. **16** is a side view of the three-section embodiment of helmet **100**, as shown in FIGS. **14**A and **14**B, showing two articulating means **104** for section **103***c*.

FIG. **17** is a front view of another alternate embodiment of articulating helmet **100** wherein pads or cushions **112** are attached to inner surface **101***a* of helmet **100**. Pads **112** may be permanently attached to inner surface **101***a* with suitable attachment devices such as rivets, screws, or adhesives. Alternatively, pads **112** may be releasably attached to inner surface **101***a* using attachment devices such as VELCRO® hook and loop material, suction cups, snap buttons, or other releasable coupling device. Releasably attached pads **112** provides the advantage of allowing a user to customize helmet **100** with cushions **112** of various sizes, materials, and arrangements that provide a snug fit when helmet **110** is worn. Pads **112** comprise any suitable foam materials known to those having ordinary skill in the art. In both embodiments, pads **112** are attached to inner surface **101***a* between vents **110** to ensure maximum air flow to the user.

FIG. **17**A is a front view of a user showing a cross-section of articulating helmet **100** as worn by user U, with outer shell **120** removed. When helmet **100** is worn, pads **112** contact the top of the head of user U to provide a snug fit. It should be appreciated that pads **112** are arranged on inner surface **101***a* such that air vents **110** are unimpeded and provide air flow to user U. In this embodiment, ear apertures **108** are covered with a membrane or diaphragm **108***a*. In one embodiment, diaphragm **108***a* is fabricated from KEVLAR® fabric.

FIGS. **18** and **18**A are front views of articulating helmet **100** showing an embodiment wherein one section of helmet **100** may nest inside the other. In FIG. **18**A, section **102***b* is nested inside section **102***a* and helmet **100** is in the open position. Articulating means **104***a* is a swivel operatively arranged to hold sections **102***a* and **102***b* together and allow sections **102***a* and **102***b* to open and turn relative to each other such that outer surface **101** of one section radially faces inner surface **101***a* of the other section. For example, section **102***b* is rotated 90 degrees radially inside of section **102***a*, or vice versa. This embodiment decreases the overall volume of helmet **100** in the open position making it easier to store.

FIG. **19**A depicts an enlarged cross-sectional view of one embodiment of swivel means **104***a* that enables sections **102***a* and **102***b* to turn and nest within one another. Cable **105** is attached to section **102***b* at one end and universal joint **107** at another end. Spring **109** is connected to universal joint **107** at a first end and section **102***b* at a second end. Universal joint **107** is rotatably connected to section **102***a* (e.g., embedded therein) such that cable **105** and section **102***b* are rotatable relative to section **102***a*, and vice versa. Spring **109** pulls attached section **102***b* (and cable **105**) toward section **102***a*. FIG. **19**B shows sections **102***a* and **102***b* pulled apart with stretched spring **105** holding the two sections together. In addition, male prongs or tubes **120** can be arranged on section **102***a* which slide into ports **122** arranged on section **102***b* to stabilize the helmet when sections **102***a* and **102***b* are joined together. Alternatively, male prongs or tubes **120** can be arranged on section **102***b* and ports **122** can be arranged on to section **102***a* (this embodiment is not shown). As shown in FIG. **19**C, universal joint **107** enables section **102***b* to rotate relative to section **102***a* after which section **102***b* is pulled back toward section **102***a*. Because section **102***b* has been rotated, outer surface **101** of section **102***b* nests against inner surface **101***a* of section **102***a*.

It will be appreciated that various aspects of the disclosure above and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

What is claimed is:

1. A protective helmet, comprising:

an outer shell;

an inner shell slidingly connected to the outer shell; and,

a leaf spring comprising a center portion, a first end, and a second end, the leaf spring anchored only at the center portion to the outer shell, the first end unattached to, and in direct sliding contact with, the inner shell, and the second end unattached to, and in direct sliding contact with, the inner shell;

wherein:

in a neutral position, the first end is spaced from the second end by a first distance; and,

when a force strikes the helmet, the first end is spaced from the second end by a second distance, the second distance being different from the first distance.

2. The protective helmet as recited in claim **1**, wherein the first end includes a first arm arrayed radially around the anchored center portion and the first arm is arranged to slide along the outer surface of the inner shell.

3. The protective helmet as recited in claim **2**, wherein the second end includes a second arm arrayed radially around the anchored center portion and the second arm is arranged to slide along the outer surface of the inner shell.

4. The protective helmet as recited in claim **1**, wherein the leaf spring is parabolic in shape.

5. The protective helmet as recited in claim **1**, further comprising an elastomeric cord extending between and connecting the outer shell and the inner shell.

6. The protective helmet as recited in claim **5**, wherein the elastomeric cord is uniform in thickness.

7. The protective helmet as recited in claim **5**, wherein the elastomeric cord passes through an intermediate shell.

8. The protective helmet as recited in claim **5**, wherein the elastomeric cord includes a thick portion and a thin portion.

9. The protective helmet as recited in claim **8**, wherein the thick portion is connected to the inner shell and the thin portion is connected to the outer shell.

10. The protective helmet as recited in claim **1**, further comprising viscoelastic material arranged between the outer shell and the inner shell.

11. The protective helmet as recited in claim **10**, wherein the viscoelastic material is made of a plurality of cone-shaped elements.

12. The protective helmet as recited in claim **1**, wherein the inner and outer shells comprise hard materials.

13. The protective helmet as recited in claim **1**, further comprising an intermediate shell arranged proximate the inner shell.

14. The protective helmet as recited in claim **13**, wherein the intermediate shell comprises a filler.

15. A protective helmet, comprising:

a hard outer shell;

a hard inner shell slidingly connected to, and spaced apart from, the hard outer shell; and,

a leaf spring comprising:

a center portion, the leaf spring anchored only at the center portion to the hard outer shell;

a first end unattached to, and in direct sliding contact with, the hard inner shell; and,

a second end, unattached to, and in direct sliding contact with, the hard inner shell;

wherein:

in a neutral position, the first end is spaced from the second end by a first distance; and,

when a force strikes the helmet, the first end is spaced from the second end by a second distance, the second distance being different from the first distance.

16. The protective helmet as recited in claim **15**, wherein the first end includes a first arm arrayed radially around the anchored center portion and the first arm is arranged to slide along the outer surface of the inner shell.

17. The protective helmet as recited in claim **16**, wherein the second end includes a second arm arrayed radially around the anchored center portion and the second arm is arranged to slide along the outer surface of the inner shell.

18. The protective helmet as recited in claim **15**, further comprising an elastomeric cord extending between and connecting the outer shell and the inner shell.

* * * * *