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Salvino et al.

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(54) **DUST MITIGATION HEADGEAR**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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(22) Filed: **Mar. 12, 2025**

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(51) **Int. Cl.**

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A41D 13/002	(2006.01)
A62B 18/00	(2006.01)
A62B 18/04	(2006.01)

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CPC ***A42B 3/28*** (2013.01); ***A41D 13/002*** (2013.01); ***A62B 18/003*** (2013.01); *A62B 18/045* (2013.01)

(58) **Field of Classification Search**
CPC A62B 18/00–006; A62B 18/04–04508; A62B 18/088; A62B 17/00; A62B 17/005; A62B 23/00–02; A62B 7/10; A42B 3/28–286; A41D 13/002–0025
See application file for complete search history.

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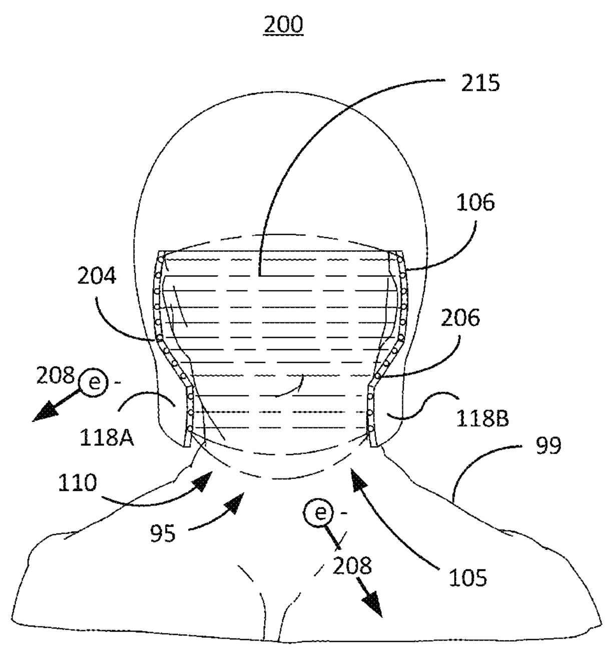
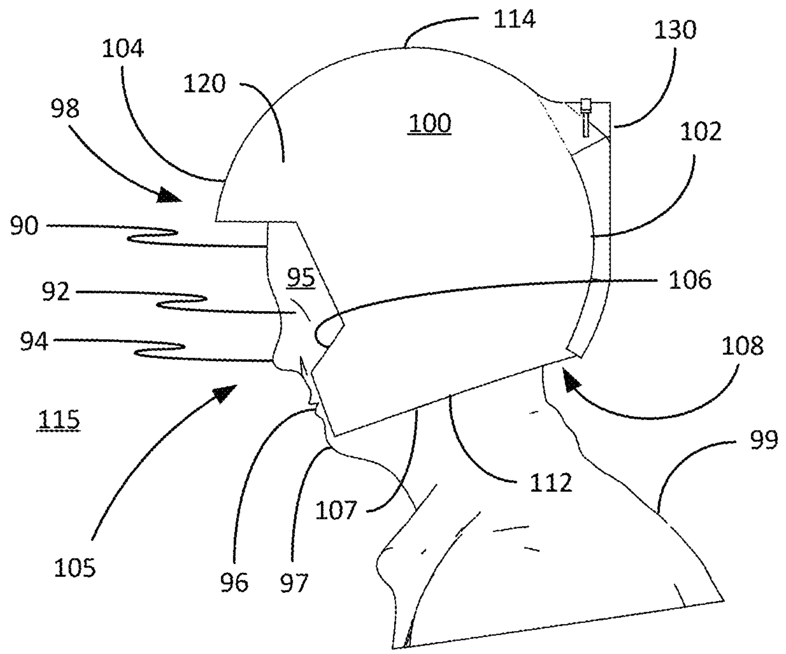
(57) **ABSTRACT**

Described herein are embodiments directed to a particle repelling helmet having particle mitigation system that keeps dust particles from going into the interior of the helmet. The helmet comprises a face vent that provides an unobstructed pathway between an external environment and a wearer's eyes, nose and mouth. A spacer arrangement connected to an inner side of the helmet provides a channel between the wearer's head and the inner helmet side. A fan blows air through the helmet, across the wearer's head and out the face vent and head receiving opening in the bottom of the helmet. Electrodes disposed along the edge of the face vent produce an electrostatic barrier that spans the face vent thereby further preventing charged dust from going into the helmet. The helmet can also comprise an ionizer that generates ions, which charges neutral dust particles that can be blocked by the barrier.

20 Claims, 14 Drawing Sheets




114
130
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98
102
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106
92
94
108
115
99
112
107
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96
97

FIG. 1A

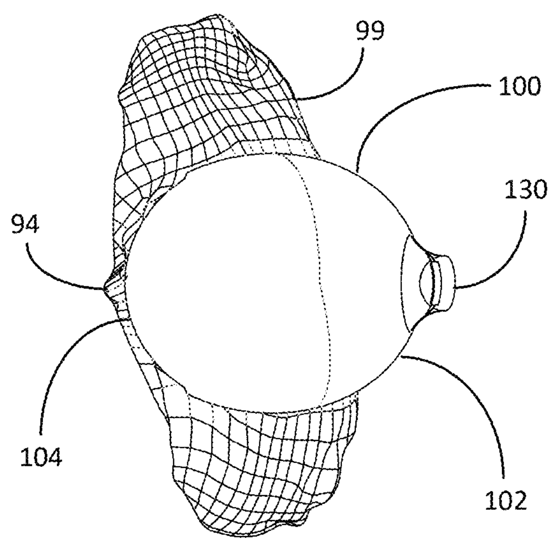

99
100
130
94
104
102

FIG. 1B

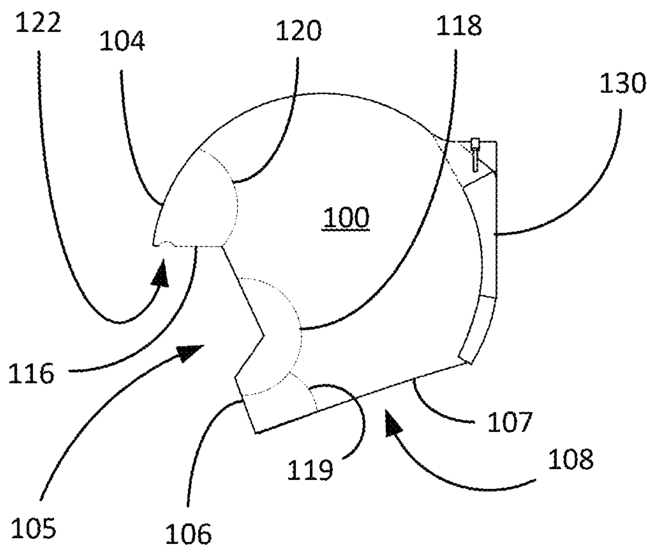
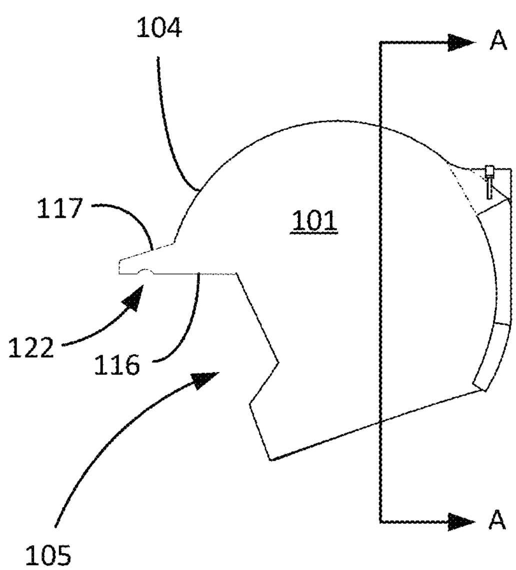

122
104
120
118
130
100
116
105
106
119
107
108

FIG. 1C


104
A
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122
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A

FIG. 1D

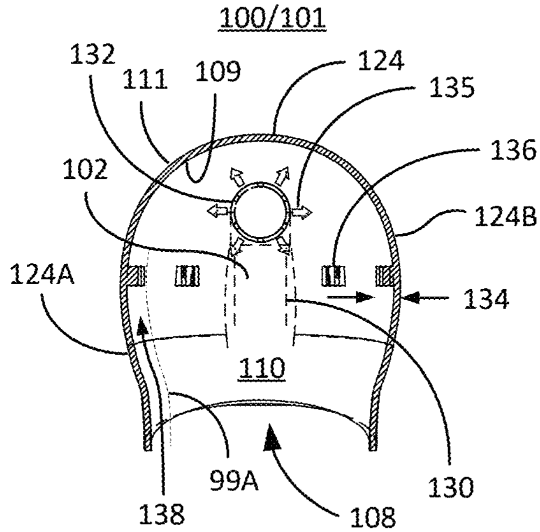
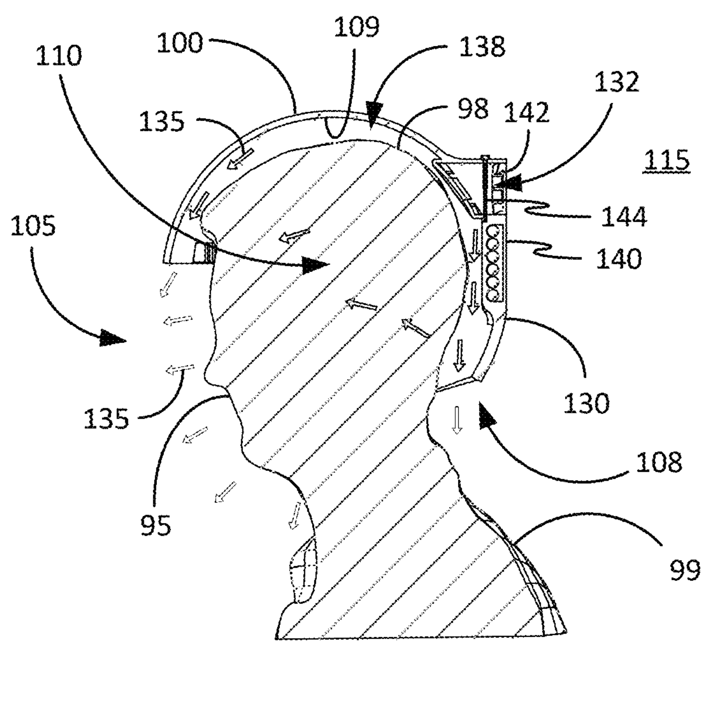

100/101
132
111
109
124
135
136
102
124B
124A
134
110
130
99A
138
108

FIG. 1E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138
135
98
142
132
115
144
105
140
130
135
108
95
99

FIG. 1F

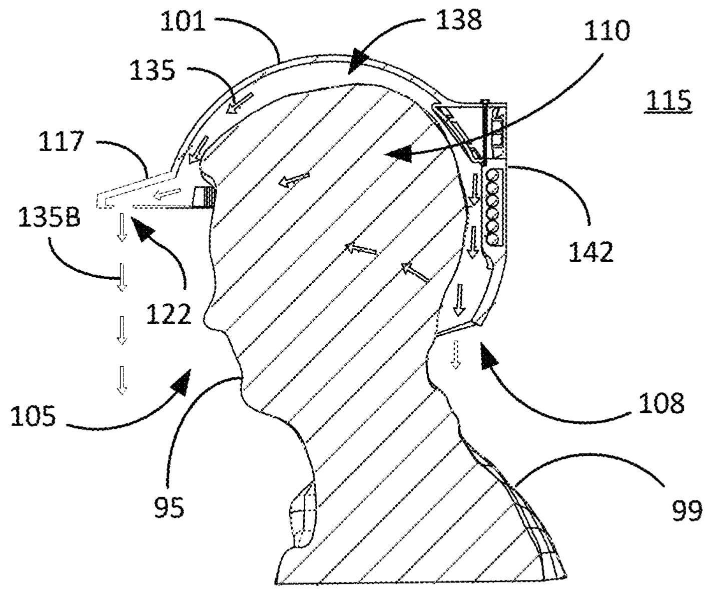
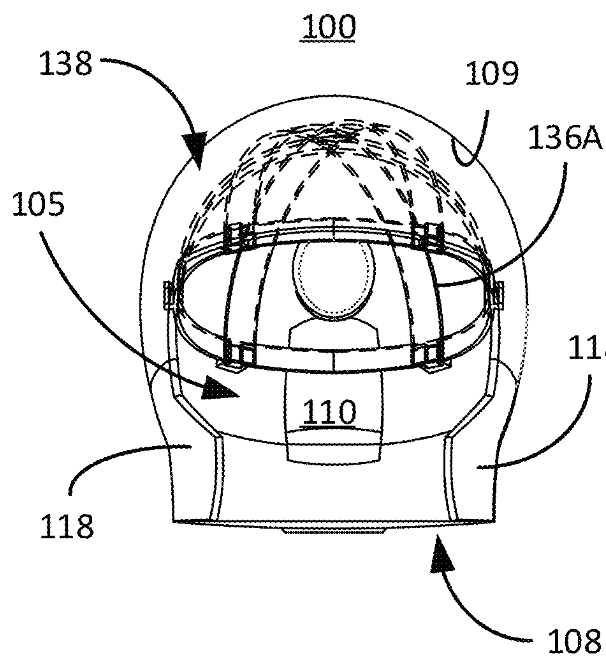

101
138
110
135
115
117
135B
142
122
105
108
95
99

FIG. 1G


100
138
109
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105
118
110
118
108

FIG. 1H

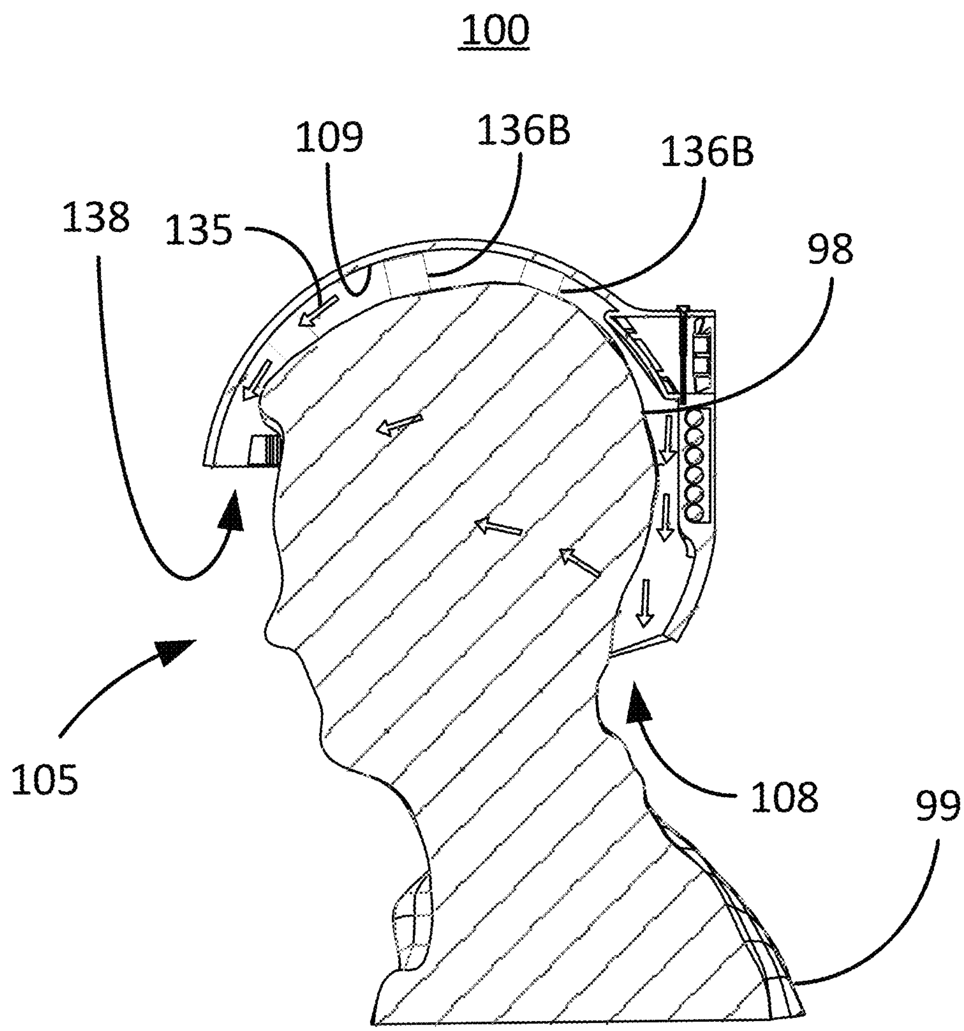


FIG. 1I

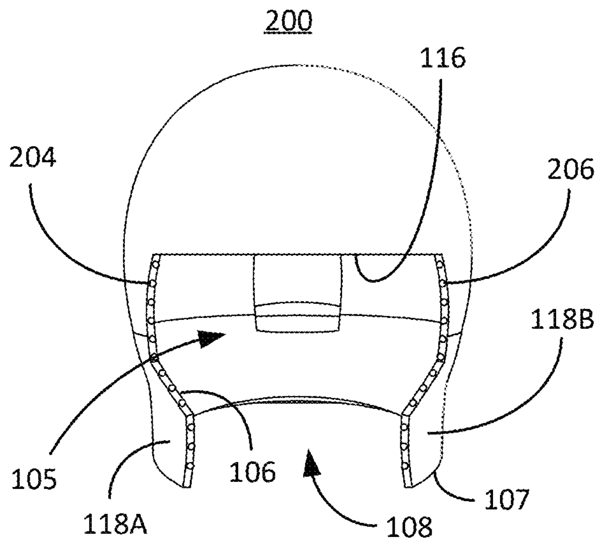
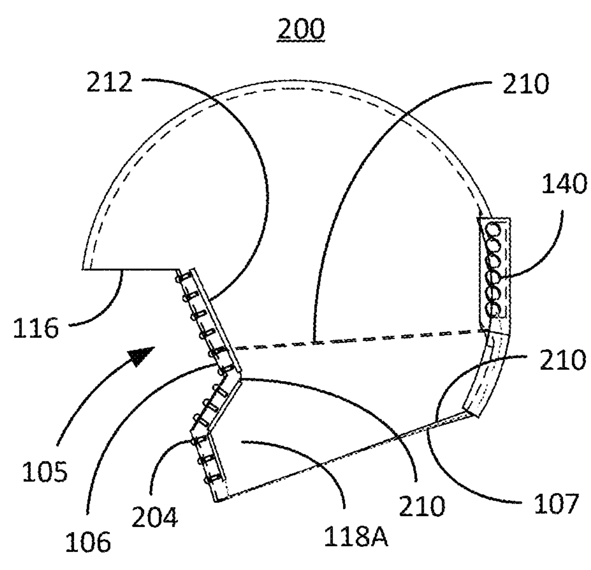

200
116
204
206
118B
105
106
107
118A
108

FIG. 2A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116
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107
204
210
106
118A

FIG. 2B

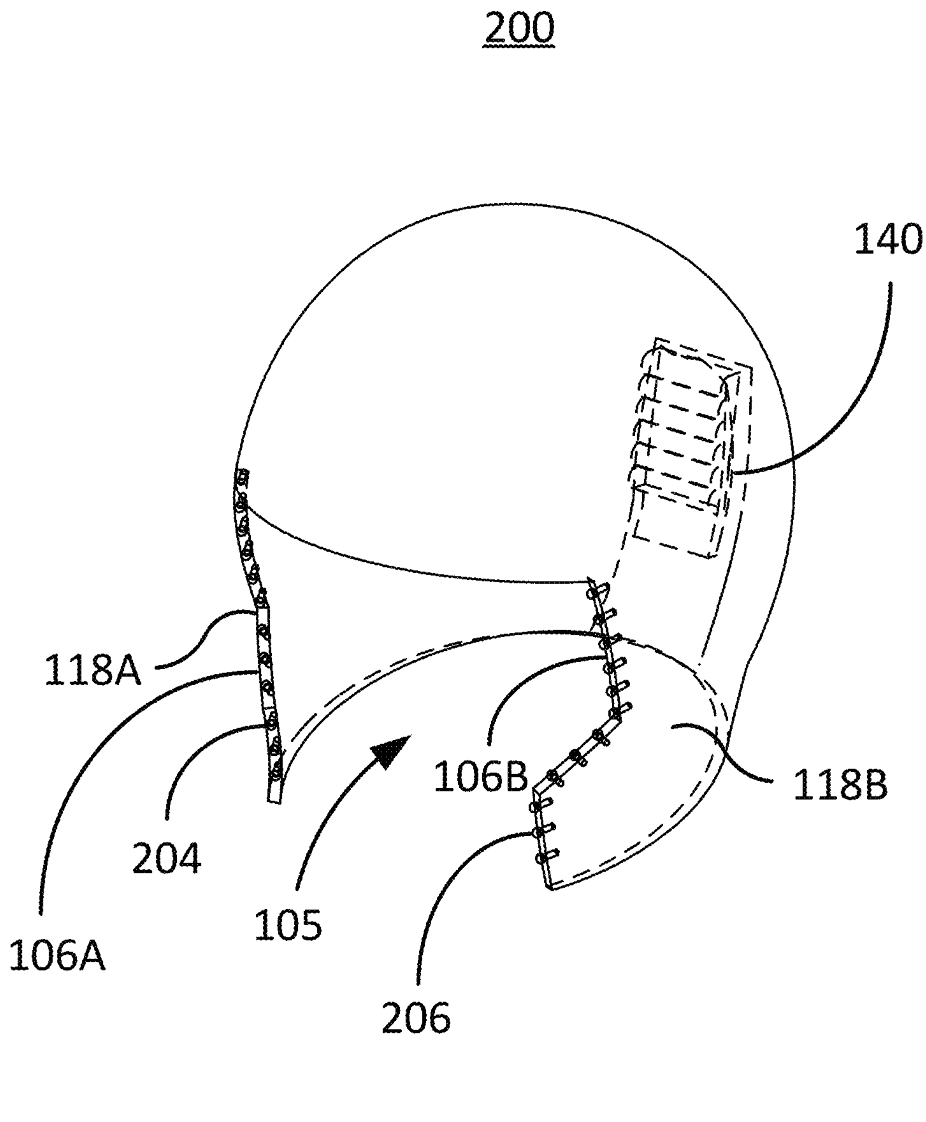


FIG. 2C

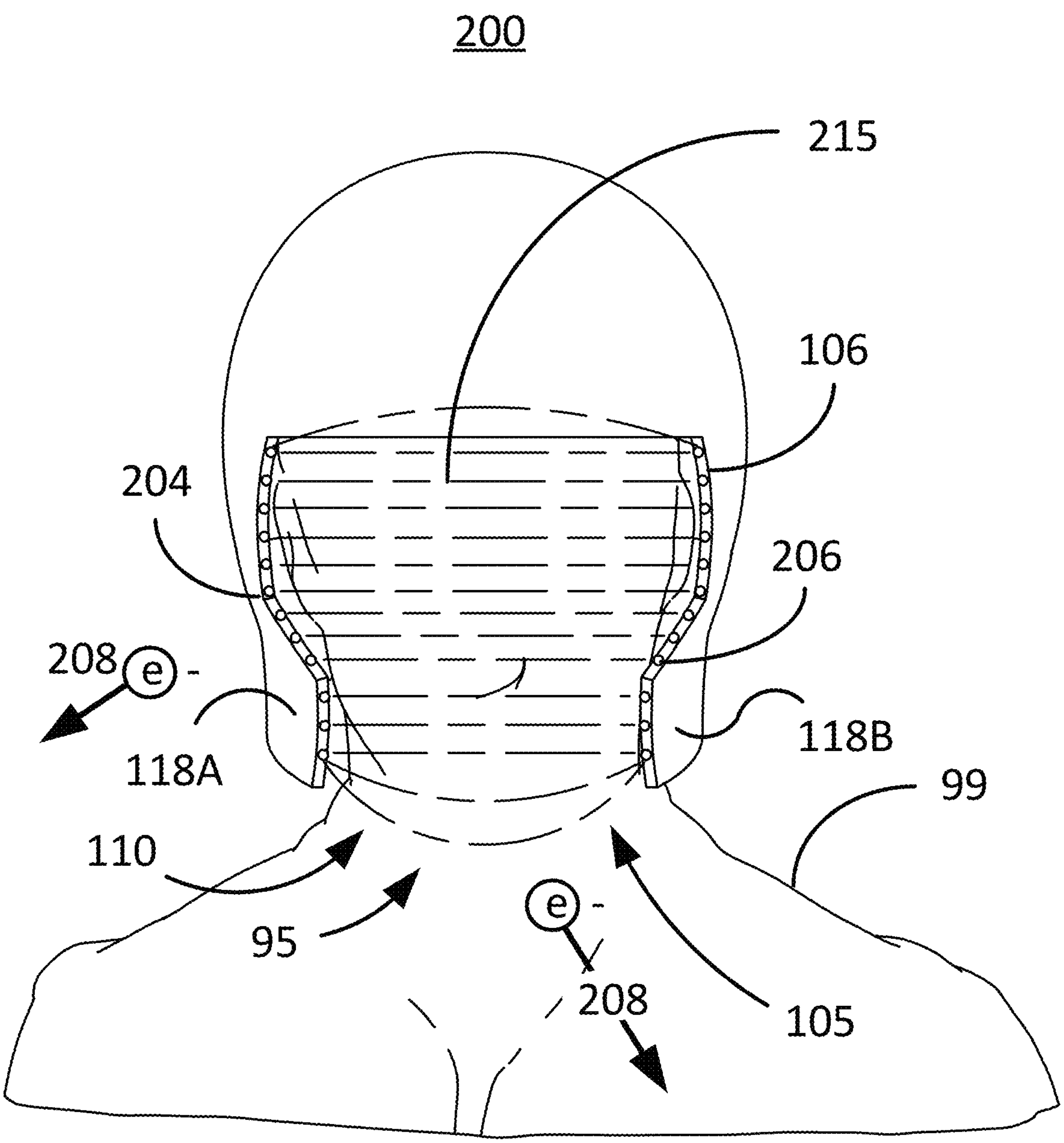


FIG. 2D

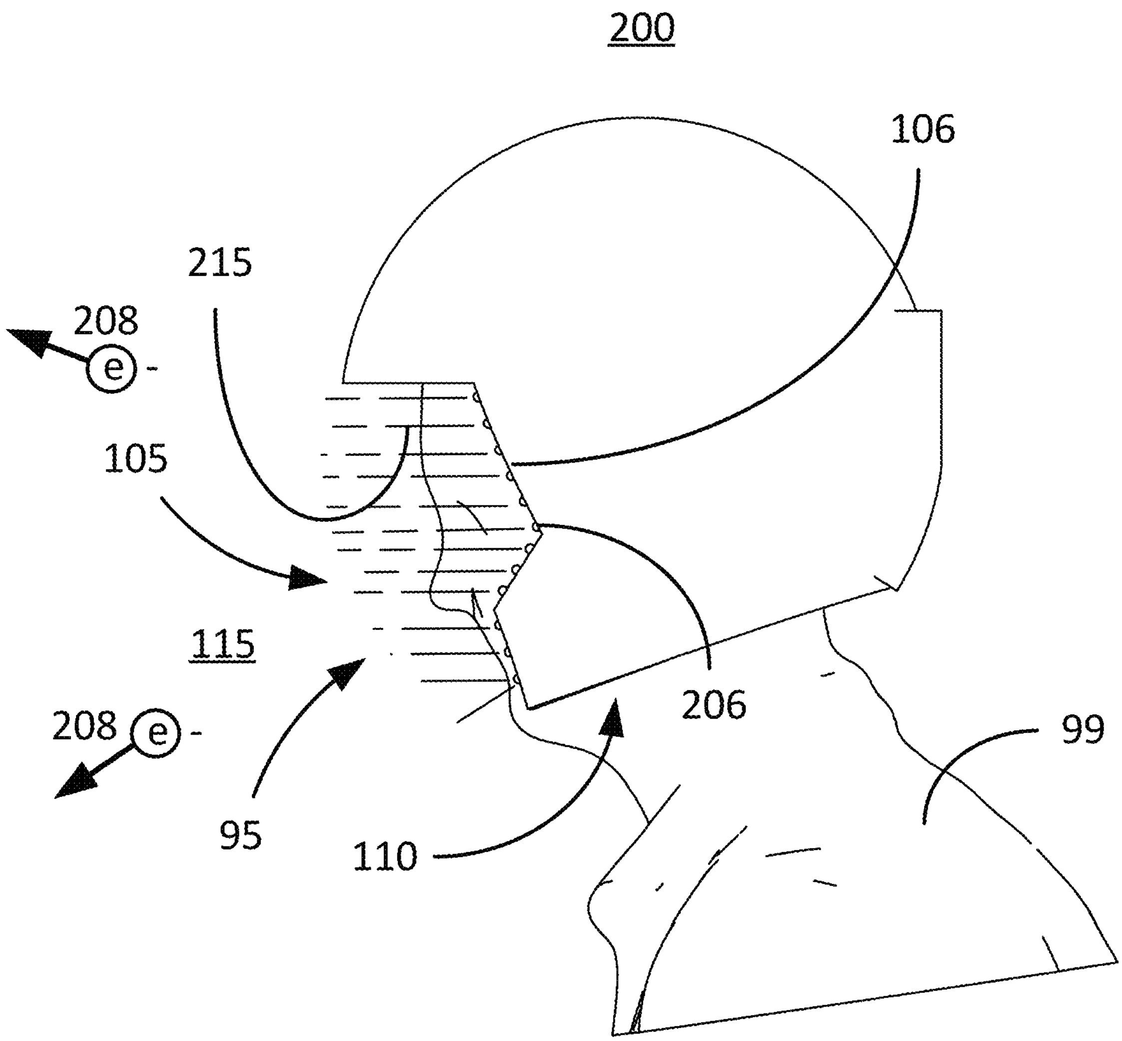
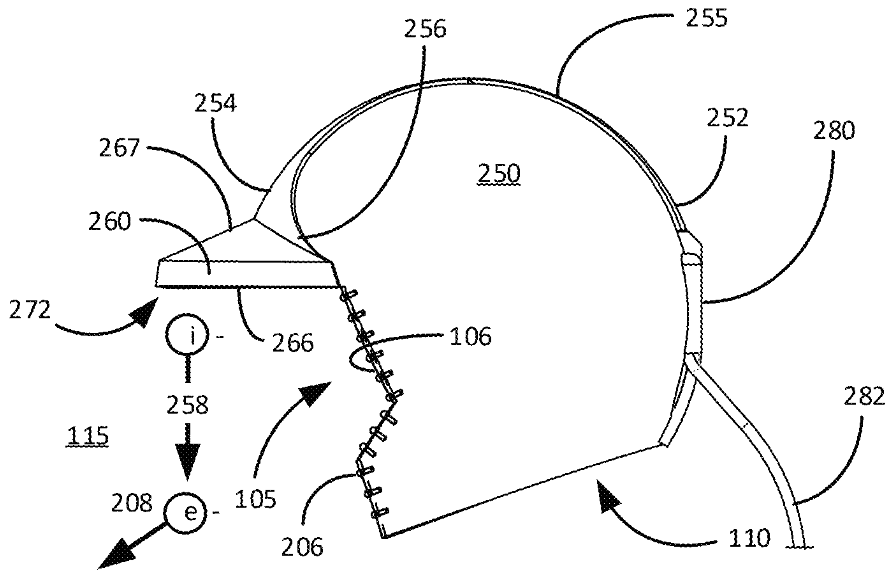


FIG. 2E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260
272
266
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115
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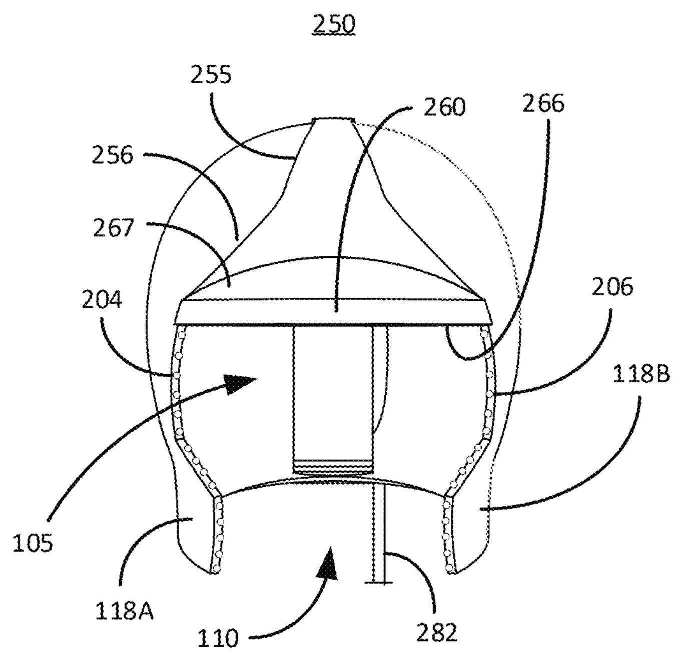
105
208
206
110

FIG. 3A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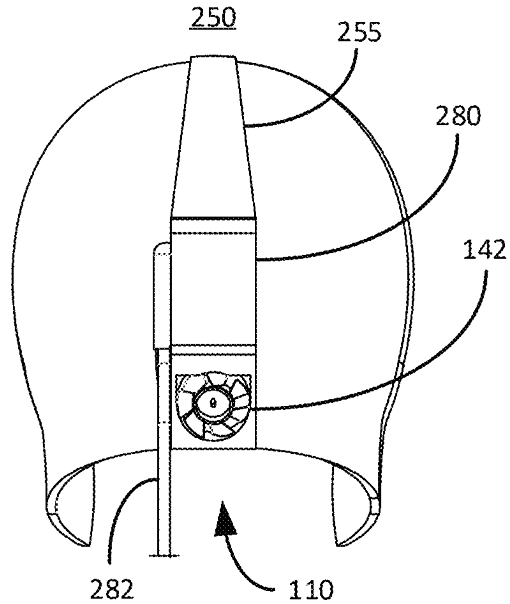
266
256
267
204
206
118B
105
118A
110
282

FIG. 3B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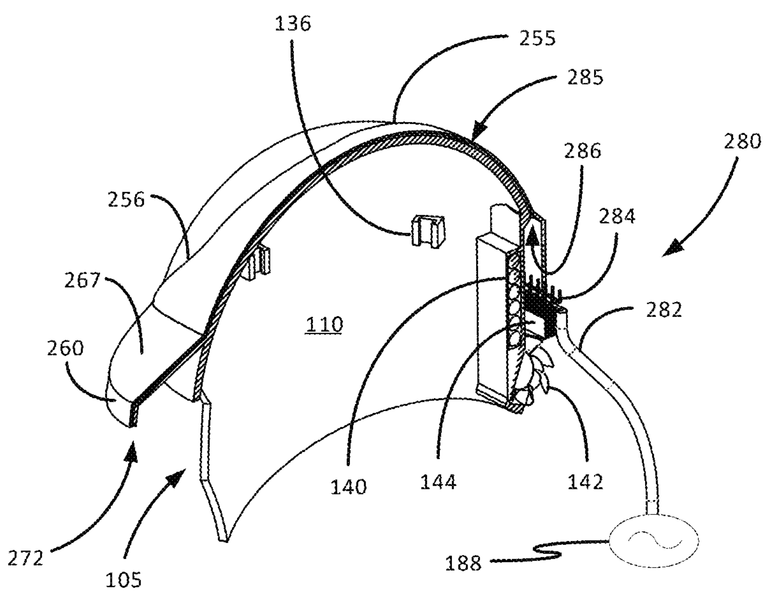
282
110

FIG. 3C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256
267
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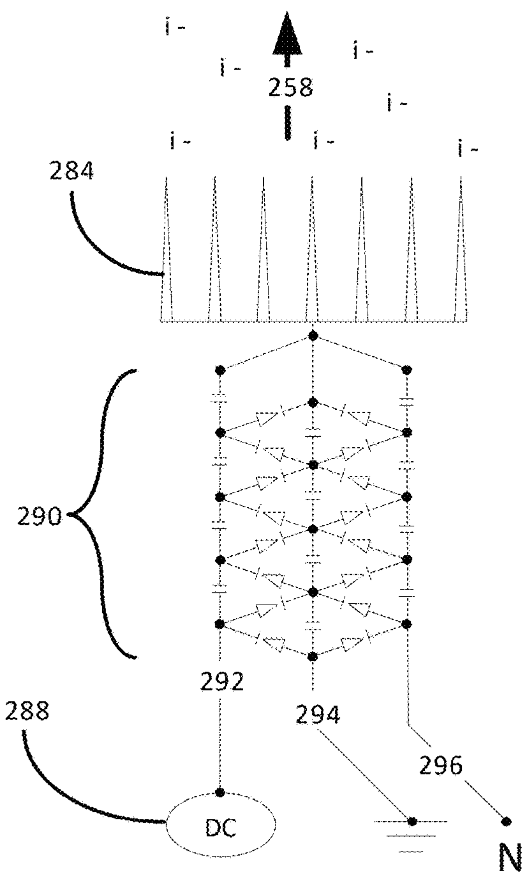
260
140
144
142
272
105
188

FIG. 3D


i -
i -
258
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292
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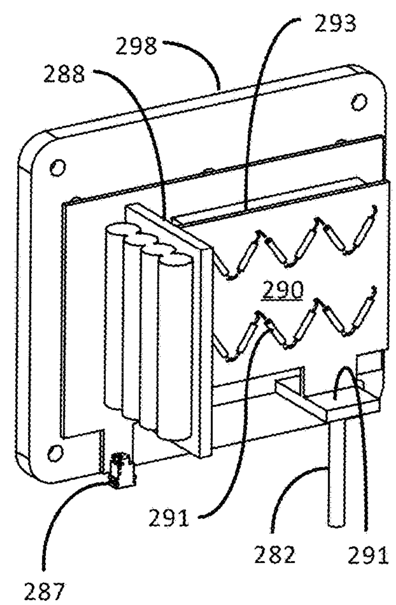
296
DC
N

FIG. 3E


293
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291

FIG. 3F

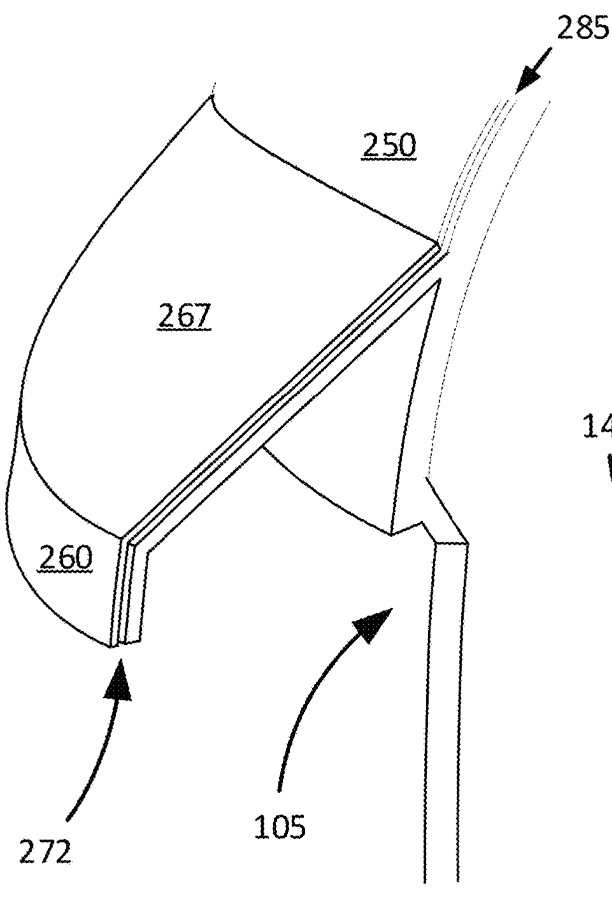

FIG. 3G

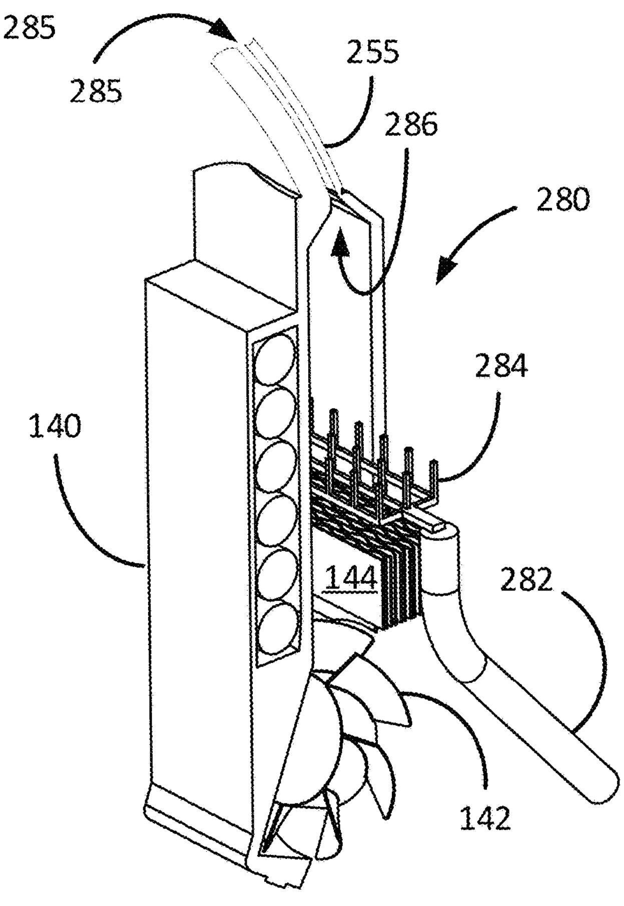

FIG. 3H

ATTORNEY DOCKET NO.: CS023 US02
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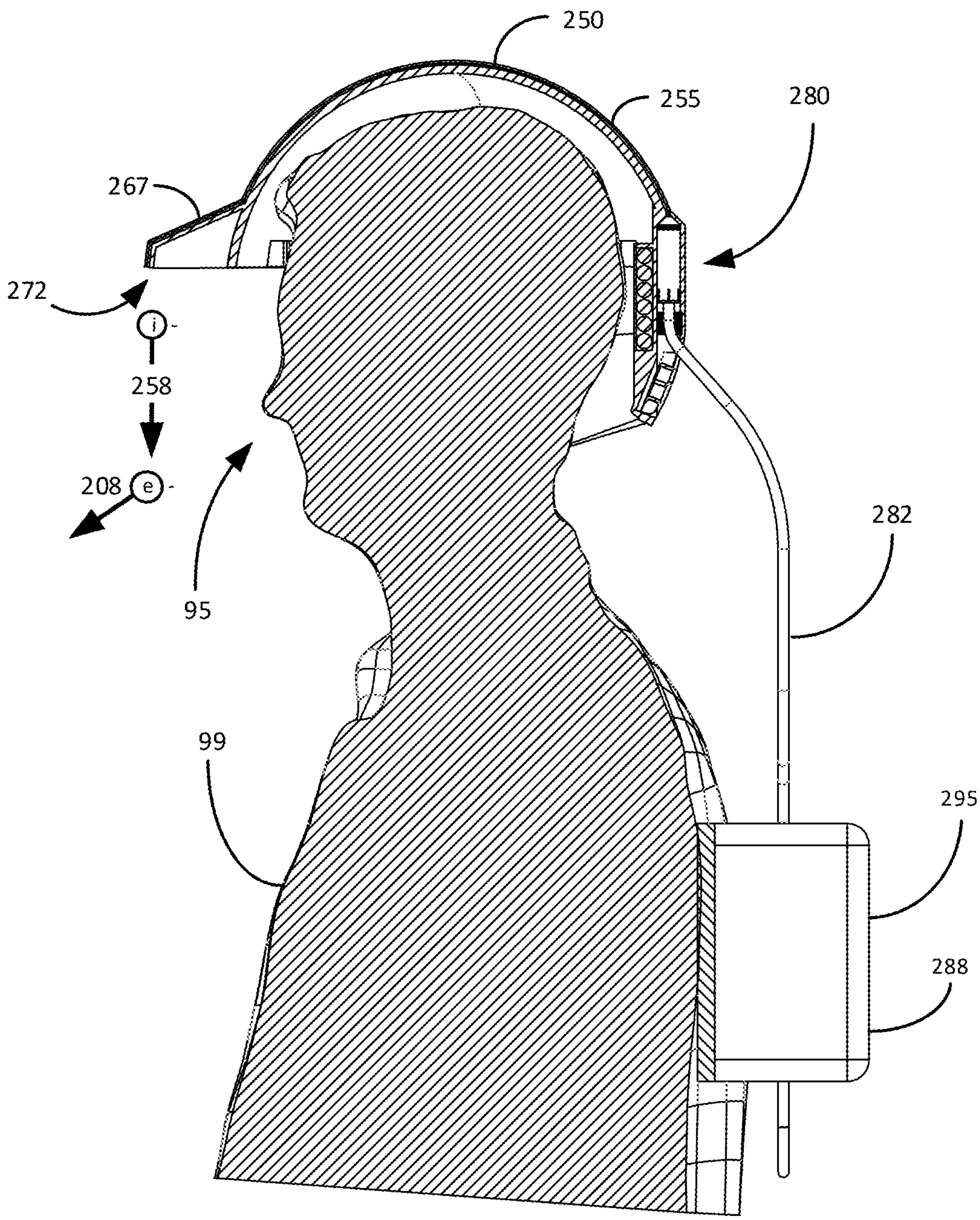

FIG. 3I

DUST MITIGATION HEADGEAR

CROSS-REFERENCE TO RELATED APPLICATIONS

This continuation application which claims priority to and the benefit of U.S. patent application Ser. No. 18/932,726 entitled DUST MITIGATION HEADGEAR, filed on Oct. 31, 2024, the entire disclosure of which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to headgear that provides an internal low dust environment.

2. Description of Related Art

Lunar dust presents significant challenges to human health and equipment due to its small particle size, electrostatic charge, and presence of ferromagnetic materials. The low gravity on the Moon (⅙th of Earth's gravity) allows dust to remain suspended longer, posing inhalation risks and potential damage to the human respiratory system. Effective dust mitigation is essential for ensuring the safety and health of astronauts within lunar habitats.

Particles less than 0.1 micrometers (μm) are known to enter the bloodstream via the respiratory system. Most lunar dust ranges from 0.1 to 50 μm in size, with the majority less than 10 m. This information underscores the importance of focusing on mitigation techniques, as not only is the respiratory system vulnerable, but the entire body via the blood. Lunar dust particles that are less than 50 μm adhere to surfaces mainly through electrostatic attractions, while the more abundant particles less than 50 μm adhere via van der Waals forces. However, unlike Earth, the lunar atmosphere is constantly charged, affecting dust of all sizes and making electrostatic charging the main force in dust adhesion independent of size.

Additionally, airborne dust on Earth, such as in mining and construction sites, face significant challenges. Particulate matter generated by excavation, drilling, and heavy machinery can lead to serious health concerns, including respiratory conditions like silicosis, pneumoconiosis, and chronic obstructive pulmonary disease (COPD). Additionally, dust can damage equipment, reduce visibility, and increase operational costs due to frequent maintenance. Moreover, like the problems in a lunar environment, dust particles here on Earth, pose risks due to their abrasive nature and ability to be inhaled deeply into the lungs.

The subject matter disclosed herein is generally directed to innovations related to managing dust particles from entering human lungs.

SUMMARY OF THE INVENTION

The present invention generally relates to headgear, such as a helmet, that discourages dust particles from entering therein thus protecting a headgear wearer's respiratory system.

In that light, certain embodiments of the present invention envision a particle repelling helmet that generally comprises an outer shell with a face vent and particle mitigation system that keeps dust particles from going into the interior of the helmet to protect the human respiratory system. The outer

shell is configured to conform to a substantial part of a wearer's head, except for their face. The face vent is in the front of the helmet and is defined along boarders that include a forehead lip, a left and a right face vent periphery. The face vent is configured to provide an unobstructed pathway between an external environment and a wearer's eyes, nose and mouth. The particle repelling helmet further comprises a spacer arrangement, a positive pressure air source and electrodes disposed at the face vent peripheries. The spacer arrangement is connected to an inner side of the particle repelling helmet, wherein the spacer arrangement is configured to provide a channel between a wearer's head and the inner side. The positive pressure air source is in communication with the channel, the positive pressure air source is located at a back side of the particle repelling helmet. The positive pressure air is filtered, and in some embodiments, charged to induce charged particles outside of the helmet. The positive pressure air source is configured to exit airflow through the face vent via the channel. The electrodes are configured to produce an electrostatic field that spans the face vent that repel charged particles outside of the helmet.

Another embodiment of the present invention envisions a helmet that is configured to receive a human head. The helmet comprising a head interfacing interior and an exterior (that interfaces an external environment) having a front side, a rear side, and a perimeter lip, and, which defines a face vent and a head receiving aperture. The head receiving aperture is configured to receive a human head. The face vent is defined between a left and a right cheek perimeter lip and of the perimeter lip and a brim that extends from a forehead region of the front side. The face vent is configured to provide an unobstructed path between an external environment and a wearer's eyes, nose and mouth. The helmet further comprises a spacer arrangement, a positive pressure air source and electrodes. The spacer arrangement is connected to the helmet inner side and is configured to provide a channel between a wearer's head and the helmet inner side. The positive pressure air source is in communication with the channel at the rear side. The positive pressure air source is configured to exit airflow through the face vent via the channel. The electrodes are disposed at the left and the right cheek perimeter lip, wherein the electrodes are configured to produce an electrostatic field that spans the face vent.

Yet another embodiment of the present invention envisions a dust repelling helmet that comprises a spacer arrangement, a positive pressure air source, and electrodes. The dust repelling helmet possesses an inner surface and an exterior surface that defines a front side, a rear side, and a face vent. The face vent is defined between a left perimeter, a right perimeter, and a brim that extends outwardly from a forehead region of the front side. The face vent is configured to provide an unobstructed path between an external environment and a wearer's eyes, nose and mouth. The spacer arrangement is located at the interior and is configured to provide a channel that is defined between a wearer's head and the inner surface. The positive pressure air source is envisioned to be in communication with the channel and is configured to flow airflow over the wearer's head and through the face vent via the channel. The electrodes are disposed at the left perimeter and the right perimeter, wherein the electrodes are configured to produce an electrostatic field that spans the face vent.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a line drawing illustratively depicting a person wearing particle repelling headgear consistent with embodiments of the present invention;

FIG. 1B is a line drawing illustratively depicting the person wearing the particle repelling helmet of FIG. 1A from a top-down view perspective;

FIG. 1C is a side-view line drawing illustratively depicting the particle repelling helmet of FIG. 1A;

FIG. 1D illustratively depicts a slight variation of the helmet embodiment of FIG. 1C but with a brim consistent with embodiments of the present invention;

FIG. 1E is a line drawing of a cross-section along cut-line AA of FIG. 1D illustratively depicting an interior perspective of the particle repelling helmet looking towards the back of the helmet;

FIG. 1F is a cross-section side view line drawing of a wearer wearing the helmet embodiment of FIG. 1A;

FIG. 1G is a cross-section side view line drawing of a wearer wearing the helmet embodiment of FIG. 1D;

FIG. 1H is a front view line drawing of the helmet depicting an internal head support cage consistent with embodiments of the present invention;

FIG. 1I is a side view cross-section line drawing of the helmet being worn by a person depicting an optional internal head support stays consistent with embodiments of the present invention;

FIG. 2A-2E are line drawings of an electrostatic face vent barrier consistent with embodiments of the present invention;

FIGS. 3A-3D are line drawings of an ionizer and electrostatic face vent barrier helmet embodiment consistent with embodiments of the present invention;

FIG. 3E is a block diagram of an exemplary voltage boosting circuit consistent with embodiments of the present invention;

FIG. 3F illustratively depicts a voltage boosting circuit and power supply that can be disposed in a power backpack;

FIGS. 3G and 3H are higher resolution cross-section views of the brim region and the ionizer arrangement of FIG. 3D; and

FIG. 3I is a cross-section line drawing of a person wearing the ionizer and with electrostatic face vent barrier helmet.

DETAILED DESCRIPTION

Initially, this disclosure is by way of example only, not by limitation. Thus, although the instrumentalities described herein are for the convenience of explanation, shown and described with respect to exemplary embodiments, it will be appreciated that the principles herein may be applied equally in other similar configurations involving the subject matter directed to the field of the invention. The phrases "in one embodiment", "according to one embodiment", and the like, generally mean the particular feature, structure, or characteristic following the phrase, is included in at least one embodiment of the present invention and may be included in more than one embodiment of the present invention. Importantly, such phrases do not necessarily refer to the same embodiment. If the specification states a component or feature "may", "can", "could", or "might" be included or have a characteristic, that particular component or feature is not required to be included or have the characteristic. As used herein, the terms "having", "have", "including" and "include" are considered open language and are synonymous with the term "comprising". Furthermore, as used herein, the term "essentially" is meant to stress that a characteristic of something is to be interpreted within acceptable tolerance margins known to those skilled in the art in keeping with typical normal world tolerance, which is analogous with "more or less." For example, essentially flat, essentially straight, essentially on time, etc. all indicate that these characteristics are not capable of being perfect within the sense of their limits. Accordingly, if there is no specific +/− value assigned to "essentially", then assume essentially means to be within +/−2.5% of exact. The term "connected to" as used herein is to be interpreted as a first element physically linked or attached to a second element and not as a "means for attaching" as in a "means plus function". In fact, unless a term expressly uses "means for" followed by the gerund form of a verb, that term shall not be interpreted under 35 U.S.C. § 112(f). In what follows, similar or identical structures may be identified using identical call-outs.

With respect to the drawings, it is noted that the figures are not necessarily drawn to scale and are diagrammatic in nature to illustrate features of interest. Descriptive terminology such as, for example, upper/lower, top/bottom, horizontal/vertical, left/right and the like, may be adopted with respect to the various views or conventions provided in the figures as generally understood by an onlooker for purposes of enhancing the reader's understanding and is in no way intended to be limiting. All embodiments described herein are submitted to be operational irrespective of any overall physical orientation unless specifically described otherwise, such as elements that rely on gravity to operate, for example.

Described herein are embodiments directed to a particle repelling headgear that has a particle mitigation system that keeps dust particles from going into the interior of the headgear thereby protecting a wearer's respiratory system. To streamline the illustrative embodiments, the headgear will be described as a helmet. The helmet comprises a face vent that provides an unobstructed pathway between an external environment and a wearer's eyes, nose and mouth. A spacer arrangement connected to an inner side of the helmet provides a channel between the wearer's head and the inner helmet side. An air flow source, such as a fan, blows air through the helmet, across the wearer's head and out the face vent and head receiving opening in the bottom of the helmet. When energized, electrodes disposed along the edge of the face vent produce an electrostatic barrier that spans the face vent thereby further preventing charged dust from going into the helmet. The helmet can also comprise an ionizer that generates ions, which charges neutral dust particles that can be blocked by the barrier.

FIG. 1A is a line drawing illustratively depicting a person wearing particle repelling headgear, such as a helmet for example, consistent with embodiments of the present invention. The helmet described herein is a hard-shelled headgear but a soft or partially soft headgear that is not a helmet can comprise all the elements described herein without departing from the scope and spirit of the present invention. One advantage of a hard-shelled helmet is to protect a wearer's head from impact of external objects. A shaped foam headgear, for example, would offer less impact protection but could be lighter and easier to manage in an inside environment, such as a lunar shelter or lunar living space.

As shown, the particle repelling helmet **100**, or simply helmet, is being worn by a person (wearer) **99**. The helmet **100** is shaped to conform to a human/person's head **98**, which is received (i.e., put on) via a head receiving aperture **108** defined by a head receiving lip **107** located along the bottom **112** of the helmet **100**. The helmet's bottom **112**, or in this example, a helmet bottom side **112**, is opposite to the helmet apex/top **114**. The helmet **100** comprises a face vent **105** that provides an unobstructed opening, or pathway, between an external environment **115** and the wearer's eyes **92**, nose **94** and mouth **96**. The face vent **105** is located at the helmet's front **104**, just under a helmet forehead region **120**, which is configured to interface the wearer's forehead **90**. A face vent lip **106** defines the shape of the face vent **105**, which extends towards the wearer's chin **97**. In this embodiment, the face vent lip **106** is connected to, or otherwise continues into, the head receiving lip **107**. The face vent **105** also provides an unobstructed view of the person's face **95** from an onlooker in front of or otherwise facing the wearer's face **95**. A positive pressure inlet housing **130** is depicted extending from the back **102** of the helmet **100**, which will be discussed later.

FIG. **1**B is a line drawing illustratively depicting the person **99** wearing the particle repelling helmet **100** of FIG. **1**A from a top-down view perspective. From this perspective, the wearer's nose **94** is shown extending from the helmet's front **104**. The positive pressure inlet housing **130** is shown extending from the helmet's rear **102**.

FIG. **1**C is a side-view line drawing illustratively depicting the particle repelling helmet **100** of FIG. **1**A devoid of a person wearing the helmet **100**. The helmet **100** comprises a pair of cheek guards **118** that extend along the lower portion of the face vent lip **106**. In this embodiment, the cheek guards **118** (a left and a right cheek guard) close in along the wearer's mouth **96** to reduce the size of the face vent **105** to increase the velocity of airflow **135** expelled from the helmet **100**, as discussed in more detail below. A forehead underside lip **116** defined in the forehead region **120** can comprise a plurality of airflow exit ports **122**. The brim underside can be part of the face vent lip **106**. In certain embodiments, the face vent **105** can further include a chin region **119** that is envisioned to extend to or below a wearer's chin **97**.

FIG. **1**D illustratively depicts a slight variation of the helmet embodiment **100** of FIG. **1**C but with a brim **117** extending from the front **104** of the helmet embodiment **101**. As shown here, the airflow exit ports **122** are in the underside of the brim **117** beyond the forehead underside lip **116**. In this way, airflow **135** can be made to flow downwards, like an air curtain, across the face vent **105**, which may add a protective barrier to the likelihood of airborne dust entering the interior helmet space **110**. Cross-section cut-line AA is presented for FIG. **1**E.

FIG. **1**E is a line drawing of a cross-section along cut-line AA of FIG. **1**D illustratively depicting an interior perspective of the particle repelling helmet looking towards the back **102** of the helmet **100**/**101**. The helmet rear **102** is identical for both helmets **100** and **101** in this embodiment. The helmet shell **124**, hashed to depict the cross-section, defines a helmet interior surface **109** and a helmet exterior surface **111**. The helmet interior space **110**, includes all that is in the helmet **100**/**101** minus the wearer's head **98**. An inlet port **132**, in the upper center of the helmet interior **110**, receives pressurized air **135**, which naturally flows (see airflow arrows) along an airflow channel **138**, defined by the head-to-interior-surface spacing **134** created by the internal head support **136**. The head-to-interior-surface spacing **134** is the spacing between a wearer's head **98** and the interior surface **109**. The airflow channel **138** is depicted along the helmet interior surface **109** and the dashed line **99**A, which is defined by the wearer **99**. The internal head support **136** spaces the wearer's head **98** from the interior surface **109** for comfort, shock management, and the formation of the airflow channel **138**. For reference, the right helmet side **124**A and the left helmet side **124**B of the helmet shell **124** are shown. Also, for reference, shown are the head receiving aperture helmet **108** and the hidden lines for the positive pressure inlet housing **130**.

FIG. **1**F is a cross-section side view line drawing of a wearer **99** wearing the helmet embodiment **100** of FIG. **1**A. As depicted, air **135** flows, through the airflow channel **138** via a fan arrangement **142**, which pressurizes the air **135** on the channel side **138** of the fan **142**. In this embodiment, the fan **142** is electrically powered by a battery pack **140** located under the fan **142**. Both the fan **142** and battery pack **140** are disposed in the positive pressure inlet housing **130** but could just as easily be elsewhere. A filter **144**, such as a HEPA (high efficiency particulate air) filter, is placed on the exit side of the fan **142** (towards the airflow channel **138**) to filter debris or dust particles from entering in the helmet interior **110** via the external environment **115**. Optional embodiments envision the filter **144** being disposed on the entry side of the fan **142** (towards the external environment **115**). As shown, the airflow channel **138** is the space defined between the helmet's interior surface **109** and the wearer's head **98**. Filtered airflow **135** is directed along the airflow channel **138** and out the face vent **105** and head receiving aperture **108** (see arrows **135**) thereby preventing particulates from entering the helmet interior **110** via the external environment **115**. The filtered air **135** that exits through the face vent **105** acts as an invisible barrier between the wearer's face **95** and the exterior environment **115**. In this way, the wearer **99** can talk to someone, eat, touch their face **95**, etc., all the while avoiding contaminated air in the external environment **115** from contaminating the interior space **110** and endangering the wearer's respiratory system. One further benefit of this arrangement is that the airflow **135** can further act as a convection cooling means for the wearer's head **98**. In other words, if the wearer **99** is using the helmet **100** in an uncomfortably hot environment, the flowing air **135** can help transfer heat from the wearer's head **98** providing some additional comfort to the wearer **99**.

FIG. **1**G is a cross-section side view line drawing of a wearer **99** wearing the helmet embodiment **101** of FIG. **1**D. As depicted, the fan arrangement **142** pressurizes the air **135** to flow through the airflow channel **138**. The filtered air **135** flows along the airflow channel **138** and out the face vent **105** and head receiving aperture **108** (see arrows **135**). Additionally, a curtain of airflow **135**B is pressurized to move from the airflow exit ports **122** in the brim **117** over the face vent adding an additional barrier to the wearer's face **95** from dust particles in the external environment **115**.

FIG. **1**H is a front view line drawing of the helmet **100** depicting an internal head support cage **136**A consistent with embodiments of the present invention. As shown here, the internal head support cage **136**A tightly conforms to the cranium of a wearer's head **98**. The internal head support cage **136**A is partly viewable via the face vent **105**. The cheek guards **118** and head receiving aperture **108** are shown here for reference. The internal head support cage **136**A illustratively depicts the airflow channel **138** between the internal head support cage **136**A the interior surface **109**. It should be appreciated that a skilled artisan would be able to design an optional internal head support cages **136**A given the number of options currently in existence.

FIG. **1**I is a side view cross-section line drawing of the helmet **100** being worn by a person **99** depicting an optional internal head support stays **136**B consistent with embodiments of the present invention. As shown here, the internal head support stays **136**B extend from the interior surface **109** to contact the wearer's head **98**. The head support stays **136**B can be made from rubber or foam, for example, to tightly conforms to the cranium of a wearer's head **98**. The internal head support stays **136**A allow air **135** to flow through the airflow channel **138** and out through the face vent **105** and head receiving aperture **108**. Air **135** will obviously flow around the head support stays **136**B, unless the head support stays **136**B are porous to allow air to sufficiently pass therethrough.

FIG. **2**A-**2**E are line drawings of an electrostatic face vent barrier consistent with embodiments of the present invention. FIG. **2**A is a front view of the helmet embodiment **200**, which is like that of the helmet embodiment **100** of FIG. **1**A but with electrodes **204** and **206** dispersed along the face vent lip **106**. The forehead lip **116** is devoid of electrodes in this embodiment. The electrodes **204** and **206** are shown evenly dispersed along the face vent lip **106** at the left cheek side **118**A and the right cheek side **118**B, respectively. Other embodiments allow for the electrodes **204** and **206** to be dispersed in an unevenly dispersed arrangement. When powered, the electrodes **204** and **206** form an electrostatic face vent barrier **215** extending over the face vent **105**, as shown by the dashed lines in FIG. **2**D. For reference, the head receiving lip **107** is contiguous with the face vent lip **106**, the head receiving lip **107** defines the head receiving aperture helmet **108**.

FIG. **2**B illustratively depicts a cross-section side view of the helmet embodiment **200** of FIG. **2**A consistent with embodiments of the present invention. As shown, the electrodes **204** are extending from the face vent lip **106** of the left cheek side **118**A from the forehead underside lip **116** to the head receiving lip **107**. The electrodes **204** are connected to the battery pack **140** via positive and negative electrode wire leads **210**, shown by the dashed lines. The electrodes **204** are connected to a power busbar **212** that follows the shape of the face vent lip **106**, as shown.

FIG. **2**C illustratively depicts an angled view of the helmet embodiment **200** of FIG. **2**A consistent with embodiments of the present invention. As shown, the left electrodes **204** extend from the left face vent lip **106**A of the left cheek side **118**A and the right electrodes **206** extend from the right face vent lip **106**B of the right cheek side **118**B. The left electrodes **204** possess a different electrostatic polarity than the right electrodes **206**. For example, the left electrodes **204** can comprise a negative charge versus a positive charge for the right electrodes **206**. Hidden lines of the battery pack **140** is shown here for reference.

FIG. **2**D is a front view of the helmet embodiment **200** being worn by a person **99** consistent with embodiments of the present invention. Here, the left electrodes **204** and corresponding right electrodes **206** are powered to generate the electrostatic field **215** acting as a face vent barrier depicted by the dashed lines. The electrostatic face vent barrier **215** spans, or otherwise extends, across the face vent **105** from the left cheek region **118**A to the right cheek region **118**B. In this way, charged particles **208** in the air are deflected by the electrostatic face vent barrier **215** thereby preventing the charged particles **208** from getting to the wearer's face **95**. Because the charged particles **208** are repelled from crossing into the helmet interior **110** via the face vent **105**, the wearer **99** is protected from breathing in the charged particles **208**. The electrostatic field **215** in front of the face vent **105** can be a static field via a direct current being delivered to the electrodes **204** and **206**. Another embodiment envisions the electrostatic field **215** in front of the face vent **105** can be an alternating electrostatic field generated by an alternating current being delivered to the electrodes **204** and **206**. Other embodiments envision a combination of alternating current and direct current being applied to the electrodes **104** and **106** over select intervals (duty cycles), such as 2 milliseconds of direct current followed by 2 milliseconds of alternating current. The electrical circuit and associated components (not shown) that drive the electrostatic face vent barrier **215** can be arranged via standard electrical circuit design practices known to those skilled in the art.

FIG. **2**E is a side view of the helmet embodiment **200** being worn by a person **99** consistent with embodiments of the present invention. As shown, the electrostatic face vent barrier **215** extends in front of the wearer's face **95** serving to repel unwanted charged particles **208** from entering in the helmet interior **110** via the face vent **105**. Accordingly, the electrostatic face vent barrier **215** protects the wearer **99** from breathing in charged particles **208** that may be suspended in the external environment **115**.

FIGS. **3**A-**3**D are line drawings of an ionizer and electrostatic face vent barrier helmet embodiment consistent with embodiments of the present invention. FIG. **3**A is a side view line drawing of the ionizer and electrostatic face vent barrier helmet embodiment **250** depicting an ionizer arrangement **280** used in conjunction with the electrostatic face vent barrier system described in conjunction with the helmet embodiment **200**, of FIG. **2**E. The ionizer arrangement **280**, which is located at the back side **252** of the helmet **250**, is configured to produce ions **258**, which are dispensed, or otherwise emitted, from the helmet **250** via at least one ion exit port **272** located at the underside lip **266** of the brim **267**. High voltage power is delivered to the ionizer arrangement **280** via the voltage power line **282**. Ions **258** produced by the ionizer **280** are transmitted through an ion conduit **255** that comprises an inlet port **286** at the back side **252** of the helmet **250**. The conduit **255** leads into a distributor **256** at the front side **254** of the helmet **250**, which spreads the ions **258** along the front periphery **260** of the brim **267**. When emitted, the ions **258** create a curtain-like geometry in front of the face vent **105**. The curtain-like geometry of ions **258** dispensed from the ion exit port **272**, traverse over the face vent **105**, thereby charging uncharged dust particles **208** floating in the external environment **115** in front of the face vent **105**. The charged dust particles **208** are repelled by the electrostatic face vent barrier (shield) **215** when the electrodes **206** and **204** are energized, as shown in FIG. **2**E. In this way, uncharged particles in the air become charged particles **208**. For reference, the right sided electrodes **206** extending from the face vent lip **106** are shown. As discussed above, the charged particles **208** are deflected by the electrostatic face vent barrier **215**, which prevents the charged particles **208** from crossing into the helmet interior **110** via the face vent **105** thereby protecting the wearer **99** from breathing in dust contamination.

FIG. **3**B is a line drawing viewing the front of the helmet **250**. From this perspective, the ion conduit **255** is shown leading into the distributor **256**, which feeds into the front periphery **260** of the brim **267**. FIG. **3**B is described in view of FIGS. **1**G, **1**F, **2**E and **3**A. As discussed above, ions **258** flowing outward from the underside lip **266** of the brim **267** charge dust particles **208** floating in the ambient environment **115** in front of the face vent **105**. The charged dust particles **208** are deflected by the electrostatic face vent barrier **215** generated when the left and right electrodes **204** and **206** are energized. The combination of charging the particles **208** floating in the external environment **115** with the repulsive action of the electrostatic face vent barrier **215** serves to prevent the influx of particulate contamination (that may have originated as neutrally charged dust particles) from reaching the helmet's interior **110**. Coupled with a filtered positive air pressure described in conjunction with FIGS. **1**G and **1**F, the helmet's interior volume **110** provides a clean environment for a wearer **99** to safely function in an otherwise dust contaminated environment.

FIG. **3**C is a back side view of the helmet **250** showing the ionizer arrangement **280**, fan **142** and ion conduit **255** consistent with embodiments of the present invention. The fan arrangement **142** is used here to at least move or blow the ions **258** generated by the ionizer arrangement **280** through the ion conduit **255**. The fan arrangement **142** can further be used to pressurize air **135** inside **110** of the helmet **250**, as shown in FIG. **1**E. The voltage power line **282**, shown here for reference, can also supply power to the electrodes **204** and **206**.

FIG. **3**D is an isometric cross-section view of the helmet **250** consistent with embodiments of the present invention. In this figure, the ionizer arrangement **280** is shown in greater detail. In one embodiment, as depicted by the exemplary power boosting circuit block diagram of FIG. **3**E, the ionizer arrangement **280** generally comprises a voltage source **288**, that produces direct current, connected to a voltage boosting circuit **290**. If alternating current is used, the circuit can include a wave rectifier to convert the alternating current into direct current. The voltage boosting circuit **290**, which is a (high voltage) voltage multiplier array, comprises a plurality of diodes each connected to capacitor in an interconnected chain, as shown. It should be appreciated that other ion generating circuits can be arranged by those skilled in the art. The left lead **292** extends from the voltage source **288**, the center lead **294** is grounded and the right lead **296** is neutral. The voltage boosting circuit **290** is connected to an ionizer tip array **284**, wherein when the voltage boosting circuit **290** is energized, ions **258** emit from the tips (free ends of the needles) of the tip array **284**. The tip array can be metal, carbon, or some other conducting material and can be pins, needles, brushes, etc. The fan **142** blows the ions **258** towards the ion duct funnel/inlet port **286**, which funnels the ions **258** down the ion duct **285** in the ion conduit **255**. The ion duct **285** extends to the ion exit port **272**. Hence, the ion exit port **272** is in communication with the ion duct funnel **286**, meaning there is a contiguous, uninterrupted path between the ion exit port **272** and the ion duct funnel **286**.

FIG. **3**F illustratively depicts a voltage boosting circuit and power supply that can be disposed in a power backpack **295**, as shown in FIG. **3**I. As shown, the voltage boosting circuit **290** is mounted on a printed circuit board (PCB) **293**, which is mounted to a circuit plate **298**, which, in turn, is mounted to the power backpack **295**. The diodes **291** are depicted mounted to the PCB **29**. The voltage source **288** is a battery arrangement that can be recharged via a connector **287**. The voltage boosting circuit output **290** is connected to the high voltage power line **282**.

FIGS. **3**G and **3**H are higher resolution cross-section views of the brim region and the ionizer arrangement **280** of FIG. **3**D. With reference to FIG. **3**H, the ions **258** that are emitted from the ionizer tip array **284** get blown into the ion duct funnel **286** via the fan **142** and down through the ion duct **285** in the ion conduit **255**. Shown for reference are the battery pack **140**, the filter **144** and the power cable **282**. With reference to FIG. **3**G, the ions **258** move from the helmet back **252** to the brim **267** where the ions **258** are emitted from the ion exit port **272** (at the bottom of the front periphery **260** of the helmet **250**). The face vent **105** is shown here for reference.

FIG. **3**I is a cross-section line drawing of a person **99** wearing the ionizer and with electrostatic face vent barrier helmet **250**. FIG. **3**I is shown in view of FIGS. **2**D and **1**F. The person **99** is wearing a backpack **295** that includes the voltage source **288** and voltage boosting circuit **290**. The voltage conditioned by the voltage boosting circuit **290** is connected to the ionizer arrangement **280** that produces ions **258**. When operating, ions **258** are moved through the ion conduit **255** and out the ion exit port **272** in the brim **267**. As discussed above, the ions **258** help to charge dust particles **208** floating in the air in front of the wearer's face **95**. The charged dust particles **208** are repelled by the electrostatic face vent barrier **215** generated by the electrodes **204** and **206** located along the face vent lip **106**. Some embodiments envision the addition of the positive air pressure **135** in the helmet **250**, all of which serve to provide essentially a dust free environment within the helmet interior **110** to protect the wearer's respiratory system.

With the present description in mind, below are some examples of certain embodiments illustratively complementing some of the apparatus embodiments discussed above and presented in the figures to aid the reader. Accordingly, the elements called out below are provided by example to aid in the understanding of the present invention and should not be considered limiting. The reader will appreciate that the below elements and configurations can be interchangeable within the scope and spirit of the present invention. The illustrative embodiments can include elements from the figures.

In that light, certain embodiments of the present invention envision a particle repelling helmet **200**, which can optionally be headgear that is not a helmet but may or may not retain the shape of the helmet, that generally comprises an outer shell **124** with a face vent **105** and particle mitigation system that keeps dust particles from going into the interior of the helmet **200**. The outer shell **124** is configured to conform to a substantial part of a wearer's head **98**, except for their face **95**. The face vent **105** is in the front **104** of the helmet **200** and is defined along boarders that include a forehead lip **116**, a left and a right face vent periphery **106**. The face vent **105** is configured to provide an unobstructed pathway between an external environment **115** and a wearer's eyes **92**, nose **94** and mouth **96**. The particle repelling helmet **200** further comprises a spacer arrangement **136**, a positive pressure air source **142** and electrodes **204** and **206** disposed at the face vent peripheries **106**. The spacer arrangement **136** is connected to an inner side **109** of the particle repelling helmet **200**, wherein the spacer arrangement **136** is configured to provide a channel **138** between a wearer's head **98** and the inner side **109**. The positive pressure air source **142** is in communication with the channel **138**, the positive pressure air source **142** is located at a back side **102** of the particle repelling helmet **200**. The positive pressure air source **142** is configured to exit airflow **135** through the face vent **105** via the channel **138**. The electrodes **204** and **206** are configured to produce an electrostatic field **215** that spans the face vent **105**.

The particle repelling helmet **200** further envisions the electrodes **204** and **206** being connected to an oscillator adapted to generate an oscillating electric field, which is emitted from the electrodes **204** and **206**. This can further be where the electrodes **204** and **206** are configured to switch between the oscillating electric field and a non-oscillating electric field.

The particle repelling helmet **250** can further comprise an ionizer **280** that is configured to expel ions **258** that convert dust particles into charged dust particles **208** in a region that is external **115** to the particle repelling helmet **250**.

The particle repelling helmet **200** can optionally further comprise a head receiving aperture **108** at a base **107** of the particle repelling helmet **200**, wherein the base **107** is opposite a helmet apex **114** of the particle repelling helmet **200**. The head receiving aperture **108** is configured to receive a human head **95**. This can further include at least one feed channel **138/285** that links to exit ports **122/272** distributed along the brim **117/267**, the exit ports **122/272** point in a downward direction **135**B defined from the helmet apex **114** towards the head receiving aperture **108**. Another embodiment envisions the at least one feed channel **138/285** being in communication with the positive pressure air source **142**, wherein the exit ports **122/272** expel the airflow **135**B across the face vent **105** in the downward direction.

Some embodiments of the particle repelling helmet **200** further envision a filter **144** in-line with the positive pressure air source **142**, wherein the airflow **135** is configured to be filtered upon entering the channel **138**.

The particle repelling helmet **200** further envisions the face vent **105** being configured to permit a wearer's hand to enter therethrough to contact the eyes **92**, the nose **94** and the mouth **96**.

The particle repelling helmet **200** further imagines the spacer arrangement **136** comprising a plurality of compressible stays **136**B that is configured to extend from the inner side **109** to the wearer's head **95**.

The particle repelling helmet **200** further envisions contemplates the spacer arrangement **136** comprising an adjustable cradle **136**A that is configured to conform to the wearer's head **95**.

The particle repelling helmet **200** further contemplates the positive pressure air source **142** being a fan located that is at back side **102** of the particle repelling helmet **200**, the back side **102** is on the opposite side of the helmet from where the face vent **105** is.

Other embodiments of the present invention contemplate a helmet **200** that is configured to receive a human head **95**. The helmet **200** comprising a head interfacing interior **110** and an exterior **111** having a front side **104**, a rear side **102**, and a perimeter lip **106**, **107** and **116**, which defines a face vent **105** and a head receiving aperture **108**. The head receiving aperture **108** is configured to receive a human head **98**. The face vent **105** is defined between a left and a right cheek perimeter lip **106**A and **106**B of the perimeter lip **106** and a brim **117** that extends from a forehead region **120** of the front side **104**. The face vent **105** is configured to provide an unobstructed path between an external environment **115** and a wearer's eyes **92**, nose **94** and mouth **96**. The helmet **200** further comprises a spacer arrangement **136**, a positive pressure air source **142** and electrodes **204** and **206**. The spacer arrangement **136** is connected to the helmet inner side **109** and is configured to provide a channel **138** between a wearer's head **95** and the helmet inner side **109**. The positive pressure air source **142** is in communication with the channel **138** at the rear side **102**. The positive pressure air source **142** is configured to exit airflow **135** through the face vent **105** via the channel **138**. The electrodes **204** and **206** are disposed at the left and the right cheek perimeter lip **106**A and **106**B, wherein the electrodes **204** and **206** are configured to produce an electrostatic field **215** that spans the face vent **105**.

The helmet **200** further envisioning the perimeter lip **106**, **107** and **116** being configured to extend to a wearer's chin **97**.

The helmet **200** further imaging the airflow **135** in the channel **138** being configured to cool the human head **95**.

The helmet **200** further contemplating the electrodes **204** and **206** being connected to an oscillator that is adapted to generate an oscillating electric field **215** emitted from the electrodes **204** and **206**. This further imagines the electrodes **204** and **206** being configured to switch between the oscillating electric field and a non-oscillating electric field.

The helmet **250** can further comprise an ionizer **280** located at the rear side **102**, wherein the ionizer **280** is configured to generate ions **258** that convert dust particles into charged dust particles **208** in an external environment **115** (to the helmet **250**).

Yet another embodiment of the present invention envisions a dust repelling helmet **200** that comprises a spacer arrangement **136**, a positive pressure air source **142**, and electrodes **204** and **206**. The dust repelling helmet **200** possesses an inner surface **109** and an exterior surface **111** that defines a front side **104**, a rear side **102**, and a face vent **105**. The face vent **105** is defined between a left perimeter **106**A, a right perimeter **106**B, and a brim **117** that extends outwardly from a forehead region **120** of the front side **104**. The face vent **105** is configured to provide an unobstructed path between an external environment **115** and a wearer's eyes **92**, nose **94** and mouth **96**. The spacer arrangement **136** is located at the interior **110** and is configured to provide a channel **138** that is defined between a wearer's head **95** and the inner surface **109**. The positive pressure air source **142** is envisioned to be in communication with the channel **138** and is configured to flow airflow **135** over the wearer's head **95** and through the face vent **105** via the channel **138**. The electrodes **204** and **206** are disposed at the left perimeter **106**A and the right perimeter **106**B, wherein the electrodes **204** and **206** are configured to produce an electrostatic field **215** that spans the face vent **105**.

The dust repelling helmet **250** can further comprise an ionizer **280** located at the rear side **102**, wherein the ionizer **280** is configured to generate ions **258** that convert dust particles into charged dust particles **208** in an external environment **115** to the helmet **250**.

The above sample embodiments should not be considered limiting to the scope of the invention whatsoever because many more embodiments and variations of embodiments are easily conceived within the teachings, scope and spirit of the instant specification.

It is to be understood that even though numerous characteristics and advantages of various embodiments of the present invention have been set forth in the foregoing description, together with the details of the structure and function of various embodiments of the invention, this disclosure is illustrative only, and changes may be made in detail, especially in matters of structure and arrangement of parts within the principles of the present invention to the full extent indicated by the broad general meaning of the terms in which the appended embodiments are expressed. For example, the orientation of the elements can vary and can include different geometries not explicitly shown in the embodiments above while maintaining essentially the same functionality without departing from the scope and spirit of the present invention. Likewise, the materials and construction of the helmet/headgear can be different but serve the same purpose without departing from the scope and spirit of the present invention. It should further be appreciated that the circuitry or electrical elements could be different while fulfilling the intended function, the basic construction being understood by those skilled in the art once in possession of the concepts disclosed herein.

It will be clear that the present invention is well adapted to attain the ends and advantages mentioned as well as those inherent therein. While presently preferred embodiments have been described for purposes of this disclosure, numerous changes may be made which readily suggest themselves to those skilled in the art and which are encompassed in the spirit of the invention disclosed and as defined in the appended claims.

What is claimed is:

1. A particle repelling helmet comprising:
 a face vent defined along a forehead lip and a left and a right face vent periphery, the face vent configured to provide an unobstructed pathway between an external environment and a wearer's face;
 a positive pressure air source located at a back side of the particle repelling helmet, the positive pressure air source configured to exit airflow through the face vent; and
 electrodes disposed at the face vent peripheries, the electrodes configured to produce an electrostatic field that spans the face vent.

2. The particle repelling helmet of claim **1**, wherein the electrodes are connected to an oscillator adapted to generate an oscillating electric field emitted from the electrodes.

3. The particle repelling helmet of claim **2**, wherein the electrodes are configured to switch between the oscillating electric field and a non-oscillating electric field.

4. The particle repelling helmet of claim **1** further comprising an ionizer that is configured to expel ions that convert dust particles into charged dust particles in a region that is external to the particle repelling helmet.

5. The particle repelling helmet of claim **1** further comprising a spacer arrangement connected to an inner side of the particle repelling helmet, the spacer arrangement configured to provide a channel between the wearer's head and the inner side.

6. The particle repelling helmet of claim **5**, wherein the channel links to exit ports distributed along a brim of the particle repelling helmet, the exit ports point in a downward direction defined from a helmet apex of the particle repelling helmet towards a head receiving aperture of the particle repelling helmet.

7. The particle repelling helmet of claim **6**, wherein the channel is in communication with the positive pressure air source and the exit ports expel the airflow across the face vent in the downward direction.

8. The particle repelling helmet of claim **5** further comprising a filter in-line with the positive pressure air source, wherein the airflow is configured to be filtered upon entering the channel.

9. The particle repelling helmet of claim **1**, wherein the face vent is configured to permit a hand of the wearer to enter therethrough to contact the eyes, the nose and the mouth.

10. The particle repelling helmet of claim **5**, wherein the spacer arrangement comprises an adjustable cradle configured to conform to the wearer's head.

11. The particle repelling helmet of claim **5**, wherein the spacer arrangement comprises a plurality of compressible stays configured to extend from the inner side to the wearer's head.

12. The particle repelling helmet of claim **1**, wherein the positive pressure air source is a fan located at the back side of the particle repelling helmet opposite to the face vent.

13. A particle repelling headgear comprising:
 a face vent defined between a left and a right cheek perimeter lip and along a brim that extends from a forehead region of a front side of the particle repelling headgear,
 the face vent configured to provide an unobstructed path between an external environment and a wearer's face;
 a spacer arrangement connected to a particle repelling headgear inner side, the spacer arrangement configured to provide a channel between the wearer's head and the particle repelling headgear inner side;
 a positive pressure air source in communication with the channel, the positive pressure air source configured to exit airflow through the face vent via the channel; and
 electrodes disposed at the left and the right cheek perimeter lip, wherein the electrodes are configured to produce an electrostatic field that spans the face vent.

14. The particle repelling headgear of claim **13**, wherein the left and right perimeter lip is configured to extend to the wearer's chin.

15. The particle repelling headgear of claim **13**, wherein the airflow in the channel is configured to cool the human head.

16. The particle repelling headgear of claim **13**, wherein the electrodes are connected to an oscillator adapted to generate an oscillating electric field emitted from the electrodes.

17. The particle repelling headgear of claim **16**, wherein the electrodes are configured to switch between the oscillating electric field and a non-oscillating electric field.

18. The particle repelling headgear of claim **13** further comprising an ionizer located at a rear side of the particle repelling headgear, wherein the ionizer is configured to generate ions that convert dust particles into charged dust particles in the external environment to the particle repelling headgear.

19. Headgear comprising:
 a face vent defined between a left perimeter and a right perimeter,
 a spacer arrangement at a headgear interior, the spacer arrangement configured to provide a channel defined between a wearer's head and an inner surface of the headgear;
 a positive pressure air source in communication with the channel, the positive pressure air source configured to flow airflow over the wearer's head and through the face vent; and
 electrodes disposed at the left and the right perimeter, wherein the electrodes are configured to produce an electrostatic field that spans the face vent.

20. The headgear of claim **19** further comprising an ionizer configured to charge dust particles in an environment that is external to the headgear.

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