US010433613B2

(12) **United States Patent**
Litvinov

(10) **Patent No.: US 10,433,613 B2**
(45) **Date of Patent: Oct. 8, 2019**

(54) **VENTILATION APPARATUS FOR FOOTWEAR**

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(72) Inventor: **Alexander Litvinov**, Brooklyn, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 30 days.

(21) Appl. No.: **15/700,413**

(22) Filed: **Sep. 11, 2017**

(65) **Prior Publication Data**

US 2018/0020768 A1 Jan. 25, 2018

Related U.S. Application Data

(63) Continuation-in-part of application No. 14/596,128, filed on Jan. 13, 2015, now Pat. No. 10,010,132.

(60) Provisional application No. 61/964,756, filed on Jan. 13, 2014.

(51) **Int. Cl.**

A43B 7/08	(2006.01)
A43B 7/00	(2006.01)
A43B 3/00	(2006.01)

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

CPC ***A43B 7/084*** (2013.01); ***A43B 3/0005*** (2013.01); ***A43B 3/0015*** (2013.01); ***A43B 7/005*** (2013.01); ***A43B 7/081*** (2013.01); ***A43B 7/082*** (2013.01); ***A43B 7/085*** (2013.01)

(58) **Field of Classification Search**

CPC A43B 7/084; A43B 7/081; A43B 7/082; A43B 7/005; A43B 3/0015; A43B 3/0005; A43B 7/06; A43B 13/203

USPC ..... 36/3 R, 3 A, 3 B, 29

See application file for complete search history.

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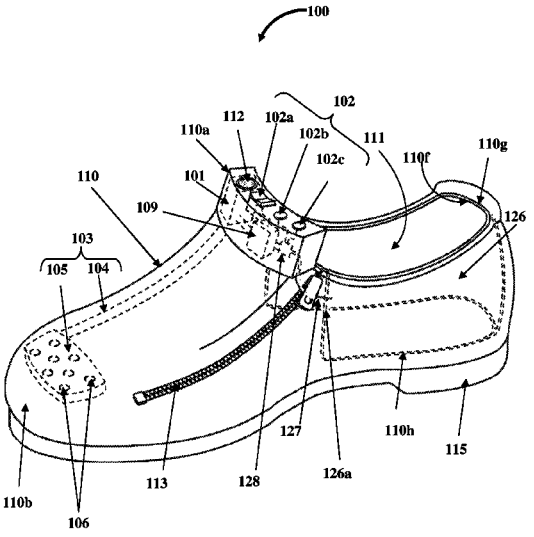
(57) **ABSTRACT**

A ventilation apparatus including at least one flexible energy storage device (FESD), a switching unit, a pump, and a fluid diffuser is provided. The FESD flexibly conforms to varying contours of footwear. The FESD positioned at one or more locations of the footwear supplies electrical energy to the pump via the switching unit. The switching unit in communication with the FESD and the pump selectively changes modes of operation of the pump. The pump attached to the footwear pumps fluid into and exhausts fluid from a cavity of the footwear. A feed pipe of the fluid diffuser connected to the pump, within the cavity of the footwear, transfers the fluid pumped from the pump to the cavity of the footwear during a pump mode and transfers the fluid in the cavity of the footwear to an ambient environment external to the footwear during an exhaust mode for ventilating the footwear.

7 Claims, 23 Drawing Sheets



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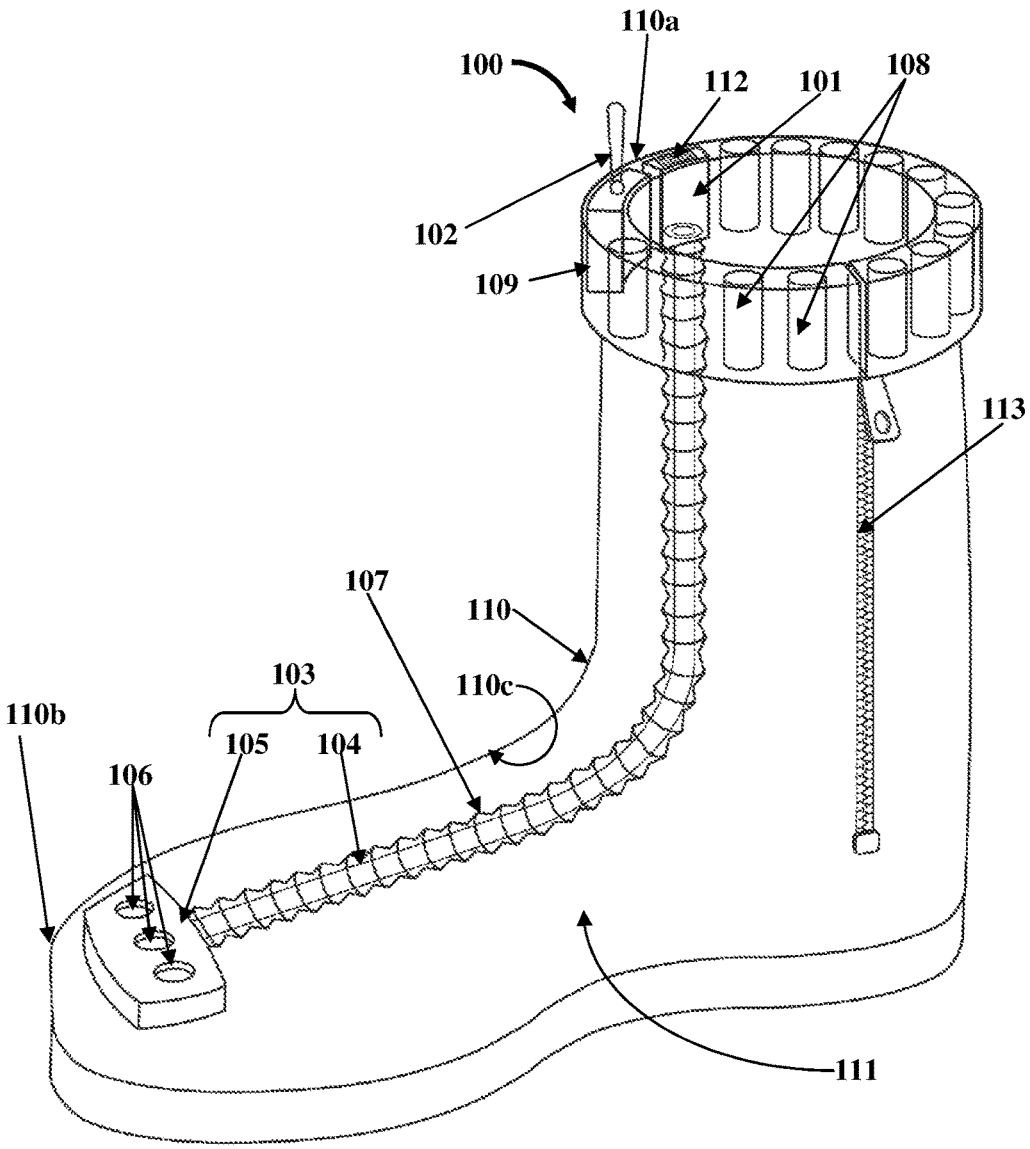
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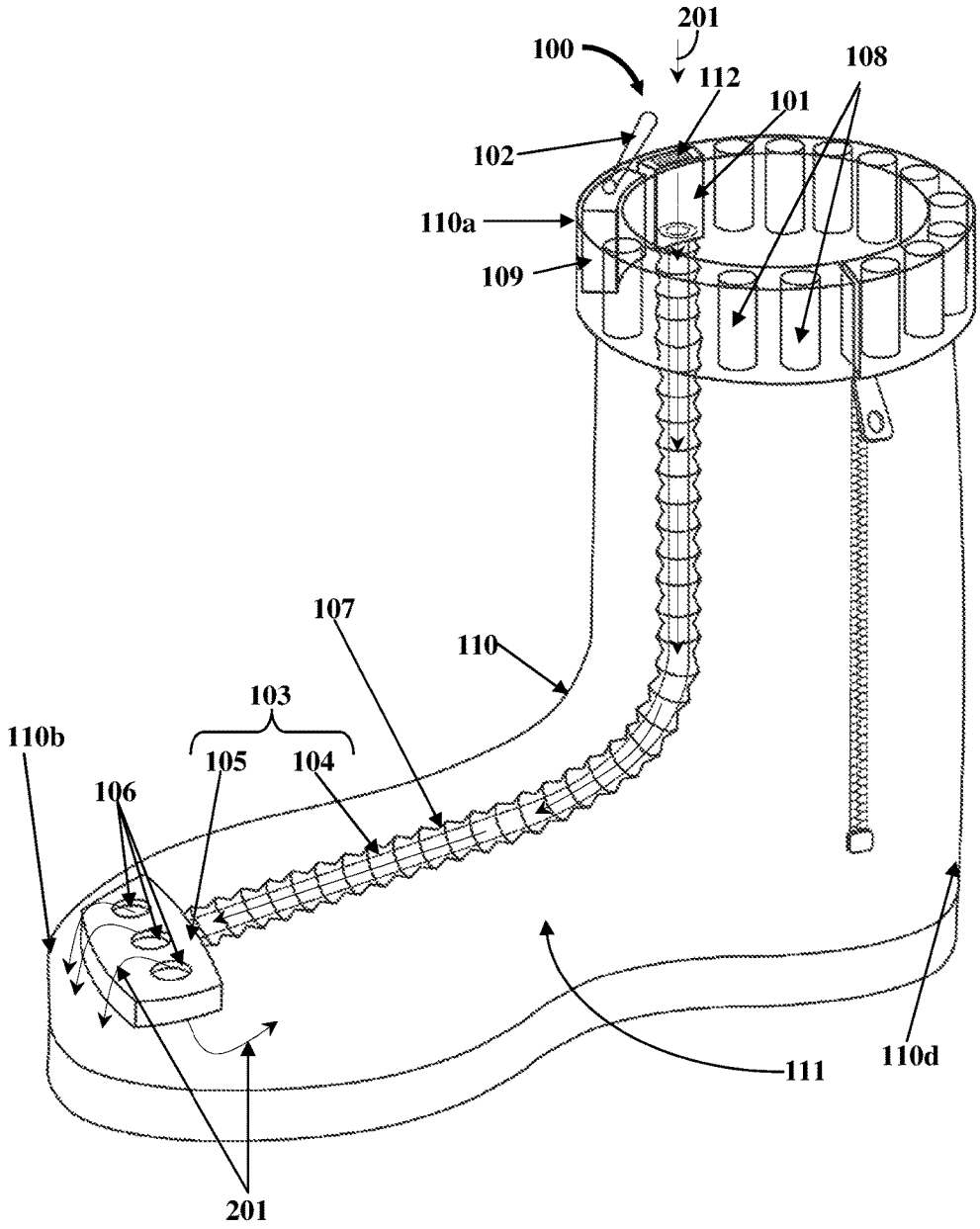
FIG. 1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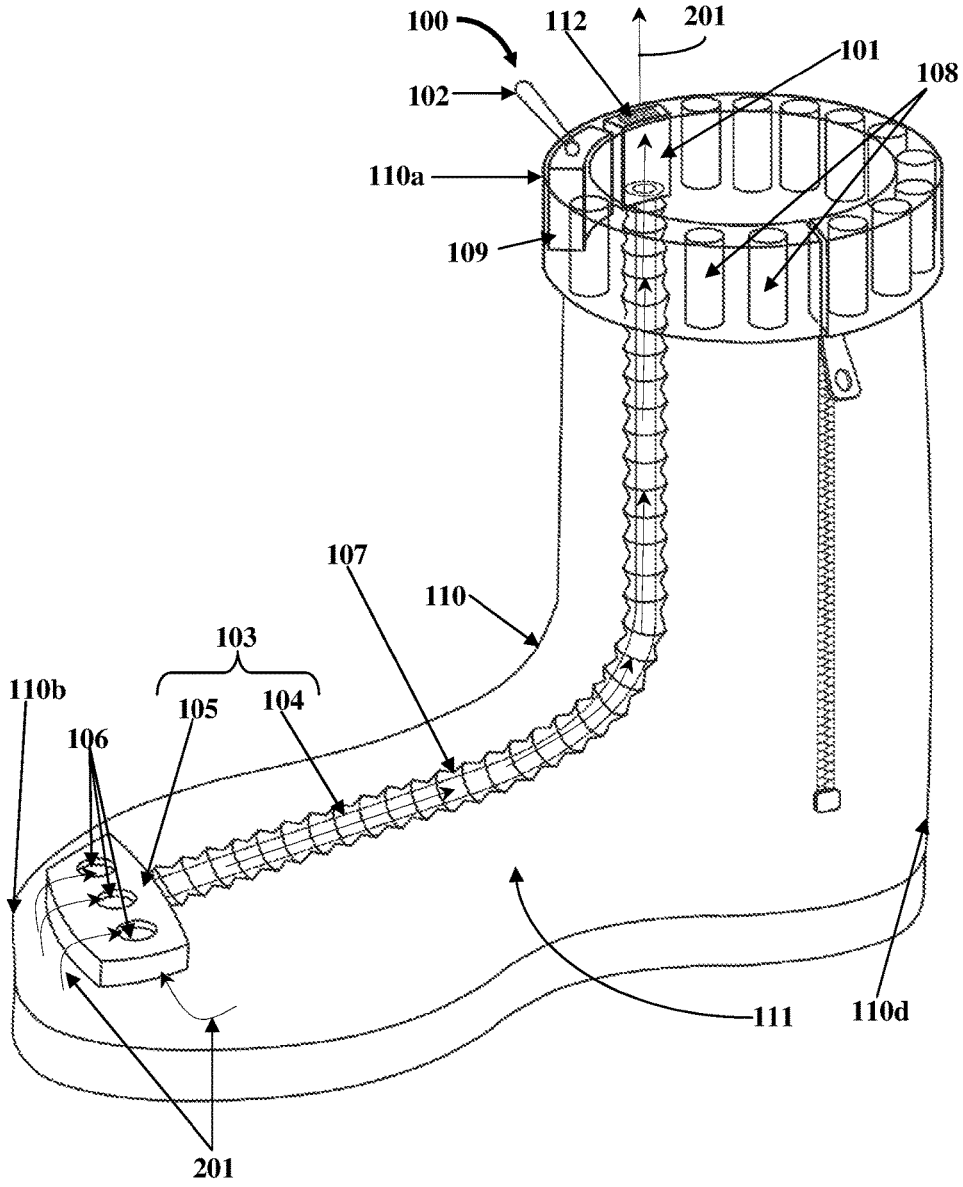
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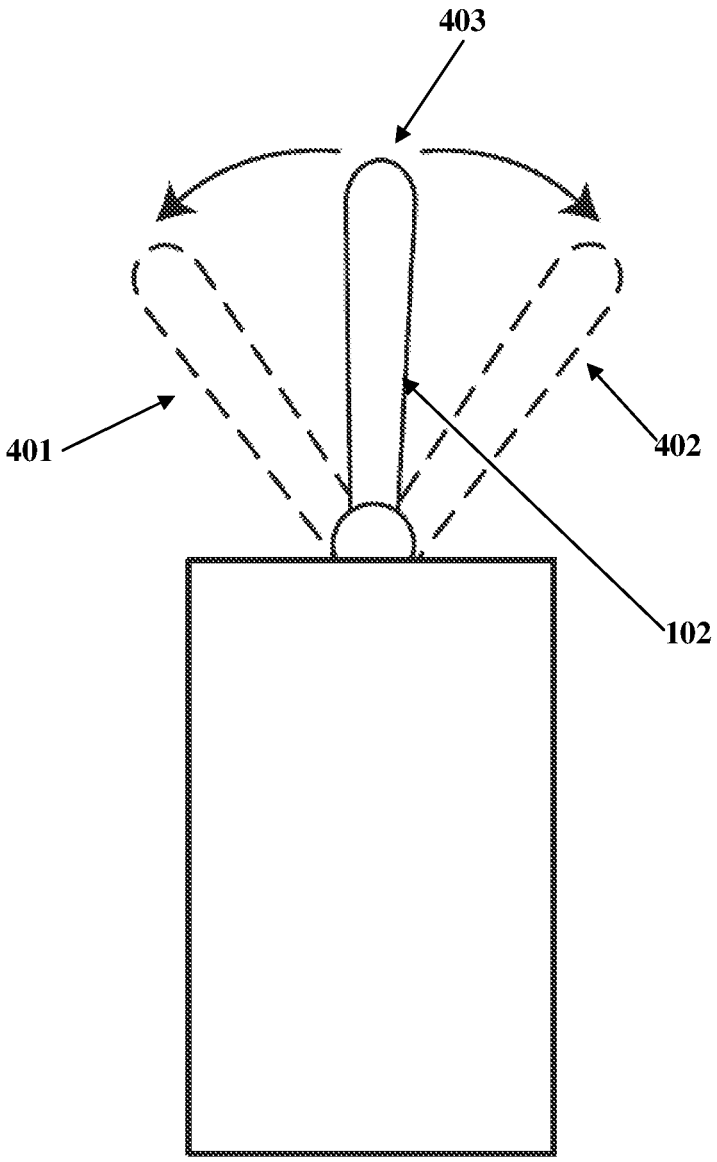

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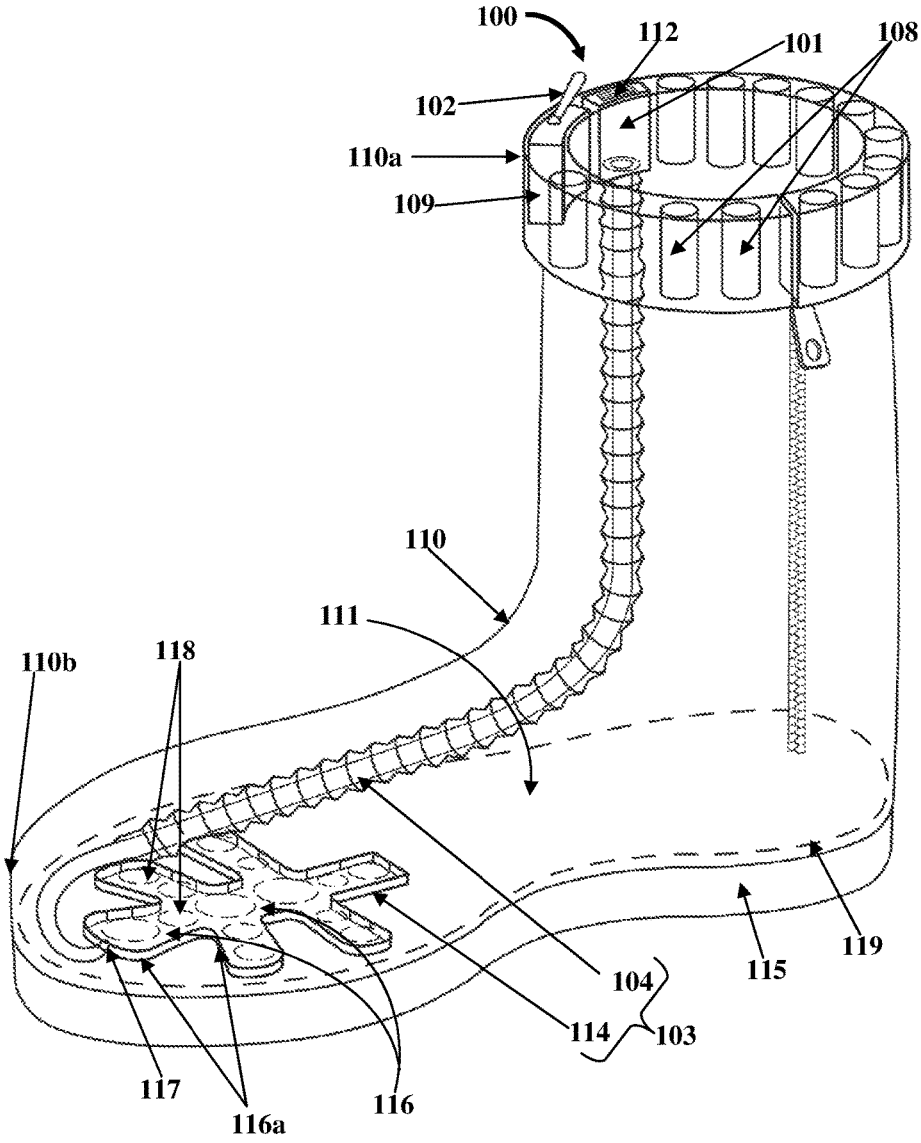
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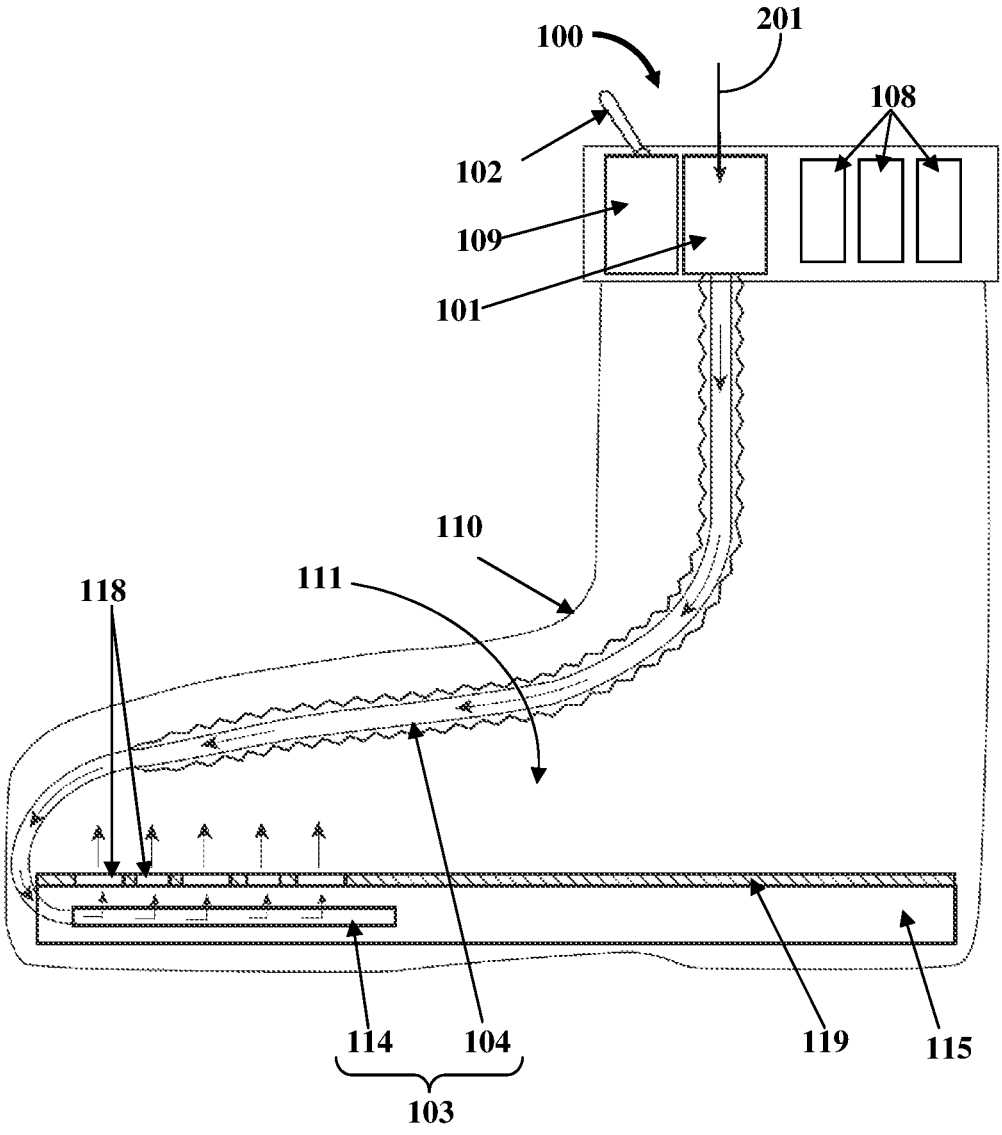

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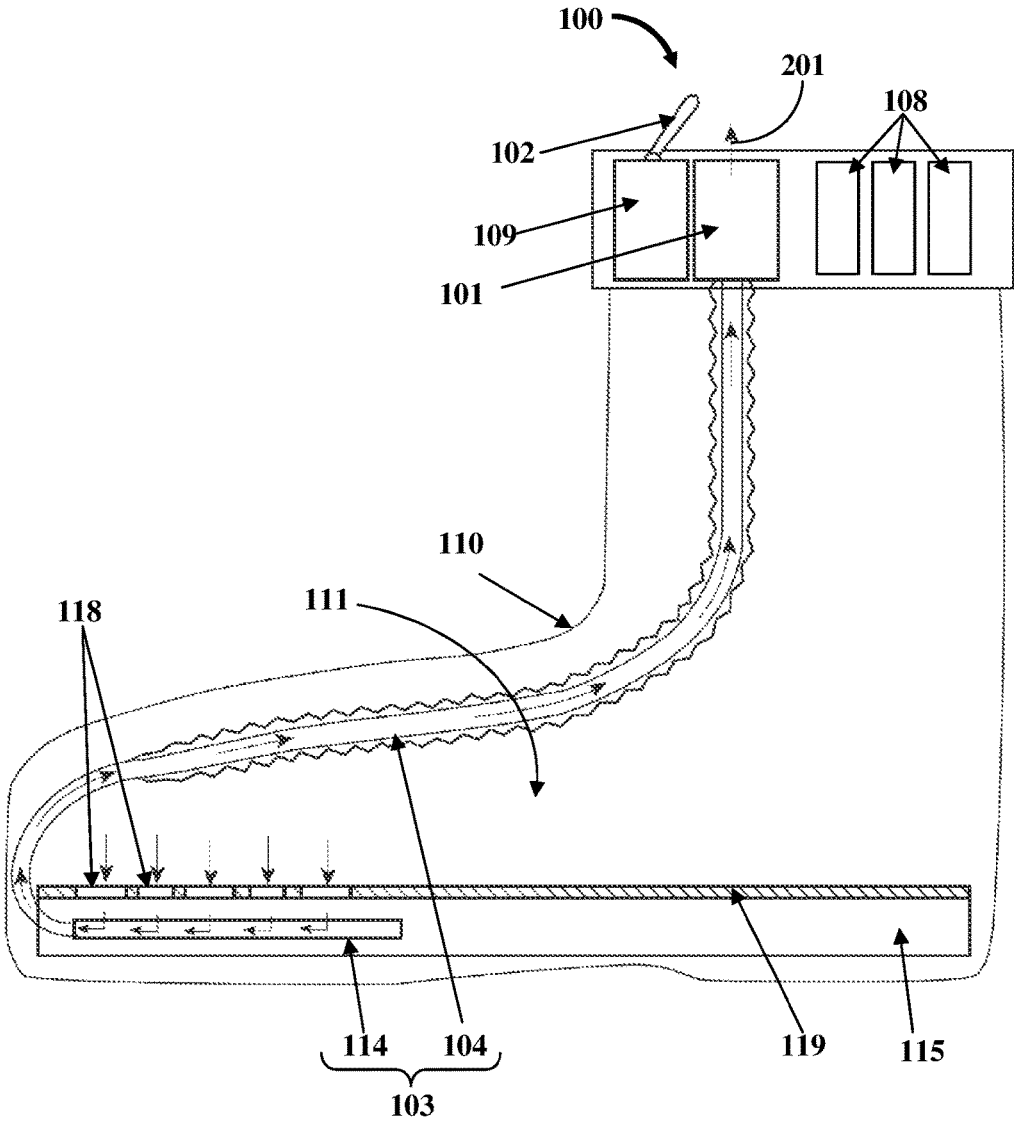

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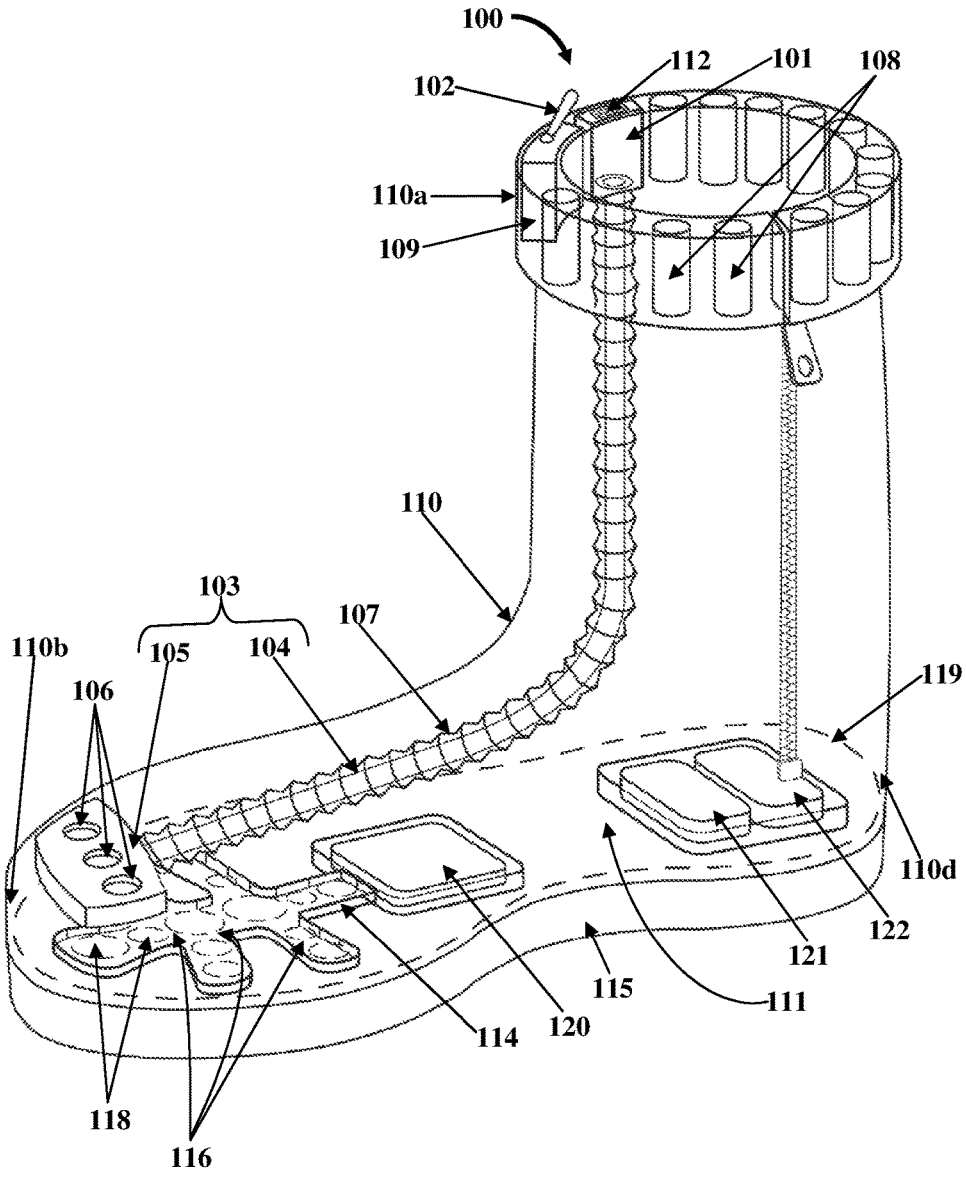
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FIG. 8

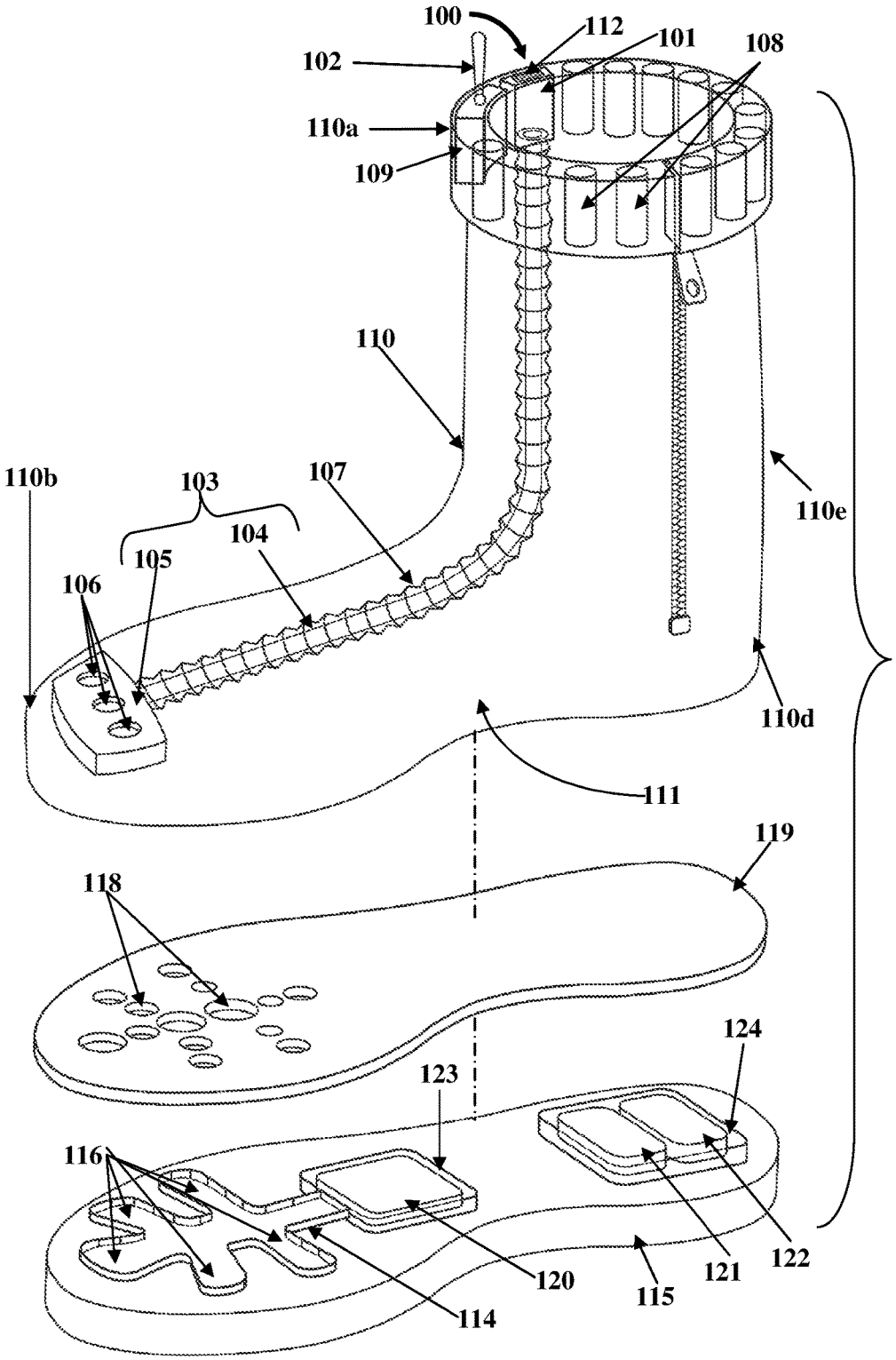
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FIG. 9

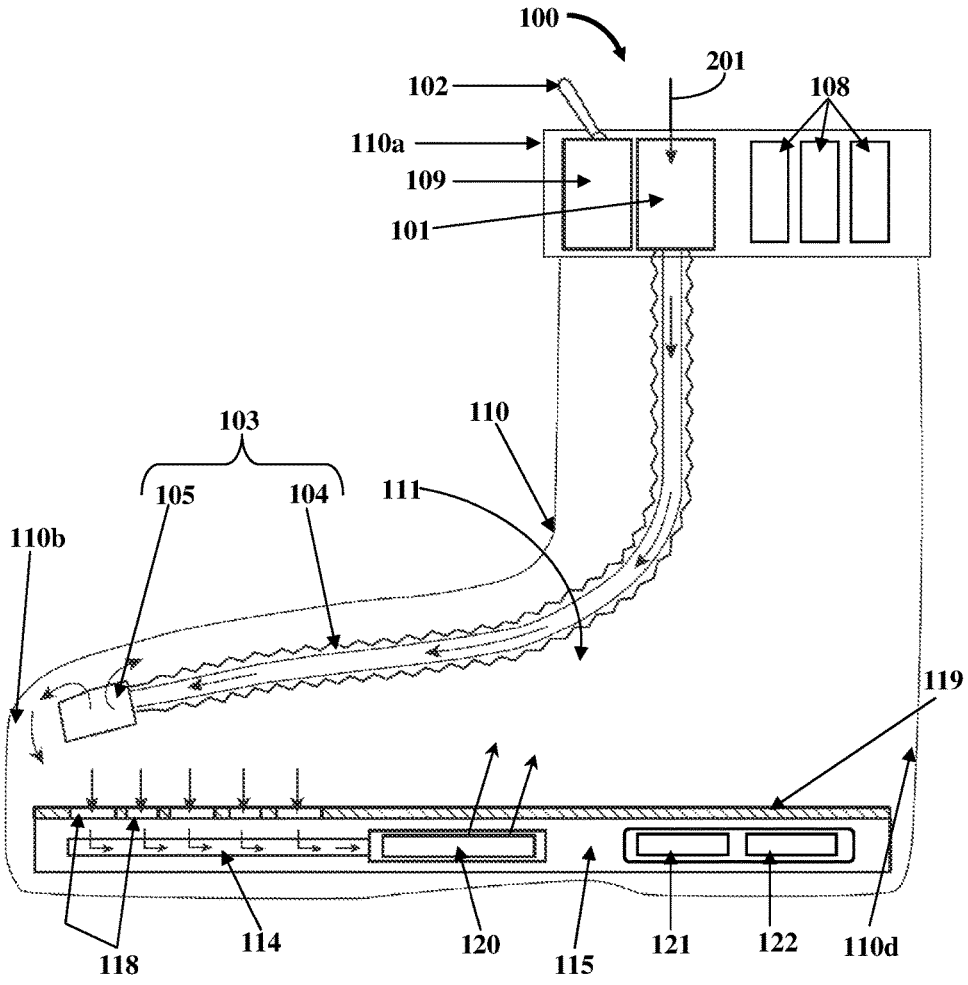
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FIG. 10

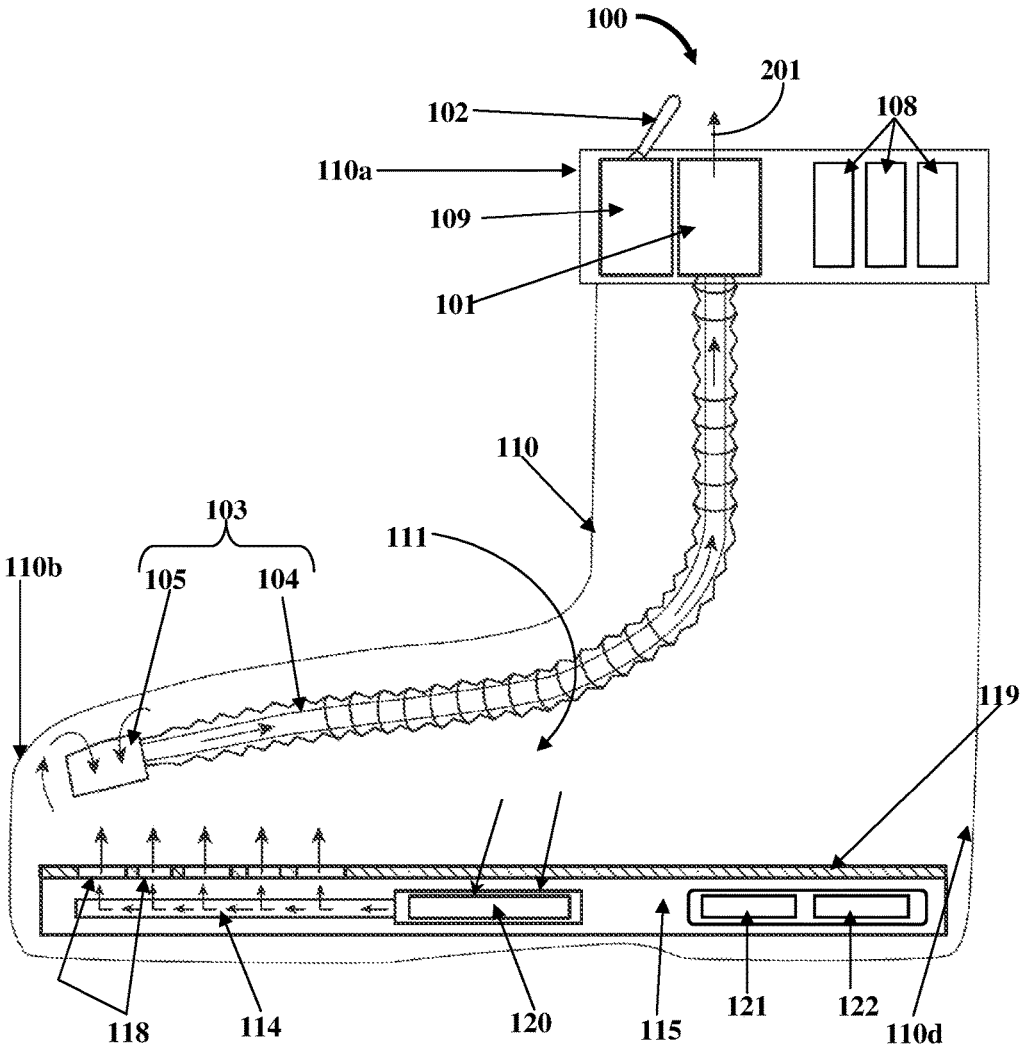
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FIG. 11

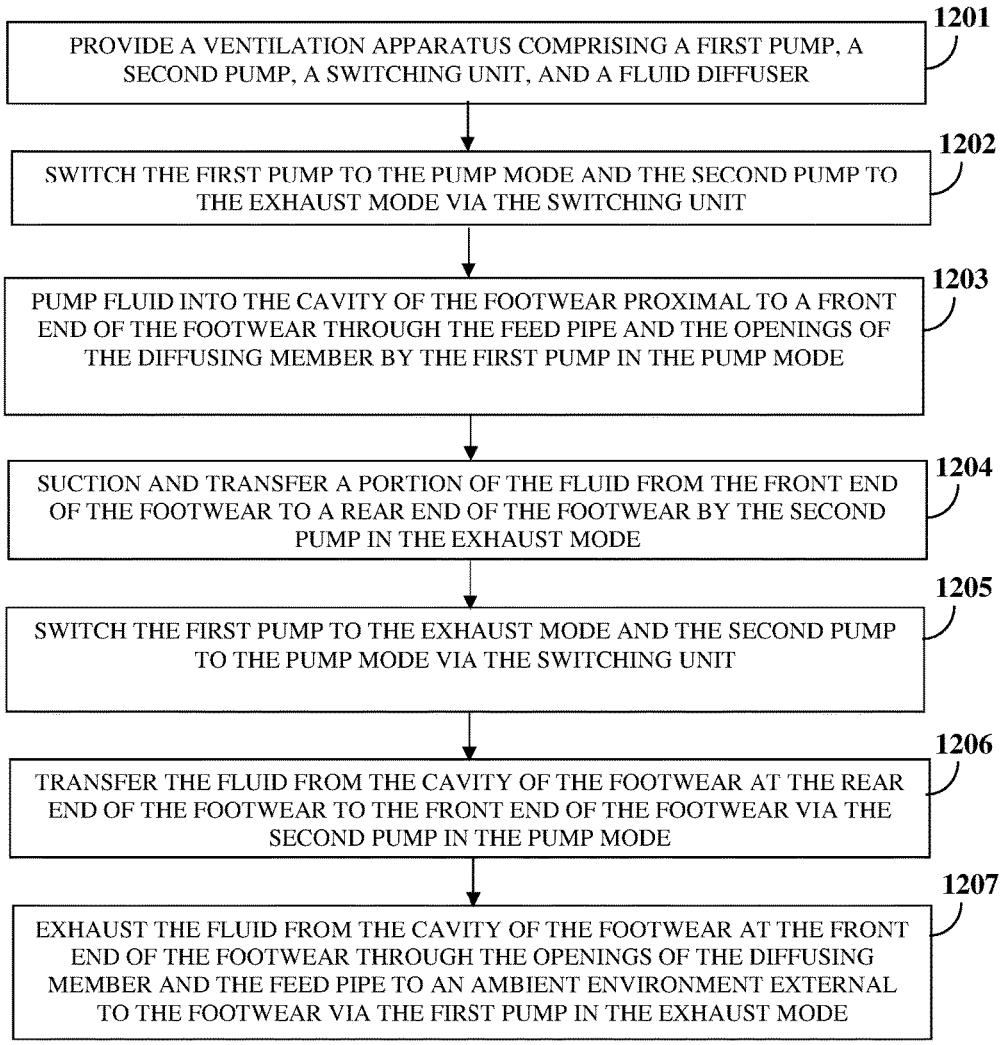
1201
PROVIDE A VENTILATION APPARATUS COMPRISING A FIRST PUMP, A SECOND PUMP, A SWITCHING UNIT, AND A FLUID DIFFUSER
1202
SWITCH THE FIRST PUMP TO THE PUMP MODE AND THE SECOND PUMP TO THE EXHAUST MODE VIA THE SWITCHING UNIT
1203
PUMP FLUID INTO THE CAVITY OF THE FOOTWEAR PROXIMAL TO A FRONT END OF THE FOOTWEAR THROUGH THE FEED PIPE AND THE OPENINGS OF THE DIFFUSING MEMBER BY THE FIRST PUMP IN THE PUMP MODE
1204
SUCTION AND TRANSFER A PORTION OF THE FLUID FROM THE FRONT END OF THE FOOTWEAR TO A REAR END OF THE FOOTWEAR BY THE SECOND PUMP IN THE EXHAUST MODE
1205
SWITCH THE FIRST PUMP TO THE EXHAUST MODE AND THE SECOND PUMP TO THE PUMP MODE VIA THE SWITCHING UNIT
1206
TRANSFER THE FLUID FROM THE CAVITY OF THE FOOTWEAR AT THE REAR END OF THE FOOTWEAR TO THE FRONT END OF THE FOOTWEAR VIA THE SECOND PUMP IN THE PUMP MODE
1207
EXHAUST THE FLUID FROM THE CAVITY OF THE FOOTWEAR AT THE FRONT END OF THE FOOTWEAR THROUGH THE OPENINGS OF THE DIFFUSING MEMBER AND THE FEED PIPE TO AN AMBIENT ENVIRONMENT EXTERNAL TO THE FOOTWEAR VIA THE FIRST PUMP IN THE EXHAUST MODE

FIG. 12

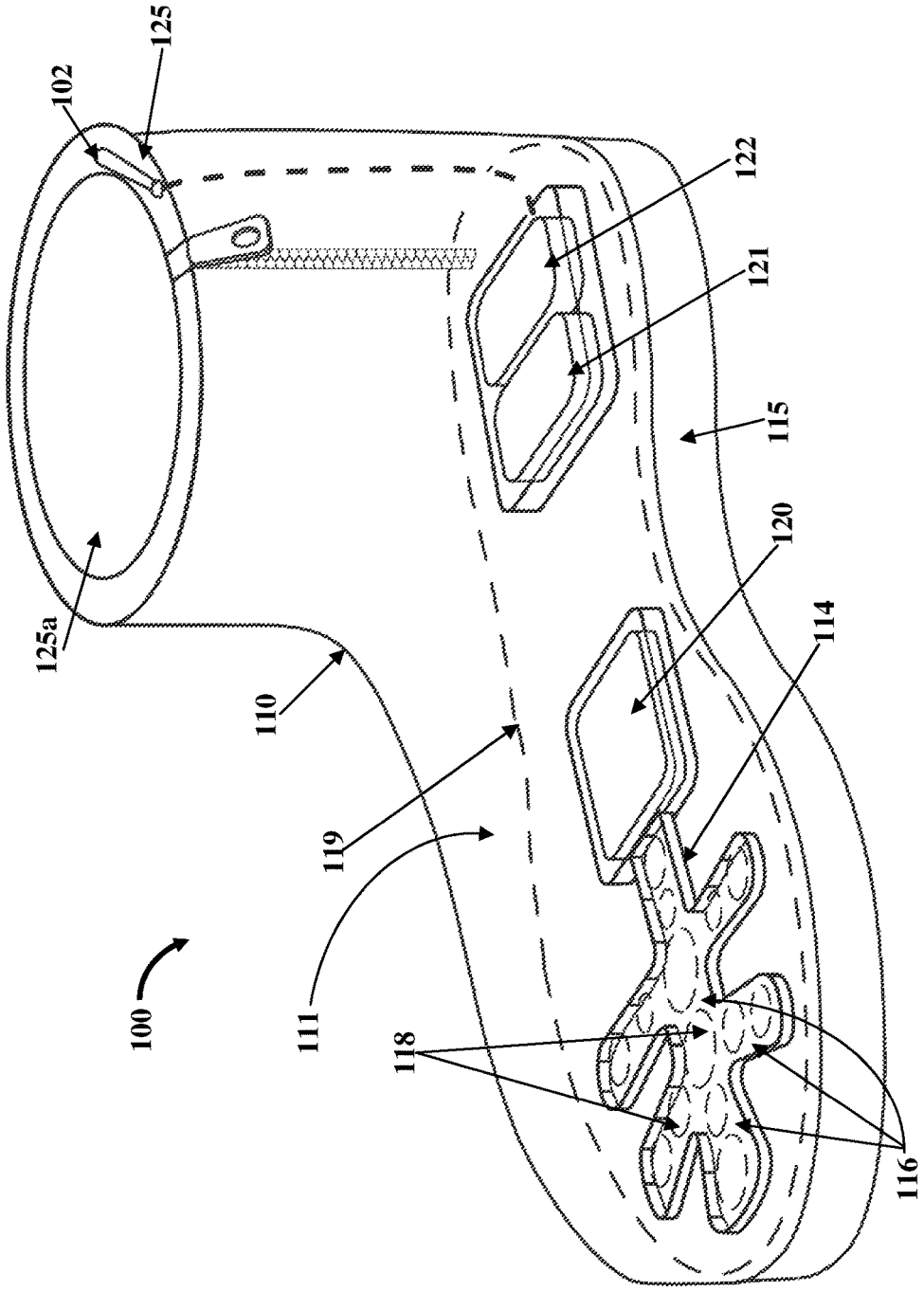

FIG. 13

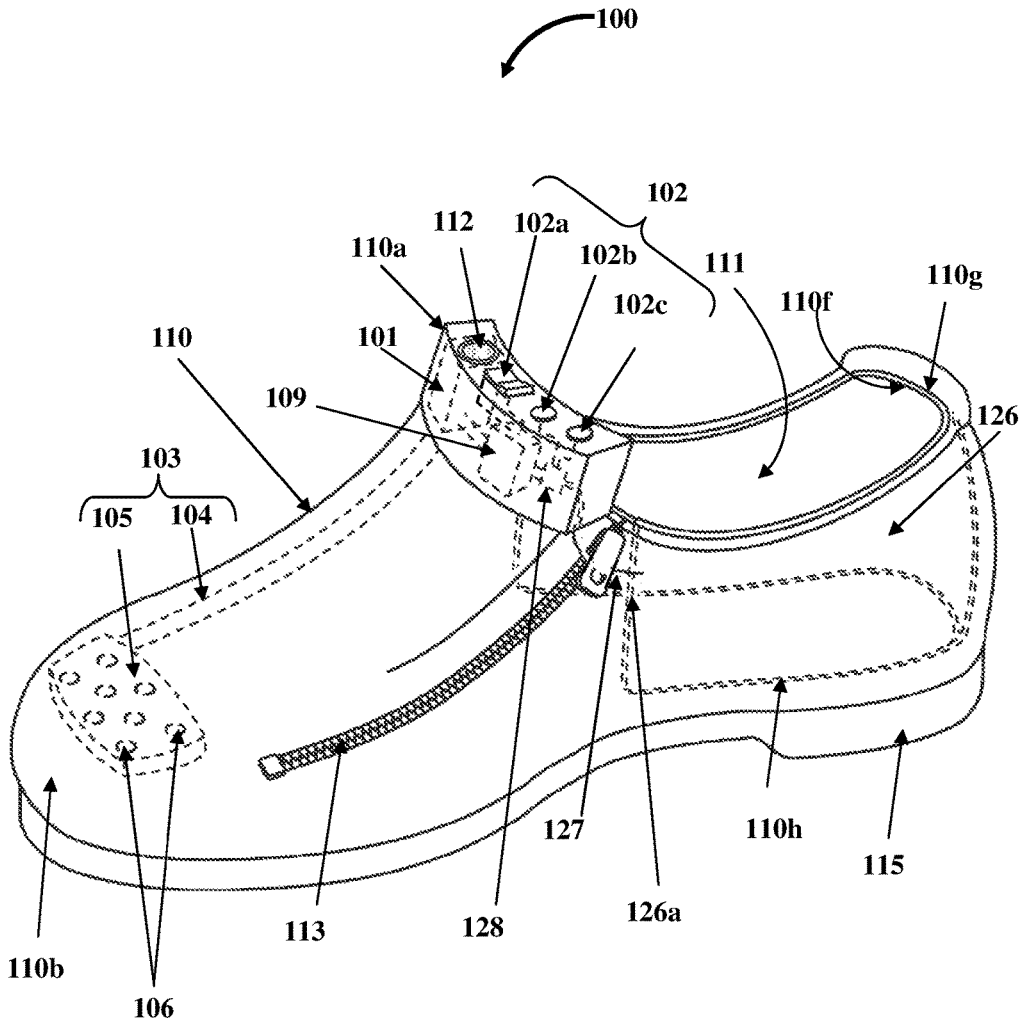
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FIG. 14A

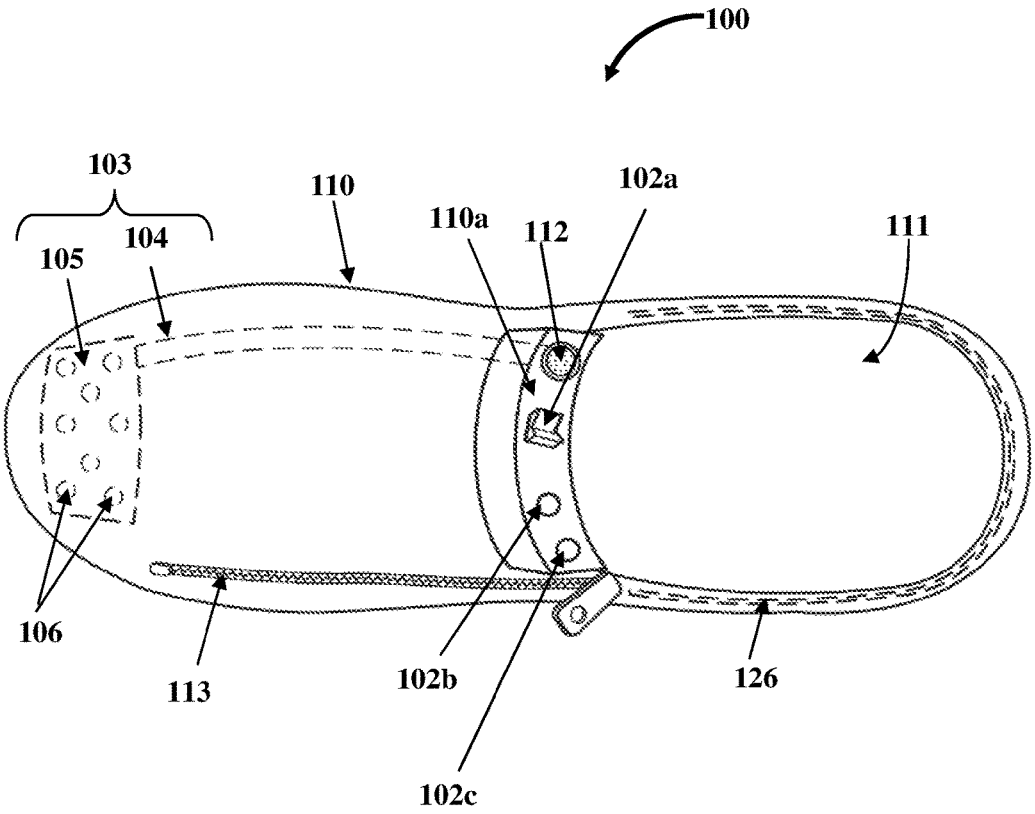

FIG. 14B

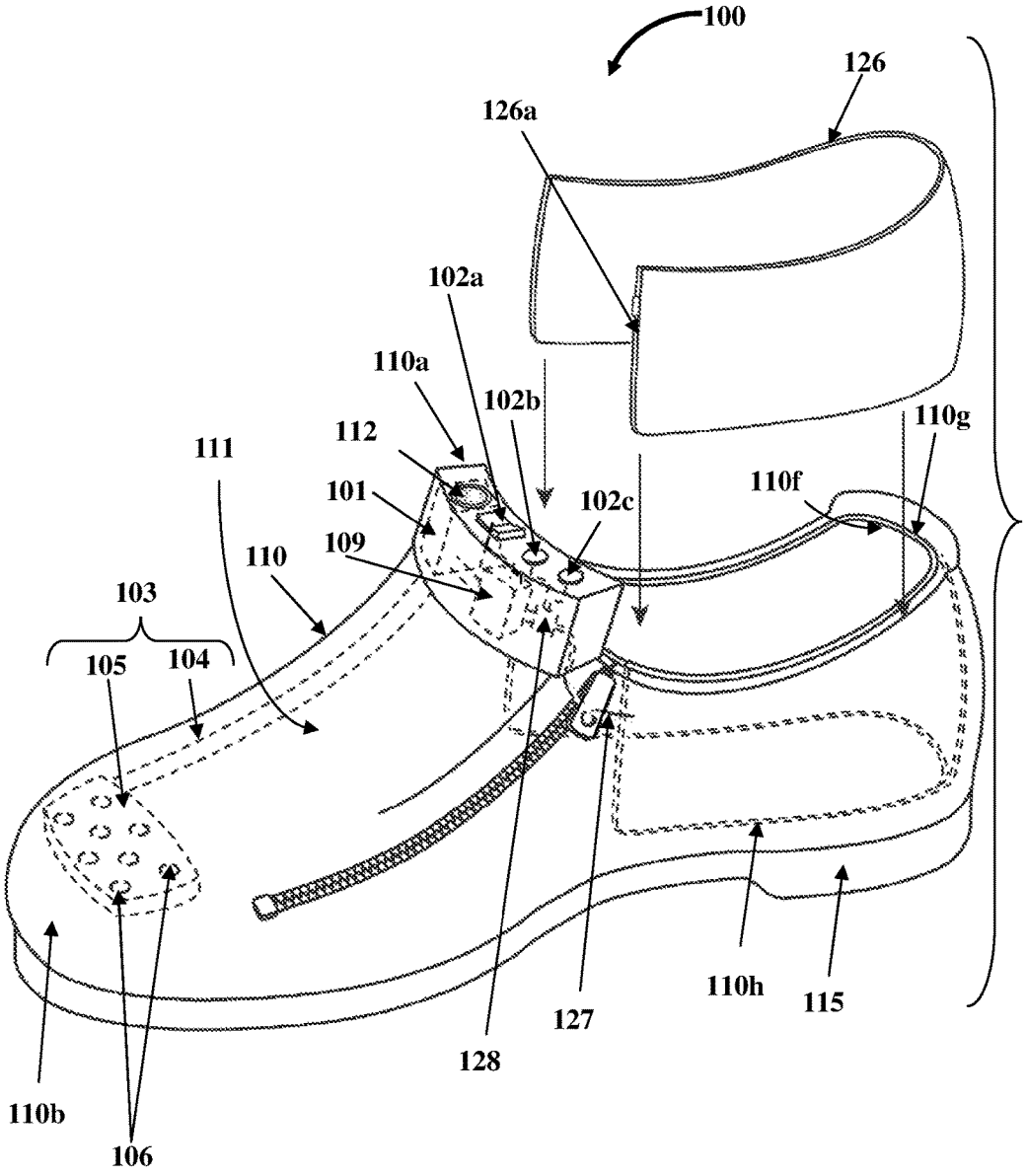
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FIG. 15

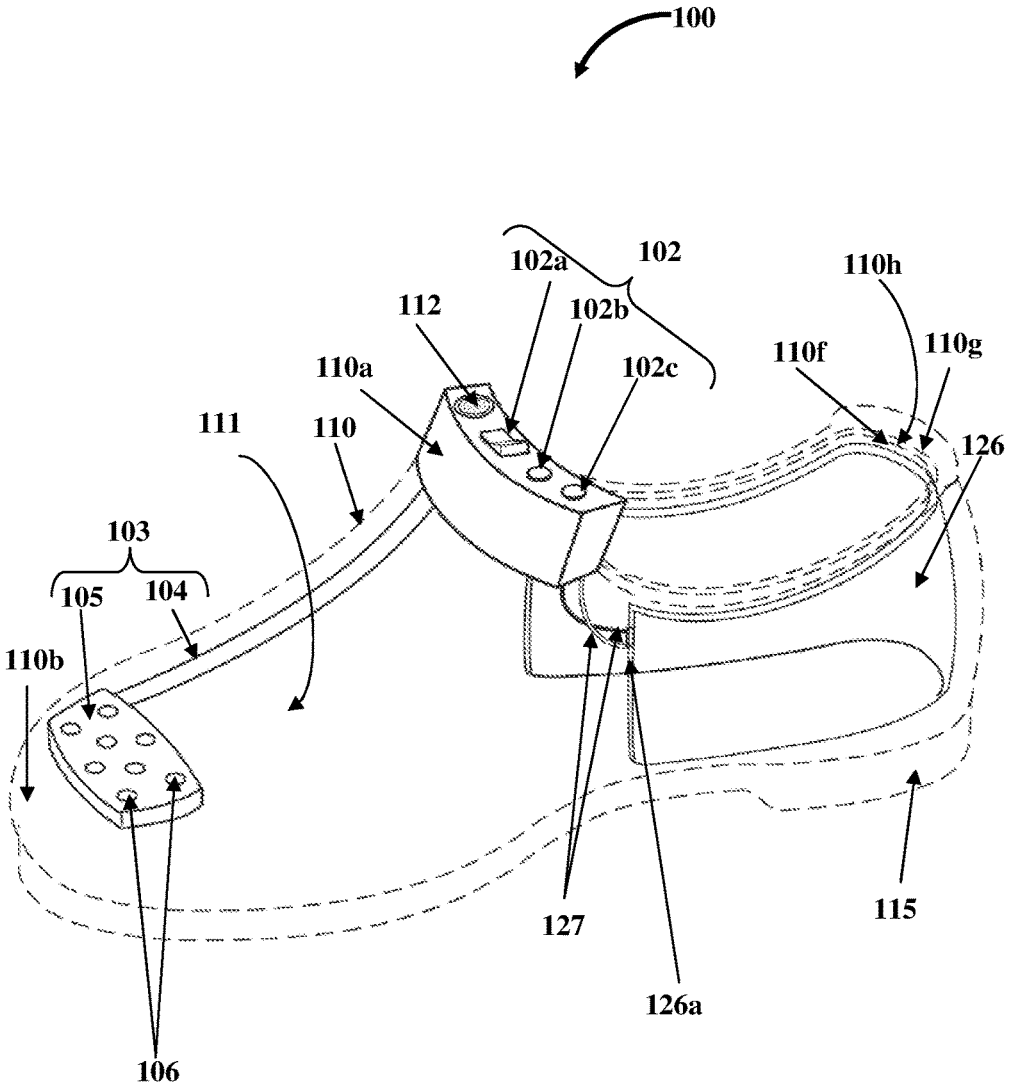
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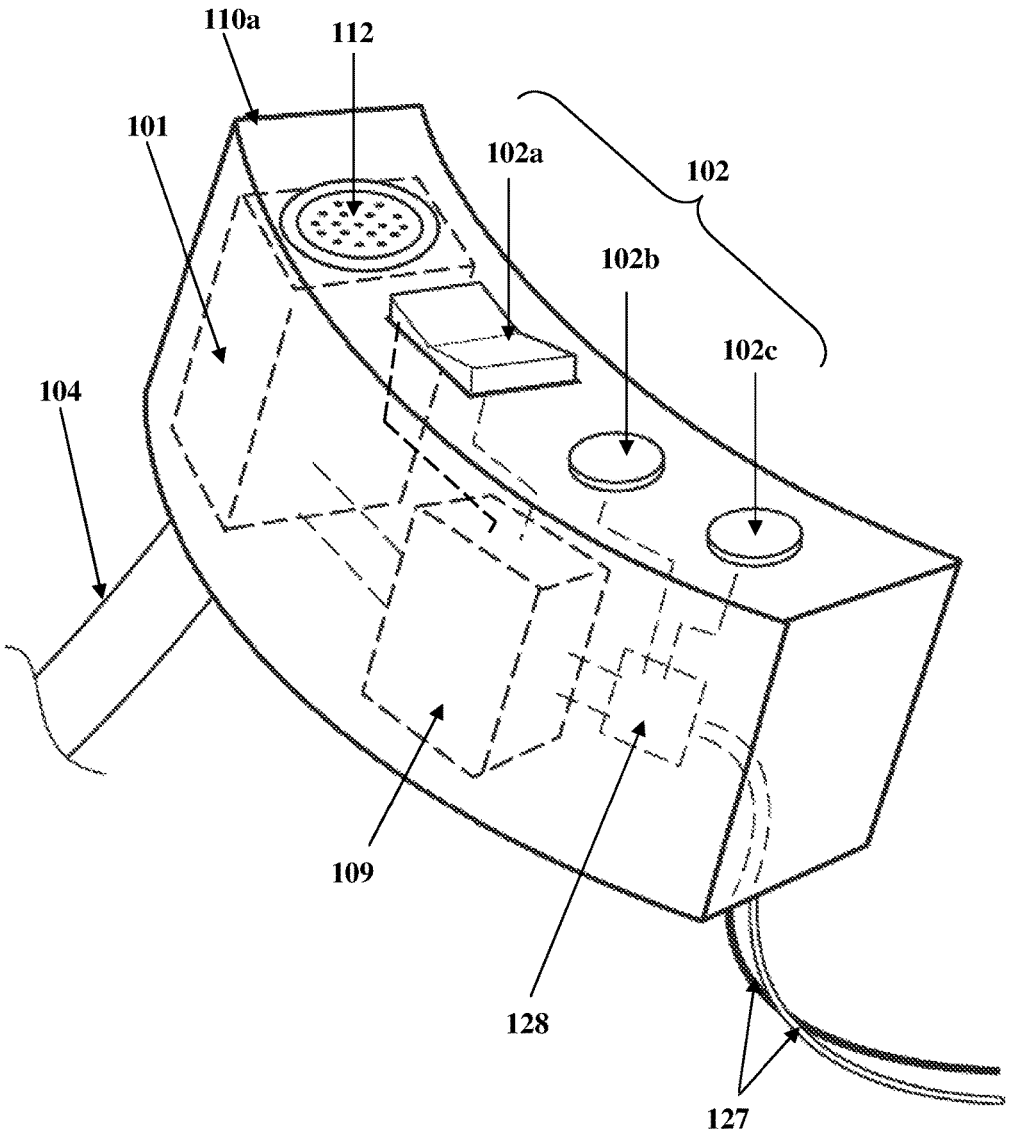
FIG. 16



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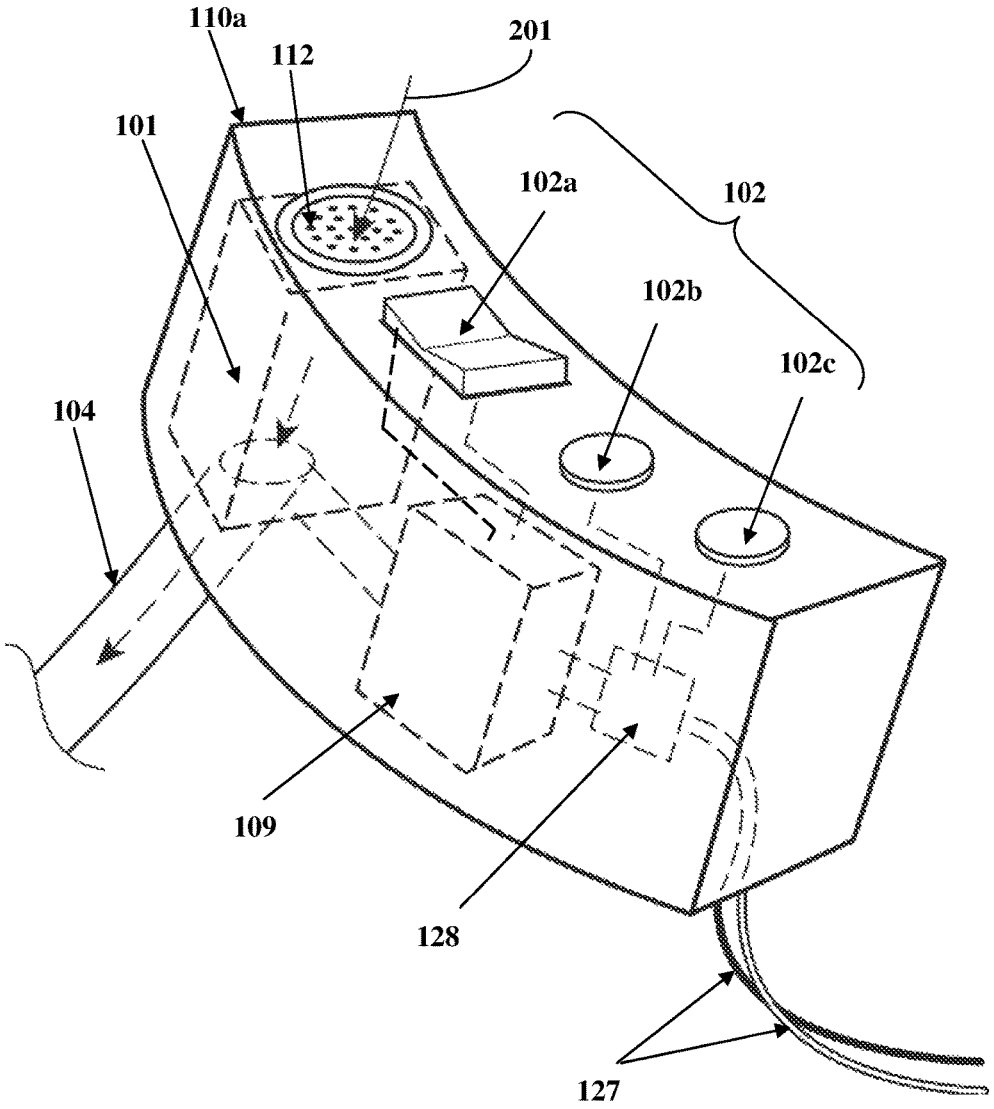
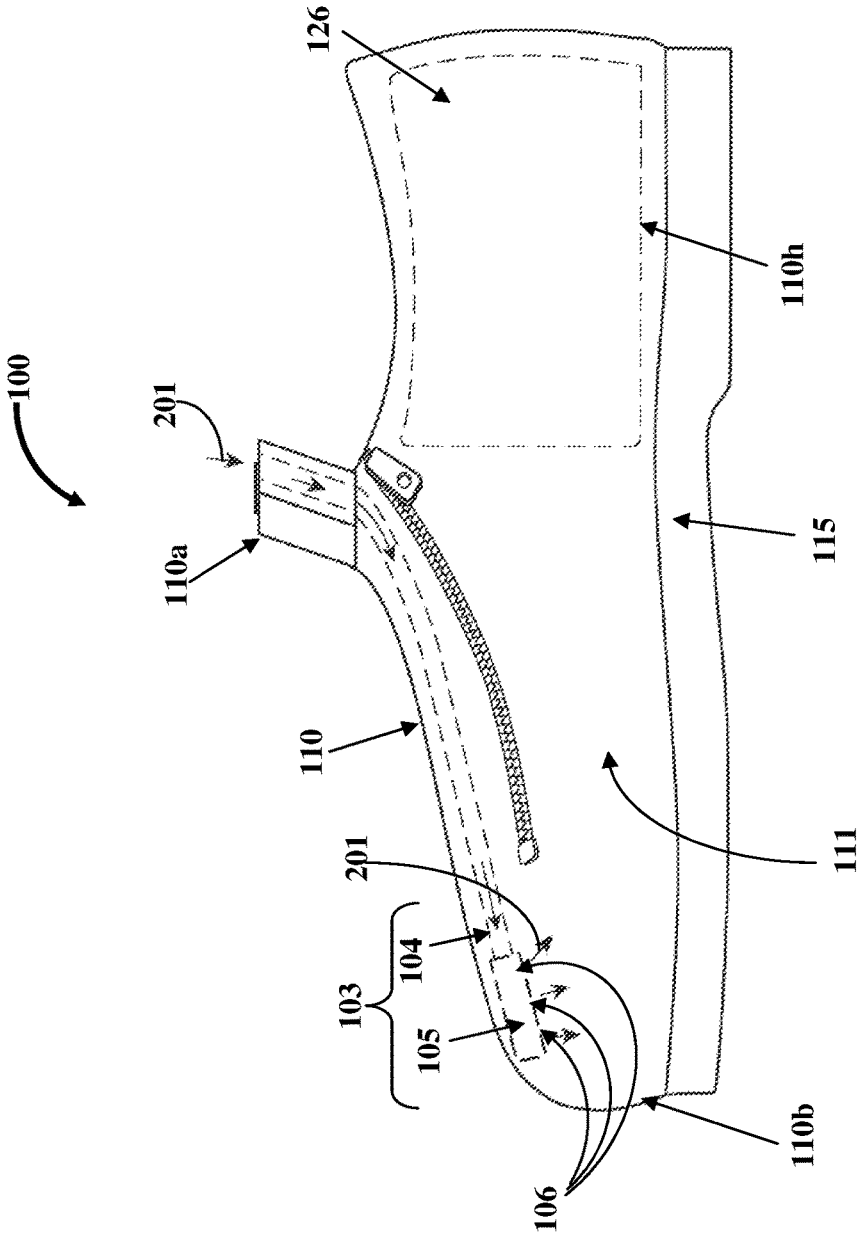


FIG. 18A



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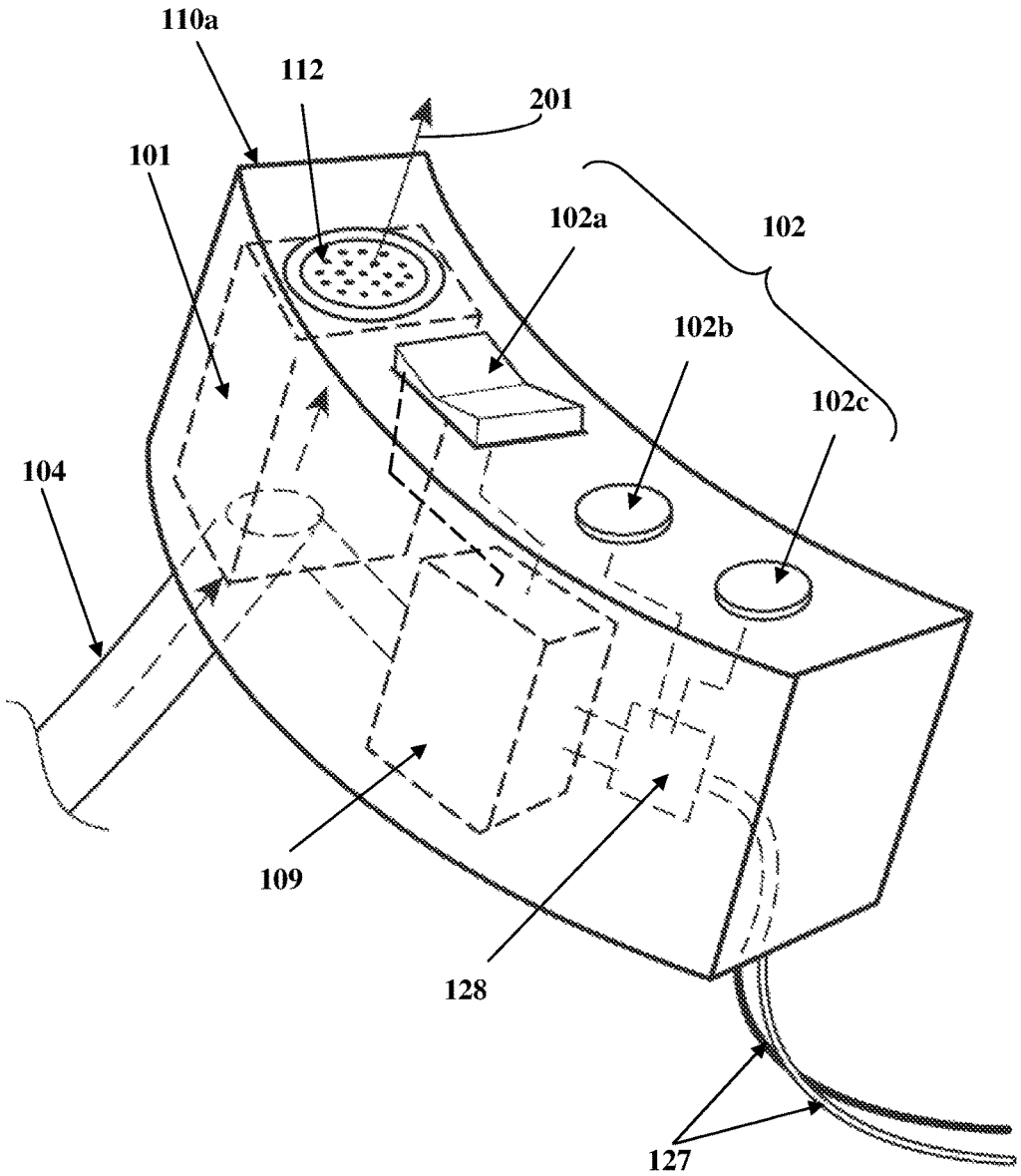


FIG. 19A

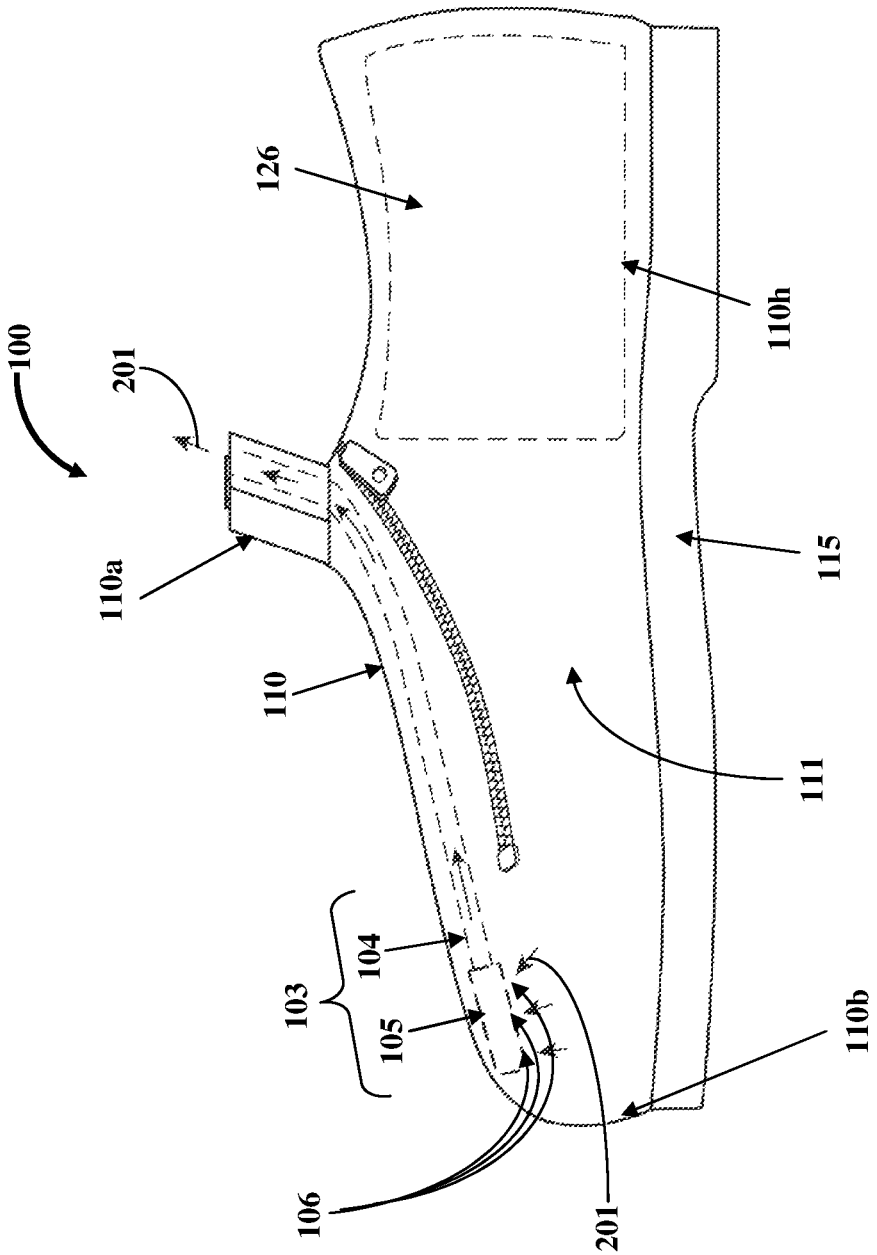
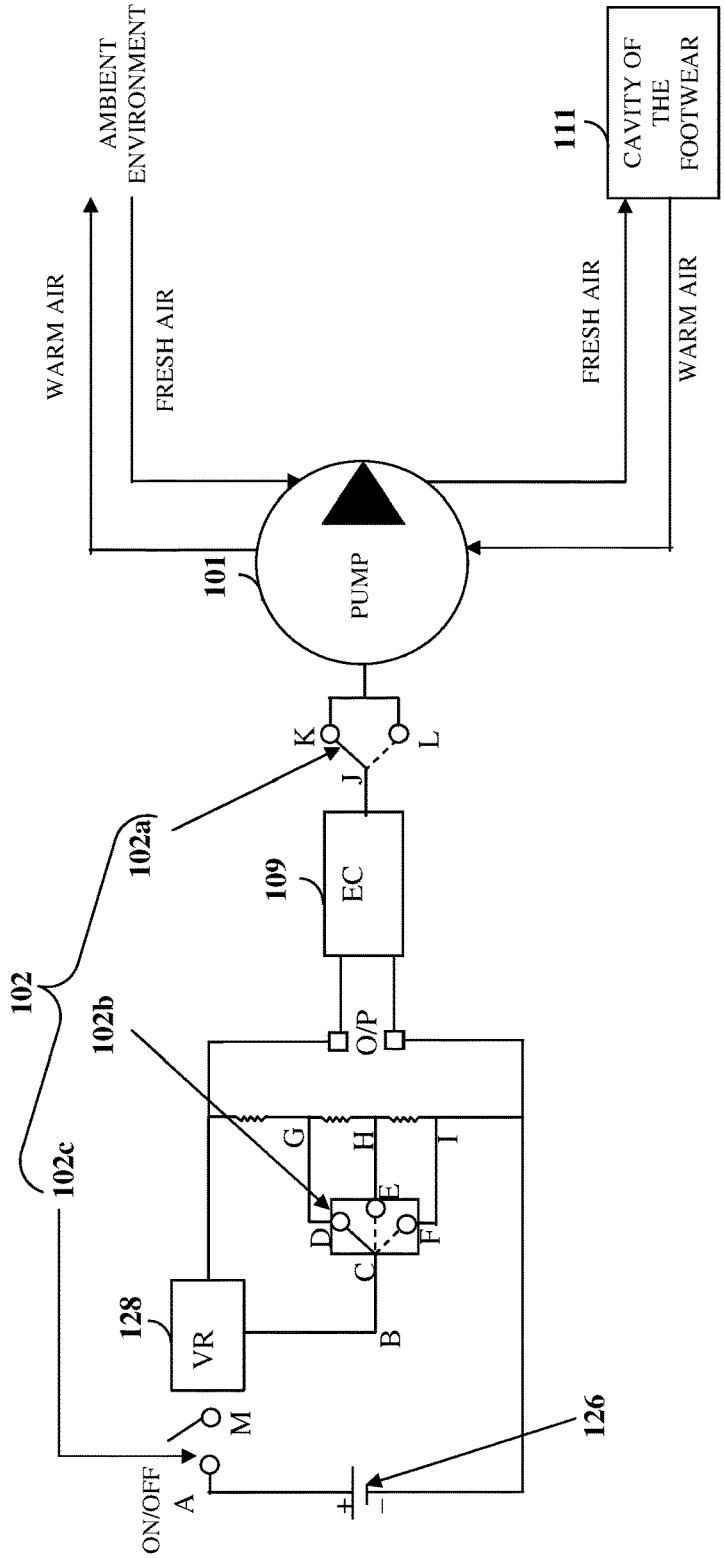


FIG. 19B


AMBIENT ENVIRONMENT
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CAVITY OF THE FOOTWEAR
WARM AIR
FRESH AIR
FRESH AIR
WARM AIR
101
PUMP
K
L
J
102a
109
EC
102
102b
O/P
102c
G
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I
E
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126

FIG. 20

VENTILATION APPARATUS FOR FOOTWEAR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part application of non-provisional patent application titled "Ventilation Of Footwear", application Ser. No. 14/596,128, filed in the United States Patent and Trademark Office on Jan. 13, 2015, which claims priority to and the benefit of provisional patent application titled "Method of mechanical ventilation of shoes", application No. 61/964,756, filed in the United States Patent and Trademark Office on Jan. 13, 2014. The specifications of the above referenced patent applications are incorporated herein by reference in their entirety.

BACKGROUND

When a person wears a proper fitting shoe, there is typically a minimal gap between an inner surface of the shoe and the surface of the person's foot inserted in the shoe. If there is no ventilation inside the shoe and the ambient temperature is high, for example, during hot summer weather or in an office environment, or when the person performs physical activities, for example, working, walking, running, exercising, etc., the air around the person's foot in the shoe becomes warm and quickly fills with water vapor which creates an uncomfortable environment around the person's foot inside the shoe. Closed shoes, for example, closed sneakers, high boots, etc., have minimal air exchange or ventilation at the front end of the shoes. Therefore, there is a need for removal of air from the shoe, especially from the front end and other parts of the shoe to improve comfort, hygiene, and foot adhesion inside the shoe.

Conventional methods for ventilating shoes typically provide ventilation holes on an outer surface of the shoe, or an arrangement of pistons to eject air out of the shoe. However, these methods actively function only when a person walks while wearing the shoe. Moreover, adding ventilation holes on the outer surface of the shoe changes the shoe design, which may not be aesthetically appealing, Furthermore, ventilating shoes by using pistons requires incorporation of bulky and ineffective additional parts into the shoe design.

Some conventional methods employ battery powered electric ventilation systems to ventilate the shoe. However, in such systems, conventional batteries are firmly fixed in the shoe, cannot be positioned at any location inside or outside the shoe, and are not easily replaceable. Moreover, conventional batteries in these battery powered electric ventilation systems are bulky and occupy more space in the shoe which may be obstructive to a user wearing the shoe and makes it difficult for the user to walk around while wearing the shoe. Furthermore, conventional batteries in these battery powered electric ventilation systems are rigid and do not conform to varying contours of the shoe, which may damage the batteries or injure the user wearing the shoe during use of the shoe.

Hence, there is a long felt need for a method and an apparatus for ventilating footwear, for example, shoes, at different times, for example, during rest, during movement, during any physical activity, during high temperature situations, while the user is in a warm environment, or at selected times. Furthermore, there is a need for flexible batteries that are compact, occupy less space in the footwear, flexibly conform to varying contours of the footwear, can be easily accommodated at any location inside or outside the footwear, and can be easily replaced, without obstructing or injuring a user wearing the footwear and without causing damage to the batteries.

SUMMARY OF THE INVENTION

This summary is provided to introduce a selection of concepts in a simplified form that are further disclosed in the detailed description of the invention. This summary is not intended to determine the scope of the claimed subject matter.

The method and the ventilation apparatus disclosed herein address the above recited need for ventilating footwear, for example, a user's shoes, at different times, for example, during rest, during movement, during any physical activity, during high temperature situations, while the user is in a warm environment, or at selected times. Furthermore, the ventilation apparatus disclosed herein addresses the above recited need for flexible energy storage devices, for example, flexible batteries that are compact, occupy less space in the footwear, flexibly conform to varying contours of the footwear, can be easily accommodated at any location inside or outside the footwear, and can be easily replaced, without obstructing or injuring the user wearing the footwear and without causing damage to the batteries. The flexible energy storage devices disclosed herein provide a mechanical robustness to the ventilation apparatus that withstands operating environments. The flexible energy storage devices disclosed herein change shape in accordance with the varying contours of the footwear.

The ventilation apparatus disclosed herein comprises at least one flexible energy storage device, a switching unit, a pump, and a fluid diffuser. The flexible energy storage device is positioned at one or more preconfigured locations of the footwear, for example, at a location between an inner rear surface and an outer rear surface of the footwear, and/or at a location on an outer surface of the footwear. The flexible energy storage device comprises one or more substantially thin electric power layers that flexibly conform to the varying contours of the footwear and sustain deforming forces that arise during usage of the footwear. The flexible energy storage device stores and supplies electrical energy to the pump via the switching unit to actuate the pump. The flexible energy storage device is rechargeable and usable over extended periods of time. The switching unit is in electric communication with the flexible energy storage device and the pump. The switching unit selectively changes modes of operation of the pump. The modes of operation comprise, for example, a pump mode for pumping fluid into a cavity of the footwear, an exhaust mode for exhausting the fluid from the cavity of the footwear, and a termination mode for terminating the operation of the pump. The pump is fixedly attached to a predefined section, for example, an upper section of the footwear and is operably connected to the switching unit. When the pump receives electrical energy from the flexible energy storage device via the switching unit, the pump pumps fluid, for example, air, into and exhausts fluid, for example, air and water vapor, from the cavity of the footwear.

The fluid diffuser is operably connected to the pump and positioned within the cavity of the footwear. In an embodiment, the fluid diffuser comprises a feed pipe. The feed pipe is fixedly connected to and extends from the pump into the cavity of the footwear. The feed pipe transfers the fluid pumped from the pump to the cavity of the footwear during the pump mode and transfers the fluid in the cavity of the footwear to an ambient environment external to the footwear

during the exhaust mode, for ventilating the footwear. In another embodiment, the fluid diffuser further comprises a diffusing member that is in fluid communication with the feed pipe. The diffusing member is positioned and attached proximal to a front end of the footwear in the cavity of the footwear. The diffusing member comprises one or more openings for allowing the fluid pumped from the pump through the feed pipe to be transferred into the cavity of the footwear during the pump mode, and for allowing the fluid in the cavity of the footwear to be transferred through the feed pipe to an ambient environment external to the footwear during the exhaust mode, for ventilating the footwear.

In another embodiment, the fluid diffuser further comprises a fluid distribution channel member fixedly attached within a sole of the footwear. The fluid distribution channel member comprises channels that are in fluid communication with the feed pipe of the fluid diffuser for allowing the fluid received from the feed pipe to be transferred to the cavity of the footwear during the pump mode and for allowing the fluid in the cavity of the footwear to be transferred through the feed pipe to the ambient environment external to the footwear during the exhaust mode, for ventilating the footwear. In another embodiment, the ventilation apparatus disclosed herein further comprises through holes configured on an insole of the footwear. The through holes of the insole are axially aligned with the channels of the fluid distribution channel member for allowing transfer of the fluid received by the channels of the fluid distribution channel member from the feed pipe to the cavity of the footwear during the pump mode and for allowing transfer of the fluid from the cavity of the footwear, through the channels of the fluid distribution channel member, into the feed pipe, and out to the ambient environment external to the footwear during the exhaust mode.

In another embodiment, the ventilation apparatus disclosed herein comprises two pumps, that is, a first pump fixedly attached to a predefined section, for example, the upper section of the footwear, and a second pump positioned within a sole of the footwear. The pumps pump fluid into and exhaust the fluid from the cavity of the footwear. The switching unit is in electric communication with the first pump and the second pump. In this embodiment, the switching unit selectively changes modes of operation of the first pump and the second pump. The modes of operation comprise, for example, a pump mode, an exhaust mode, and a termination mode. In this embodiment, the feed pipe of the fluid diffuser is fixedly connected to and extends from the first pump into the cavity of the footwear. The feed pipe transfers the fluid pumped from the first pump to the diffusing member that is in fluid communication with the feed pipe. The openings of the diffusing member allow the fluid pumped from the first pump through the feed pipe to be transferred into the cavity of the footwear proximal to the front end of the footwear for ventilating the footwear. The openings of the diffusing member further allow the fluid in the cavity of the footwear at the rear end of the footwear to be transferred via the second pump and through the feed pipe to an ambient environment external to the footwear for ventilating the footwear.

In one or more embodiments, related systems comprise circuitry for effecting the methods disclosed herein. The circuitry can be any combination of hardware, software, and/or firmware configured to effect the methods disclosed herein depending upon the design choices of a system designer. Also, various structural elements can be employed depending on the design choices of the system designer.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing summary, as well as the following detailed description of the invention, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, exemplary constructions of the invention are shown in the drawings. However, the invention is not limited to the specific methods, structures, and components disclosed herein. The description of a method step or a structure or a component referenced by a numeral in a drawing is applicable to the description of that method step or structure or component shown by that same numeral in any subsequent drawing herein.

FIG. **1** exemplarily illustrates a right side perspective view of a ventilation apparatus for ventilating footwear.

FIG. **2** exemplarily illustrates a right side perspective view of the ventilation apparatus, showing a pump mode of operation of the ventilation apparatus.

FIG. **3** exemplarily illustrates a right side perspective view of the ventilation apparatus, showing an exhaust mode of operation of the ventilation apparatus.

FIG. **4** exemplarily illustrates a front elevation view of a switching unit of the ventilation apparatus, showing the operation of the switching unit.

FIG. **5** exemplarily illustrates an embodiment of the ventilation apparatus for ventilating footwear.

FIG. **6** exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus shown in FIG. **5**, showing a pump mode of operation of the ventilation apparatus.

FIG. **7** exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus shown in FIG. **5**, showing an exhaust mode of operation of the ventilation apparatus.

FIG. **8** exemplarily illustrates an embodiment of the ventilation apparatus for ventilating footwear.

FIG. **9** exemplarily illustrates an exploded view of the embodiment of the ventilation apparatus shown in FIG. **8**.

FIG. **10** exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus shown in FIG. **8**, showing a first pump in a pump mode and a second pump in an exhaust mode.

FIG. **11** exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus shown in FIG. **8**, showing the first pump in an exhaust mode and the second pump in a pump mode.

FIG. **12** exemplarily illustrates a method for ventilating footwear.

FIG. **13** exemplarily illustrates an embodiment of the ventilation apparatus for ventilating footwear of a low height.

FIG. **14**A exemplarily illustrates a right side perspective view of an embodiment of the ventilation apparatus for ventilating footwear.

FIG. **14**B exemplarily illustrates a top plan view of the embodiment of the ventilation apparatus shown in FIG. **14**A, for ventilating footwear.

FIG. **15** exemplarily illustrates a partial disassembled view of the embodiment of the ventilation apparatus shown in FIG. **14**A, showing positioning of a flexible energy storage device in a compartment of the footwear.

FIG. **16** exemplarily illustrates a right side perspective view of the embodiment of the ventilation apparatus shown

in FIG. **14**A, showing the flexible energy storage device electrically connected to the switching unit in the footwear.

FIG. **17** exemplarily illustrates an enlarged view of an upper section of the footwear, showing components of the embodiment of the ventilation apparatus shown in FIG. **14**A.

FIG. **18**A exemplarily illustrates an enlarged view of the upper section of the footwear, showing a flow of fluid into the footwear in the pump mode of operation of the embodiment of the ventilation apparatus shown in FIG. **14**A.

FIG. **18**B exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus shown in FIG. **14**A, showing the flow of fluid into the footwear in the pump mode of operation.

FIG. **19**A exemplarily illustrates an enlarged view of the upper section of the footwear, showing a flow of fluid from the footwear to the ambient environment outside the footwear in the exhaust mode of operation of the embodiment of the ventilation apparatus shown in FIG. **14**A.

FIG. **19**B exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus shown in FIG. **14**A, showing the flow of fluid to the ambient environment outside the footwear in the exhaust mode of operation.

FIG. **20** exemplarily illustrates a block diagram showing an electric operation of the embodiment of the ventilation apparatus shown in FIG. **14**A.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** exemplarily illustrates a right side perspective view of a ventilation apparatus **100** for ventilating footwear **110**, for example, shoes, sneakers, boots, high boots, etc. The ventilation apparatus **100** disclosed herein is a mechanical ventilation unit comprising a pump **101**, a switching unit **102**, and a fluid diffuser **103**. The pump **101** is fixedly attached on a predefined section, for example, an upper section **110***a* of the footwear **110**. The pump **101** is, for example, one of an electric pump, a piezoelectric pump, an electromechanical pump, etc. The pump **101** can be of any predefined size or shape and can be positioned on any section inside or outside the footwear **110**. The pump **101** pumps fluid **201** directly from an ambient environment external to the footwear **110** into a cavity **111** of the footwear **110**, and exhausts fluid **201** from the cavity **111** of the footwear **110** directly to the ambient environment external to the footwear **110** as exemplarily illustrated in FIGS. **2-3**. As used herein, the term "fluid" refers to a substance, for example, a liquid and/or a gas, capable of flowing. The fluid **201** pumped into or exhausted out from the cavity **111** of the footwear **110** comprises, for example, air, water vapor, etc. Also, as used herein, the term "cavity" refers to an interior space defined by the footwear **110** where a foot of a user is inserted. Also, as used herein, "user" refers to a person who wears the footwear **110**. The switching unit **102** is in electric communication with the pump **101**. The switching unit **102** selectively changes modes of operation of the pump **101**. The modes of operation comprise, for example, a pump mode for pumping the fluid **201** into the cavity **111** of the footwear **110**, and an exhaust mode for exhausting the fluid **201** from the cavity **111** of the footwear **110**. In an embodiment, the modes of operation of the pump **101** further comprise a termination mode for terminating the operation of the pump **101**. The switching unit **102** can therefore be a two way switch or a three way switch depending on the number of modes of operation. The switching unit **102** enables actuation of the pump **101** at different times, for example, during rest, during movement, during any physical activity, during high temperature situations, while the user is in a warm environment, or at selected times for ventilating the footwear **110**.

The fluid diffuser **103** is operably connected to the pump **101** and positioned within the cavity **111** of the footwear **110**. The fluid diffuser **103** comprises a feed pipe **104** fixedly connected to and extending from the pump **101** into the cavity **111** of the footwear **110**. The feed pipe **104** transfers the fluid **201** pumped from the pump **101** to the cavity **111** of the footwear **110** during the pump mode and further transfers the fluid **201** in the cavity **111** of the footwear **110** to an ambient environment external to the footwear **110** during the exhaust mode, for ventilating the footwear **110**.

In an embodiment as exemplarily illustrated in FIG. **1**, the fluid diffuser **103** further comprises a diffusing member **105** in fluid communication with the feed pipe **104**. The feed pipe **104** is, for example, a small caliber pipe that provides an air tight connection between the pump **101** and the diffusing member **105**. The diffusing member **105** is positioned and attached proximal to a front end **110***b* of the footwear **110** in the cavity **111** of the footwear **110**. The diffusing member **105** comprising one or more openings **106** for allowing the fluid **201** pumped from the pump **101** through the feed pipe **104** to be transferred into the cavity **111** of the footwear **110** during the pump mode for ventilating the footwear **110**. The openings **106** of the diffusing member **105** also allow the fluid **201** in the cavity **111** of the footwear **110** to be transferred through the feed pipe **104** to an ambient environment external to the footwear **110**, via vents **112** configured on the pump **101**, during the exhaust mode for ventilating the footwear **110**. The feed pipe **104** and the diffusing member **105** are made, for example, of synthetic materials with elastic properties. In an embodiment, the fluid diffuser **103** further comprises a metallic tube **107** configured as a hose for enclosing and securing the feed pipe **104**. The feed pipe **104** is enclosed within the metallic tube **107**. The metallic tube **107** provides protection against crumpling of the feed pipe **104**. The metallic tube **107** with the enclosed feed pipe **104** is positioned in recesses proximal to an inner surface **110***c* of the footwear **110**.

The ventilation apparatus **100** disclosed herein further comprises one or more energy storage devices **108**, for example, batteries positioned proximal to or in the predefined section, for example, the upper section **110***a* of the footwear **110**. The energy storage devices **108** are operably connected to the pump **101**. The energy storage devices **108** supply electrical energy to the pump **101** to actuate the pump **101**. In an embodiment, the ventilation apparatus **100** disclosed herein further comprises an energy converter **109**, for example, an electric current converter in electric communication with the energy storage devices **108** and the pump **101**. In an embodiment, the energy converter **109** is positioned in an ankle section of the footwear **110**. The energy converter **109** converts direct current received from the energy storage devices **108** to an alternating current to be supplied to the pump **101** to actuate the pump **101**. In an embodiment, the energy storage devices **108** supply direct current to the pump **101** to actuate the pump **101**. In an embodiment, the pump **101**, the energy storage devices **108**, and the energy converter **109** are positioned within a horseshoe shaped upper section **110***a* of the footwear **110** as exemplarily illustrated in FIG. **1**. In another embodiment, the pump **101**, the energy storage devices **108**, and the energy converter **109** can be positioned at any convenient location inside or outside the footwear **110**. A zipper **113** is fixedly attached to the footwear **110** for allowing the user to

access the cavity **111** of the footwear **110** and insert the foot into the cavity **111** of the footwear **110**.

FIG. **2** exemplarily illustrates a right side perspective view of the ventilation apparatus **100**, showing a pump mode of operation of the ventilation apparatus **100**. In an embodiment, the switching unit **102** of the ventilation apparatus **100** is a three way switch for triggering the pump mode, the exhaust mode, and the termination mode of the pump **101**. The pump **101** is elastically suspended in the upper section **110***a* of the footwear **110** and forms a rigid connection with the feed pipe **104** of the fluid diffuser **103**. The pump **101** is used to pump fluid **201** into the footwear **110** or suction fluid **201** out of the footwear **110**. The pump **101** is connected to the fluid diffuser **103** that transports fluid **201** in and out of the cavity **111** of the footwear **110**. To reverse a direction of rotation of a motor (not shown) of the pump **101**, the pump **101** is activated or energized through the switching unit **102**, for example, the three way switch, which has an intermediate neutral position corresponding to the termination mode of the pump **101**. The alternative positions of the switching unit **102** correspond to alternative directions of rotation of the motor of the pump **101**.

The arrows directed through the pump **101** and through the fluid diffuser **103** shown in FIG. **2**, indicate the direction of flow of the fluid **201** from the ambient environment into the cavity **111** of the footwear **110** in the pump mode of operation. Initially, on activation by the user, the switching unit **102** switches the pump **101** from the neutral position, that is, the termination mode to the pump mode. In the pump mode, the pump **101** pumps fluid **201** from the ambient environment external to the footwear **110** via the vents **112**, and then into the cavity **111** of the footwear **110** via the fluid diffuser **103**. The pumped fluid **201** from the pump **101** is transferred to the feed pipe **104**, from where the pumped fluid **201** is further transferred to the diffusing member **105** that is distally connected to the feed pipe **104**. In an embodiment, the feed pipe **104** is configured as a fluid dispersing pipe. The diffusing member **105** can be any type of diffuser, for example, a type of diffuser through which air is bubbled into water in aquariums. The fluid **201** received from the feed pipe **104** is transferred through the openings **106** of the diffusing member **105** into the cavity **111** of the footwear **110**, for example, towards the front end **110***b* of the footwear **110** and then towards the rear end **110***d* of the footwear **110**. The pumped fluid **201** is therefore circulated around the foot of a user wearing the footwear **110**, thereby providing cooling around the foot of the user. The switching unit **102** can be turned on or off at any time, for example, when the user wears the footwear **110** for a long duration, when the user wearing the footwear **110** is in a warm air environment, when the user wearing the footwear **110** exercises, etc. The movements of the user's foot inside the footwear **110**, for example, during working, walking, running, etc., further adds to the intermixing of warm fluid and the incoming pumped fluid **201** from the pump **101**. On activation by the user, the switching unit **102** can then switch the pump **101** from the pump mode to the exhaust mode to exhaust the fluid **201** from the cavity **111** of the footwear **110** as disclosed in the detailed description of FIG. **3**.

FIG. **3** exemplarily illustrates a right side perspective view of the ventilation apparatus **100**, showing an exhaust mode of operation of the ventilation apparatus **100**. The arrows directed from the cavity **111** of the footwear **110** and through the fluid diffuser **103** shown in FIG. **3**, indicate the direction of flow of the fluid **201** from the cavity **111** of the footwear **110** to the ambient environment in the exhaust mode of operation. After the pump mode, the pump **101** is switched to the exhaust mode by reversing polarity of the voltage supplied by the energy storage devices **108** via the switching unit **102**, or by changing the direction of rotation of the motor (not shown) of the pump **101**, that is, by mechanical turning of the motor of the pump **101** between input and output connections of the motor. The pump **101** exhausts fluid **201** from the cavity **111** of the footwear **110** through the fluid diffuser **103**. When the pump **101** is switched to the exhaust mode, exhaust fluid **201** from the cavity **111** of the footwear **110** is directed through the openings **106** of the diffusing member **105** of the fluid diffuser **103** and into the feed pipe **104**, and then exhausted through the pump **101**. The pump **101** exhausts the fluid **201** into the ambient environment external to the footwear **110** via the vents **112**. The exhaust mode of operation ventilates the footwear **110** by exhausting the warm fluid **201** around the foot of a user wearing the footwear **110**, thereby providing cooling around the user's foot.

FIG. **4** exemplarily illustrates a front elevation view of the switching unit **102** of the ventilation apparatus **100** exemplarily illustrated in FIG. **1**, showing the operation of the switching unit **102**. The switching unit **102** selectively changes modes of operation, for example, the pump mode, the exhaust mode, and the termination mode of the pump **101** exemplarily illustrated in FIG. **1**. The pump mode for pumping the fluid **201** exemplarily illustrated in FIG. **2**, into the cavity **111** of the footwear **110** is activated when the switching unit **102** is moved to a first position **401**. The exhaust mode for exhausting the fluid **201** exemplarily illustrated in FIG. **3**, from the cavity **111** of the footwear **110** is activated when the switching unit **102** is moved to a second position **402**. A third position **403** of the switching unit **102** exemplarily illustrated in FIG. **4**, shows the termination mode of the pump **101** for deactivating the pump **101**.

FIG. **5** exemplarily illustrates an embodiment of the ventilation apparatus **100** for ventilating footwear **110**. The ventilation apparatus **100** comprises the pump **101**, the switching unit **102**, the energy storage devices **108**, and the energy converter **109** positioned, for example, on the upper section **110***a* of the footwear **110** as disclosed in the detailed description of FIG. **1**. In an embodiment, in addition to the feed pipe **104**, the fluid diffuser **103** of the ventilation apparatus **100** further comprises a fluid distribution channel member **114** fixedly attached within a sole **115** of the footwear **110**. The fluid distribution channel member **114** comprises channels **116**, in fluid communication with the feed pipe **104** of the fluid diffuser **103**, for allowing the fluid **201** received from the feed pipe **104** exemplarily illustrated in FIG. **6**, to be transferred to the cavity **111** of the footwear **110** during the pump mode and for allowing the fluid **201** in the cavity **111** of the footwear **110** to be transferred through the feed pipe **104** to the ambient environment external to the footwear **110** during the exhaust mode, for ventilating the footwear **110**. In an embodiment as exemplarily illustrated in FIG. **5**, the channels **116** are configured along multiple branches **116***a* of the fluid distribution channel member **114** for enhanced transfer of the fluid **201** to and from the cavity **111** of the footwear **110**. The fluid **201** is transferred between the feed pipe **104** and the fluid distribution channel member **114** via a connection opening **117** positioned on the fluid distribution channel member **114**.

In an embodiment, through holes **118** are configured on an insole **119** of the footwear **110**. The through holes **118** of the insole **119** are axially aligned with the channels **116** of the fluid distribution channel member **114** for allowing the transfer of the fluid **201** received by the channels **116** of the fluid distribution channel member **114** from the feed pipe

104 to the cavity 111 of the footwear 110 during the pump mode and for allowing transfer of the fluid 201 from the cavity 111 of the footwear 110, through the channels 116 of the fluid distribution channel member 114, into the feed pipe 104, and out to the ambient environment external to the footwear 110 during the exhaust mode.

FIG. 6 exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus 100 shown in FIG. 5, showing a pump mode of operation of the ventilation apparatus 100. As exemplarily illustrated in FIG. 6, when a user wants to pump fluid 201 into the cavity 111 of the footwear 110 to ventilate the footwear 110, the user switches the pump 101 to the pump mode using the switching unit 102. The energy storage devices 108 supply electrical energy to the pump 101 via the switching unit 102 to actuate the pump 101. In the pump mode, the pump 101 starts pumping the fluid 201 from the ambient environment external to the footwear 110 through the vents 112 exemplarily illustrated in FIG. 5, and through the feed pipe 104, which is connected to the fluid distribution channel member 114 through the connection opening 117 exemplarily illustrated in FIG. 5. The fluid 201 from the feed pipe 104 enters the channels 116 of the fluid distribution channel member 114 through the connection opening 117. The fluid 201 is then transferred from the channels 116 of the fluid distribution channel member 114 to the cavity 111 of the footwear 110 through the through holes 118 of the insole 119.

FIG. 7 exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus 100 shown in FIG. 5, showing an exhaust mode of operation of the ventilation apparatus 100. As exemplarily illustrated in FIG. 7, when a user wants to exhaust fluid 201 from the cavity 111 of the footwear 110, the user switches the pump 101 to the exhaust mode using the switching unit 102. The energy storage devices 108 supply electrical energy to the pump 101 via the switching unit 102 to actuate the pump 101. In the exhaust mode, the pump 101 suctions or exhausts the fluid 201 from inside the cavity 111 of the footwear 110 to the ambient environment external to the footwear 110. The fluid 201 from the cavity 111 of the footwear 110 is first transferred through the through holes 118 of the insole 119 and into the channels 116 of the fluid distribution channel member 114 positioned inside the sole 115 below the insole 119 as exemplarily illustrated in FIG. 5. The fluid 201 is then transferred from the channels 116 of the fluid distribution channel member 114 to the feed pipe 104 via the connection opening 117 exemplarily illustrated in FIG. 5. The feed pipe 104 then transfers the fluid 201 out to the ambient environment external to the footwear 110 through the vents 112 positioned on the pump 101 exemplarily illustrated in FIG. 5.

FIG. 8 exemplarily illustrates an embodiment of the ventilation apparatus 100 for ventilating footwear 110. In this embodiment, the ventilation apparatus 100 comprises pumps 101 and 120, the switching unit 102, and the fluid diffuser 103. The pumps 101 and 120 comprise a first pump 101 fixedly attached on a predefined section, for example, the upper section 110*a* of the footwear 110, and a second pump 120 positioned within a sole 115 of the footwear 110. The second pump 120 is, for example, centrally positioned on the sole 115 of the footwear 110 as exemplarily illustrated in FIG. 8. The pumps 101 and 120 are, for example, piezoelectric pumps, electromechanical pumps, etc. The pumps 101 and 120 pump fluid 201 into the cavity 111 of the footwear 110 and exhaust the fluid 201 from the cavity 111 of the footwear 110 as exemplarily illustrated in FIGS. 10-11. The switching unit 102 is in electric communication with the first pump 101 and the second pump 120. The switching unit 102 selectively changes modes of operation of the first pump 101 and the second pump 120. The modes of operation comprise a pump mode and an exhaust mode. In an embodiment, the modes of operation further comprise a termination mode. In an embodiment, the pumps 101 and 120 are interlocked, so that when the switching unit 102 actuates one pump 101 into the exhaust mode or a suction mode, the other pump 120 starts to pump in the pump mode and vice versa. In another embodiment, when the switching unit 102 switches one pump 101 to the pump mode, the other pump 120 also operates in the pump mode, and when the switching unit 102 switches one pump 101 to the exhaust mode or a suction mode, the other pump 120 also operates in the exhaust mode.

The fluid diffuser 103 is operably connected to the first pump 101 and the second pump 120 within the cavity 111 of the footwear 110. In this embodiment, the fluid diffuser 103 comprises the feed pipe 104 and the diffusing member 105. The feed pipe 104 is fixedly connected to and extends from the first pump 101 into the cavity 111 of the footwear 110. The feed pipe 104 transfers the fluid 201 pumped from the first pump 101 to the diffusing member 105 that is in fluid communication with the feed pipe 104. The diffusing member 105 is positioned and attached proximal to a front end 110*b* of the footwear 110 in the cavity 111 of the footwear 110. The diffusing member 105 comprises one or more openings 106 that allow the fluid 201 pumped from the first pump 101 through the feed pipe 104 to be transferred into the cavity 111 of the footwear 110, proximal to the front end 110*b* of the footwear 110, and allow the fluid 201 in the cavity 111 of the footwear 110 at the rear end 110*d* of the footwear 110 to be transferred via the second pump 120 and through the feed pipe 104 to an ambient environment external to the footwear 110, for ventilating the footwear 110.

In this embodiment, the fluid diffuser 103 further comprises a fluid distribution channel member 114 fixedly attached within the sole 115 of the footwear 110. The fluid distribution channel member 114 is operably connected to and in fluid communication with the second pump 120 within the sole 115 of the footwear 110. The fluid distribution channel member 114 comprises channels 116 that are in fluid communication with the openings 106 of the diffusing member 105 via through holes 118 configured on the insole 119 of the footwear 110, for allowing the fluid 201 received from the openings 106 of the diffusing member 105 to be transferred to the second pump 120, and for allowing the fluid 201 pumped by the second pump 120 to be transferred to the openings 106 of the diffusing member 105, into the feed pipe 104, and out to the ambient environment external to the footwear 110 via the first pump 101, for ventilating the footwear 110. The channels 116 of the fluid distribution channel member 114 allow unobstructed passage of fluid 201, for example, air to and from the second pump 120. The ventilation apparatus 100 further comprises an energy storage device 121 and an energy converter 122 as disclosed in the detailed description of FIG. 9.

FIG. 9 exemplarily illustrates an exploded view of the embodiment of the ventilation apparatus 100 shown in FIG. 8. The exploded view shows an upper portion 110*e* of the footwear 110, the insole 119 of the footwear 110, and the sole 115 of the footwear 110. As exemplarily illustrated in FIG. 9, the upper portion 110*e* of the footwear 110 accommodates the first pump 101, the switching unit 102, the energy storage devices 108, the energy converter 109, and the feed pipe 104 and the diffusing member 105 of the fluid

diffuser **103**. The energy storage devices **108**, for example, batteries are operably connected to the first pump **101** for supplying electrical energy to the first pump **101** to actuate the first pump **101**. The energy converter **109** is in electric communication with the energy storage devices **108** and the first pump **101**. The energy converter **109** converts direct current received from the energy storage devices **108** to an alternating current to be supplied to the first pump **101** to actuate the first pump **101**.

The upper portion **110***e* of the footwear **110** is removably attached to the insole **119** of the footwear **110**. The insole **119** of the footwear **110** is attached to the sole **115** of the footwear **110**. The sole **115** of the footwear **110** accommodates an encasing **123** that holds the second pump **120**, and another encasing **124** that holds another energy storage device **121**, for example, a battery, and another energy converter **122**. The encasings **123** and **124** are rigid protective frames that protect the second pump **120**, and the energy storage device **121** and the energy converter **122** respectively. The energy storage device **121** is operably connected to the second pump **120** for supplying electrical energy to the second pump **120** to actuate the second pump **120**. The energy converter **122**, for example, an electric current converter, is in electric communication with the energy storage device **121** and the second pump **120**. The energy converter **122** converts direct current received from the energy storage device **121** to an alternating current to be supplied to the second pump **120** to actuate the second pump **120**. In an embodiment, the energy storage device **121** supplies direct current to the second pump **120** to actuate the second pump **120**. The second pump **120**, and the energy storage device **121** and the energy converter **122** which are subjected to stress during walking, are mounted inside their respective encasings **123** and **124**, which are elastically suspended inside the sole **115** of the footwear **110**.

The second pump **120** is operably connected to the fluid distribution channel member **114** within the sole **115** of the footwear **110**. In this embodiment, the through holes **118** configured on the insole **119** of the footwear **110** are axially aligned with the channels **116** of the fluid distribution channel member **114** for allowing transfer of the fluid **201** received from the openings **106** of the diffusing member **105** to the channels **116** of the fluid distribution channel member **114** for transfer of the fluid **201** to the second pump **120** as exemplarily illustrated in FIG. **10**, and for allowing transfer of the fluid **201** pumped by the second pump **120** to the openings **106** of the diffusing member **105** via the channels **116** of the fluid distribution channel member **114**, into the feed pipe **104**, and out to the ambient environment external to the footwear **110** via the first pump **101** as exemplarily illustrated in FIG. **11**.

FIG. **10** exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus **100** shown in FIG. **8**, showing the first pump **101** in a pump mode and the second pump **120** in an exhaust mode. In an example, when a user wants to ventilate the cavity **111** of the footwear **110** by pumping fluid **201** into the cavity **111** of the footwear **110**, the user activates the switching unit **102** to switch the first pump **101** to the pump mode and the second pump **120** to the exhaust mode. In the pump mode, the first pump **101** pumps fluid **201**, for example, air from the ambient environment external to the footwear **110**, into the cavity **111** of the footwear **110** through the fluid diffuser **103**. The fluid **201** pumped from the first pump **101** is transferred to the diffusing member **105** of the fluid diffuser **103** through the feed pipe **104** of the fluid diffuser **103**. The fluid **201** is then transferred to the cavity **111** proximal to the front end **110***b* of the footwear **110** through the openings **106** of the diffusing member **105**. In the exhaust mode, the second pump **120** suctions a portion of the fluid **201** from the front end **110***b* of the footwear **110** and transfers the suctioned portion of the fluid **201** to the rear end **110***d* of the footwear **110**. The fluid **201** is suctioned and transferred from the cavity **111** proximal to the front end **110***b* of the footwear **110** to the second pump **120** via the through holes **118** on the insole **119** and the channels **116** of the fluid distribution channel member **114** exemplarily illustrated in FIGS. **8-9**.

FIG. **11** exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus **100** shown in FIG. **8**, showing the first pump **101** in an exhaust mode and the second pump **120** in a pump mode. In another example, when a user wants to ventilate the cavity **111** of the footwear **110** by exhausting fluid **201**, for example, air and water vapor from the cavity **111** of the footwear **110**, the user activates the switching unit **102** to switch the first pump **101** to the exhaust mode and the second pump **120** to the pump mode. The first pump **101** is switched to the exhaust mode by reversing the polarity of the voltage supplied by the energy storage devices **108** via the switching unit **102**. In the pump mode, the second pump **120** pumps the fluid **201** from the rear end **110***d* of the footwear **110** through the channels **116** of the fluid distribution channel member **114** and through the through holes **118** on the insole **119** exemplarily illustrated in FIGS. **8-9**, towards the front end **110***b* of the footwear **110** as exemplarily illustrated in FIG. **11**. In the exhaust mode, the first pump **101** further suctions the fluid **201** from the cavity **111** proximal to the front end **110***b* of the footwear **110** through the openings **106** of the diffusing member **105** and the feed pipe **104** and exhausts the fluid **201** to the ambient environment external to the footwear **110**.

FIG. **12** exemplarily illustrates a method for ventilating footwear **110** exemplarily illustrated in FIGS. **8-9**. The ventilation apparatus **100** comprising the first pump **101** and the second pump **120**, the switching unit **102**, and the fluid diffuser **103** as exemplarily illustrated in FIGS. **8-9**, is provided **1201**. The switching unit **102** switches **1202** the first pump **101** to the pump mode and the second pump **120** to the exhaust mode. The first pump **101** in the pump mode pumps **1203** the fluid **201**, for example, air from the ambient environment external to the footwear **110** into the cavity **111** of the footwear **110** proximal to the front end **110***b* of the footwear **110** through the feed pipe **104** and the openings **106** of the fluid diffuser **103** as exemplarily illustrated in FIG. **10**. The fluid distribution channel member **114** comprising the channels **116** in fluid communication with the openings **106** of the diffusing member **105** via the through holes **118** of the insole **119** of the footwear **110** exemplarily illustrated in FIGS. **8-9**, transfer the fluid **201** received from the openings **106** of the diffusing member **105** to the second pump **120**. The second pump **120** in the exhaust mode suctions and transfers **1204** a portion of the fluid **201** from the front end **110***b* of the footwear **110** to a rear end **110***d* of the footwear **110**. Replacing the fluid exhausted from the cavity **111** of the footwear **110** with the fluid **201**, for example, air from the ambient environment ventilates the cavity **111** inside the footwear **110**.

The switching unit **102** then switches **1205** the first pump **101** to the exhaust mode and the second pump **120** to the pump mode. In the pump mode, the second pump **120** transfers **1206** the fluid **201** from the cavity **111** of the footwear **110** at the rear end **110***d* of the footwear **110** to the front end **110***b* of the footwear **110** as exemplarily illustrated in FIG. **11**. The channels **116** of the fluid distribution channel

member **114** transfer the fluid **201** pumped by the second pump **120** to the openings **106** of the diffusing member **105** via the through holes **118** of the insole **119** of the footwear **110**. In the exhaust mode, the first pump **101** exhausts **1207** the fluid **201** from the cavity **111** of the footwear **110** at the front end **110***b* of the footwear **110** through the openings **106** of the diffusing member **105** and the feed pipe **104** to the ambient environment external to the footwear **110**. The first pump **101** and the second pump **120** are selectively switched to the pump mode and the exhaust mode to ventilate the footwear **110**. The switching unit **102** switches the first pump **101** and the second pump **120** to the termination mode for terminating the operation of the first pump **101** and the second pump **120**.

FIG. **13** exemplarily illustrates an embodiment of the ventilation apparatus **100** for ventilating footwear **110** of a low height. In this embodiment, the ventilation apparatus **100** is configured to operate without the first pump **101**, the feed pipe **104**, and the diffusing member **105** exemplarily illustrated in FIGS. **8-9**. The ventilation apparatus **100**, in this embodiment, comprises a switching unit **102**, a pump **120**, the fluid distribution channel member **114** with the channels **116**, the energy storage device **121**, and the energy converter **122**. The switching unit **102** is positioned on a collar **125** of the footwear **110** as exemplarily illustrated in FIG. **13**. The pump **120**, the fluid distribution channel member **114** with the channels **116**, the energy storage device **121**, and the energy converter **122** are positioned below the insole **119** of the footwear **110**, inside the sole **115** of the footwear **110**. The pump **120** is centrally positioned within the sole **115** of the footwear **110**, while the energy storage device **121** and the energy converter **122** are positioned proximal to the rear end **110***d* of the footwear **110**. The insole **119** of the footwear **110** is positioned above the sole **115** of the footwear **110** and comprises through holes **118** axially aligned with the channels **116** of the fluid distribution channel member **114**. The switching unit **102** is electrically connected to the energy storage device **121** and the energy converter **122** to actuate the pump **120** in a pump mode and an exhaust mode.

During the exhaust mode, the switching unit **102** actuates the pump **120** to exhaust the fluid from the cavity **111** of the footwear **110**. The exhaust fluid pumped by the pump **120** enters the channels **116** of the fluid distribution channel member **114** and exits the channels **116** into the through holes **118** of the insole **119**. The fluid is further exhausted out from the through holes **118** of the insole **119** to the ambient environment external to the footwear **110** through an opening **125***a* defined by the collar **125** of the footwear **110** exemplarily illustrated in FIG. **13**. During the pump mode, the pump **120** pumps the fluid from the ambient environment external to the footwear **110** in through the opening **125***a* of the footwear **110**, through the through holes **118** of the insole **119**, through the channels **116** of the fluid distribution channel member **114**, and into the cavity **111** of the footwear **110**. In this embodiment, the ventilation or cooling of a user's foot inserted into the cavity **111** of the footwear **110** is performed due to forced air movement around the foot by the pump **120**.

FIGS. **14A-14B** exemplarily illustrate a right side perspective view and a top plan view respectively, of an embodiment of the ventilation apparatus **100** for ventilating footwear **110**. The ventilation apparatus **100** disclosed herein is integrated into the footwear **110** having a zipper **113** as exemplarily illustrated in FIGS. **14A-14B**. In this embodiment, the ventilation apparatus **100** comprises at least one flexible energy storage device **126**, a pump **101**, a switching unit **102**, and a fluid diffuser **103**. As used herein, "flexible energy storage device" refers to a thin film flexible battery composed of substantially thin materials having thicknesses measured in nanometers or micrometers. These thin materials are integrated to produce a thin flexible energy storage device **126** having a thickness of, for example, about 0.4 millimeters (mm) to about 0.5 mm. The flexible energy storage device **126** comprises one or more substantially thin electric power layers of flexible components that flexibly conform to varying contours of the footwear **110** and sustain deforming forces that arise during usage of the footwear **110**. Footwear **110**, for example, high boots provide a substantially vast space for positioning one or more flexible energy storage devices **126**. The flexible energy storage device **126** can be fabricated into different shapes and sizes by different methods for positioning in the footwear **110**. For example, in one method, polymer binders are used to fabricate composite electrodes of the flexible energy storage device **126** where conductive additives are added to enhance conductivity of the composite electrodes. Electrode materials can be printed or coated onto flexible substrates to fabricate the flexible energy storage device **126**. Cells are assembled into flexible packaging materials to maintain bendability in the flexible energy storage device **126**. In other methods, an electrode suspension is filtered through filters to form free-standing films that constitute the flexible energy storage device **126**, or a flexible matrix is used to hold electrode materials that constitute the flexible energy storage device **126**. The flexible energy storage device **126** is compact, occupies less space in the footwear **110**, flexibly conforms to varying contours of the footwear **110**, can be easily accommodated at any location inside or outside the footwear **110**, and can be easily replaced, without obstructing or injuring a user wearing the footwear **110** and without causing damage to the flexible energy storage device **126**.

The flexible energy storage device **126** disclosed herein is a compact flexible structure capable of conforming to surfaces of different profiles. The flexible energy storage device **126** is, for example, a flexible lithium battery made of a lithium polymer such as the lithium polymer battery of BrightVolt Inc., Fla., USA, the flexible lithium ion battery of Panasonic Corporation, Japan, etc. The substrates of the flexible energy storage device **126** are flat and thin, unlike cylindrical surfaces or thick rectangular surfaces of conventional energy storage devices. The flexible energy storage device **126** regains its original shape upon bending, deforming, etc., because of the elasticity of the flexible energy storage device **126**. Because of this elasticity, the flexible energy storage device **126** can be accommodated in places with space restrictions, for example, in footwear **110** without hampering the functionality of the flexible energy storage device **126**, thereby occupying less space.

The flexible energy storage device **126** of the ventilation apparatus **100** disclosed herein is positioned at one or more of multiple preconfigured locations of the footwear **110**. In an embodiment as exemplarily illustrated in FIGS. **14A-14B**, the flexible energy storage device **126** is positioned in a compartment **110***h* formed between an inner rear surface **110***f* and an outer rear surface **110***g* of the footwear **110**. In another embodiment (not shown), the flexible energy storage device **126** is positioned in the sole **115** of the footwear **110**. In another embodiment (not shown), the flexible energy storage device **126** is positioned in the upper section **110***a* of the footwear **110**. In another embodiment (not shown), the flexible energy storage device **126** is positioned in a compartment (not shown) positioned on an outer surface of the footwear **110**. In other embodiments, the flexible energy

storage device **126** is positioned at any one or more preconfigured locations inside and/or outside the footwear **110**. The flexible energy storage device **126** is operably connected to the pump **101**, for example, using conducting wires **127**. The flexible energy storage device **126** stores electrical energy and supplies electrical energy to the pump **101** via the switching unit **102** to actuate the pump **101**. Examples of the flexible energy storage device **126** utilized in the ventilation apparatus **100** for supplying electrical energy to the pump **101** are a thin film flexible lithium ion battery, a thin film flexible lithium battery, a thin film flexible nickel cadmium battery, a thin film flexible zinc carbon battery, a thin film flexible carbon battery, etc. In an embodiment, the flexible energy storage device **126** is covered with a decorative layer for enhancing the aesthetic appeal of the footwear **110**.

In an embodiment as exemplarily illustrated in FIGS. **14**A-**14**B, the switching unit **102** of the ventilation apparatus **100** is positioned in the upper section **110***a* of the footwear **110**. The switching unit **102** is in electric communication with the flexible energy storage device **126** and the pump **101**. The switching unit **102** selectively changes modes of operation of the pump **101**. The modes of operation of the pump **101** comprise, for example, a pump mode for pumping fluid **201** into the cavity **111** of the footwear **110** as exemplarily illustrated in FIGS. **18**A-**18**B, and an exhaust mode for exhausting the fluid **201** from the cavity **111** of the footwear **110** as exemplarily illustrated in FIGS. **19**A-**19**B. In an embodiment, the modes of operation of the pump **101** further comprise a termination mode for terminating the operation of the pump **101**. In an embodiment, the switching unit **102** comprises distinct switches **102***a*, **102***b*, and **102***c* for selectively changing the modes of operation of the pump **101**. In an embodiment, the ventilation apparatus **100** comprises a voltage regulator **128** for regulating voltage supplied to the pump **101** by the flexible energy storage device **126**. When the switch **102***b* is activated or deactivated a preconfigured number of times, the voltage regulator **128** increases or decreases the voltage supplied from the flexible energy storage device **126** to the pump **101**.

The pump **101** of the ventilation apparatus **100** is fixedly attached to a predefined section, for example, within the upper section **110***a* of the footwear **110**, and is operably connected to the switching unit **102**. The pump **101** is operably connected to the flexible energy storage device **126** via the switching unit **102**. The pump **101** pumps fluid **201** into and exhausts fluid **201** from the cavity **111** of the footwear **110** on receiving the electrical energy from the flexible energy storage device **126** via the switching unit **102**. The fluid **201** from the ambient environment enters the pump **101** through vents **112** configured on the pump **101** and positioned adjacent to the switches **102***a*, **102***b*, and **102***c* of the switching unit **102** on the upper section **110***a* of the footwear **110**. The vents **112** are positioned above the pump **101** on the upper section **110***a* of the footwear **110**. The fluid **201** from the cavity **111** of the footwear **110** exhausts the pump **101** through the vents **112**. The pump **101** can be of different sizes and in an embodiment, can be positioned in any section of the footwear **110**. The switch **102***a* of the switching unit **102** operates the pump **101** in the pump mode and the exhaust mode as disclosed in the detailed description of FIGS. **18**A-**19**B. In an embodiment, the switch **102***b* operates the voltage regulator **128** to increase or decrease the voltage supplied to the pump **101**, thereby changing the speed of the operation of the pump **101** according to the convenience of the user. The switch **102***c* of the switching unit **102** turns the ventilation apparatus **100** on and off. In an embodiment, multiple configurations of switches **102***a*, **102***b*, and **102***c* and/or other switches can be incorporated in the ventilation apparatus **100** and used to operate the pump **101** according to the convenience of the user.

The fluid diffuser **103** of the ventilation apparatus **100** is operably connected to the pump **101** and positioned within the cavity **111** of the footwear **110**. The fluid diffuser **103** circulates the fluid **201** to and from the cavity **111** of the footwear **110**. The fluid diffuser **103** comprises a feed pipe **104** and a diffusing member **105** with openings **106** in fluid communication with the feed pipe **104**. The structure of the feed pipe **104** and the diffusing member **105** of the fluid diffuser **103** is disclosed in the detailed description of FIG. **1**. In an embodiment, the ventilation apparatus **100** disclosed herein further comprises an energy converter **109** in electric communication with the flexible energy storage device **126**, the switching unit **102**, and the pump **101**. The energy converter **109** converts direct current received from the flexible energy storage device **126** to an alternating current to be supplied to the pump **101** via the switching unit **102** to actuate the pump **101**. In an embodiment, the flexible energy storage device **126** supplies direct current to the pump **101** via the switching unit **102**. The voltage regulator **128** regulates the voltage supplied by the flexible energy storage device **126** to the pump **101** using the switch **102***b* that is in electric communication with the voltage regulator **128**.

In an embodiment (not shown), the pump **101**, the energy converter **109**, the switching unit **102**, the flexible energy storage device **126**, and the voltage regulator **128** are positioned in one or more compartments (not shown) positioned on an outer surface of the footwear **110** to prevent any damage from the user's foot to the ventilation apparatus **100**.

FIG. **15** exemplarily illustrates a partial disassembled view of the embodiment of the ventilation apparatus **100** shown in FIG. **14**A, showing positioning of the flexible energy storage device **126** in a compartment **110***h* of the footwear **110**. The compartment **110***h* is formed between the inner rear surface **110***f* and the outer rear surface **110***g* of the footwear **110**. In an embodiment, more than one flexible energy storage device **126** is positioned in the compartment **110***h* of the footwear **110**. The flexible energy storage device **126** conforms to the varying contours of the footwear **110** during walking, running, and other movements or physical activities performed by the user using the footwear **110**.

The flexible energy storage device **126** disclosed herein comprises flexible substrates coated with anode and cathode materials for storing electrical energy. Different methods are used to coat the flexible substrates with the anode and cathode materials. The flexible energy storage device **126** comprises a solid polymer (not shown) as an electrolyte to facilitate transfer of ions from the anode to the cathode. The solid polymer is obtained by dissolving lithium salts, for example, lithium hexafluorophosphate ($LiPF_6$), lithium tetrafluoroborate ($LiBF_4$), or lithium perchlorate ($LiClO_4$) in polymer solvents, for example, polyethers, polyesters, polyimines, and polythiols. The solid polymer is deposited in multiple layers according to electric power capacity of the flexible energy storage device **126**. The solid polymer electrolyte further acts as a binder and a separator, thereby reducing the need for multiple elements as in the case of conventional energy storage devices. Due to the flexibility of the substrates and the solid polymer electrolyte, the flexible storage device **126** can sustain small deforming forces that arise during the movement of the foot. In an embodiment, the electrolyte is a polymer matrix electrolyte, for example, the BrightVolt PME™ of BrightVolt Inc. In an embodiment,

the flexible energy storage device **126** is rechargeable and can be used repetitively over extended periods of time.

In an embodiment, the flexible energy storage device **126** is configured as a stretchable power source. In this embodiment, the flexible energy storage device **126** comprises substantially small lithium-ion cells on a stretchable silicone substrate. The lithium-ion cells on the silicone substrate are connected by conducting wires. The lithium-ion cells are protected by silicone layers on the top and bottom of the lithium-ion cells. In an embodiment, each lithium-ion cell comprises a copper electrode sandwiched between two layers of polyimide. The lithium-ion cells are also provided with an anode slurry and a cathode slurry. A gel electrolyte is provided within a silicone spacer that separates the anode slurry and the cathode slurry of each lithium-ion cell. The gel electrolyte facilitates the transfer of ions from the anode slurry to the cathode slurry of the lithium-ion cell, which results in the flow of electrical energy. In an embodiment, the gel electrolyte is formed by dissolving an electrolyte in a polar solvent and adding an inactive polymeric material. An example of the gel electrolyte is a poly(vinylidene fluoride-co-hexafluoropropene) (PVDF-co-HFP) electrolyte obtained by mixing a lithium ion salt solution in carbonate esters.

In another embodiment (not shown), a flexible energy storage device **126** configured as a coil is used in the footwear **110**. In this embodiment, the anode and cathode elements of the flexible energy storage device **126** are configured as coils and an electrolyte is poured in a hollow space formed by winding of the anode and cathode coils. The electrolyte is, for example, a solution of lithium salts such as lithium hexafluorophosphate ($LiPF_6$), lithium tetrafluoroborate ($LiBF_4$), or lithium perchlorate ($LiClO_4$) with organic solvents such as ethylene carbonate, dimethyl carbonate, and diethyl carbonate. A protective cover is provided to enclose the anode and cathode coils and the electrolyte. The flexible energy storage device **126** of different configurations can be inserted at multiple different locations inside and outside the footwear **110**.

FIG. **16** exemplarily illustrates a right side perspective view of the embodiment of the ventilation apparatus **100** shown in FIG. **14**A, showing the flexible energy storage device **126** electrically connected to the switching unit **102** in the footwear **110**. The flexible energy storage device **126** is electrically connected to the switching unit **102**, the voltage regulator **128**, the energy converter **109**, and the pump **101** exemplarily illustrated in FIG. **14**A and FIG. **15**, using the conducting wires **127**. In an embodiment, the conducting wires **127** extend from one end **126***a* of the flexible energy storage device **126** and connect to the switching unit **102**, the voltage regulator **128**, the energy converter **109**, and the pump **101**. The electrical energy from the flexible energy storage device **126** is transferred to the switching unit **102** through the conducting wires **127** and further transferred to the pump **101** through an electric circuit exemplarily illustrated in FIG. **20**. The electrical energy actuates the pump **101** for circulating the fluid **201** exemplarily illustrated in FIGS. **18**A-**18**B and FIGS. **19**A-**19**B, into and out of the cavity **111** of the footwear **110**.

FIG. **17** exemplarily illustrates an enlarged view of an upper section **110***a* of the footwear **110**, showing components of the embodiment of the ventilation apparatus **100** shown in FIG. **14**A. The upper section **110***a* of the footwear **110** accommodates the pump **101**, the switching unit **102**, the voltage regulator **128**, and the energy converter **109** as exemplarily illustrated in FIG. **17**. The flexible energy storage device **126** exemplarily illustrated in FIG. **16**, is positioned external to the upper section **110***a* of the footwear **110** and electrically communicates with the pump **101**, the switching unit **102**, the voltage regulator **128**, and the energy converter **109** through the conducting wires **127**. The upper section **110***a* of the footwear **110** also accommodates the switches **102***a*, **102***b*, and **102***c* of the switching unit **102**. The switch **102***a* electrically controls the energy converter **109** and in turn the pump **101**. The switch **102***b* electrically controls the voltage regulator **128** for increasing or decreasing the voltage supplied by the flexible energy storage device **126**. The switch **102***c* controls activation and termination of the operation of the pump **101**.

FIG. **18**A exemplarily illustrates an enlarged view of the upper section **110***a* of the footwear **110**, showing a flow of fluid **201** into the footwear **110** in the pump mode of operation of the embodiment of the ventilation apparatus **100** shown in FIG. **14**A. When the switch **102***a* is pressed in a first position to activate the pump mode, the pump **101** pumps the fluid **201** from the ambient environment external to the footwear **110** through the vents **112** and into the cavity **111** of the footwear **110** through the feed pipe **104** of the fluid diffuser **103** as exemplarily illustrated in FIG. **18**B.

FIG. **18**B exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus **100** shown in FIG. **14**A, showing the flow of fluid **201** into the footwear **110** in the pump mode of operation. When the switch **102***a* is pressed to activate the pump mode, the pump **101** draws the fluid **201** from the ambient environment outside the footwear **110** through the vents **112** and into the feed pipe **104** of the fluid diffuser **103**. The diffusing member **105** is in fluid communication with the feed pipe **104** and is positioned and attached proximal to the front end **110***b* of the footwear **110** in the cavity **111** of the footwear **110**. The diffusing member **105** comprises openings **106** for allowing the fluid **201** pumped from the pump **101** through the feed pipe **104** to be transferred into the cavity **111** of the footwear **110** during the pump mode for ventilating the footwear **110**.

FIG. **19**A exemplarily illustrates an enlarged view of the upper section **110***a* of the footwear **110**, showing a flow of fluid **201** from the footwear **110** to the ambient environment outside the footwear **110** in the exhaust mode of operation of the embodiment of the ventilation apparatus **100** shown in FIG. **14**A. When the switch **102***a* is pressed in a second position to activate the exhaust mode, the pump **101** draws the fluid **201** from the cavity **111** of the footwear **110** exemplarily illustrated in FIG. **19**B, and into the feed pipe **104**, and exhausts the fluid **201** to the ambient environment outside the footwear **110** through the vents **112**.

FIG. **19**B exemplarily illustrates a right side elevation view of the embodiment of the ventilation apparatus **100** shown in FIG. **14**A, showing the flow of fluid **201** to the ambient environment outside the footwear **110** in the exhaust mode of operation. When the switch **102***a* is pressed to activate the exhaust mode, the pump **101** draws the fluid **201** from the cavity **111** of the footwear **110** as exemplarily illustrated in FIG. **19**B, and into the feed pipe **104** of the fluid diffuser **103**. The openings **106** of the diffusing member **105** allow the fluid **201** from the cavity **111** of the footwear **110** to be transferred through the feed pipe **104** and then through the vents **112** via the pump **101** to the ambient environment during the exhaust mode for ventilating the footwear **110**.

FIG. **20** exemplarily illustrates a block diagram showing an electric operation of the embodiment of the ventilation apparatus **100** shown in FIG. **14**A. The electric circuitry of the ventilation apparatus **100** comprises electric connections between the pump **101**, the energy converter (EC) **109**, the voltage regulator (VR) **128**, and the switches **102***a*, **102***b*,

and **102***c* of the switching unit **102** with the flexible energy storage device **126**. The block diagram exemplarily illustrated in FIG. **20**, shows the electric operation of the pump **101** in the pump mode, the exhaust mode, and an ON and OFF mode. When the switch **102***c* is closed, the switch **102***c* establishes contact between points A and M of the electric circuitry exemplarily illustrated in FIG. **20**, electrical energy, for example, electric current from the flexible energy storage device **126** circulates in the electric circuit formed by the conducting wires **127** exemplarily illustrated in FIGS. **16-17**, that connect the flexible energy storage device **126**, the voltage regulator **128**, the energy converter **109**, the switching unit **102**, and the pump **101**, and the electrical energy from the flexible energy storage device **126** flows to the voltage regulator **128** that is operated by the switch **102***b*. When the switch **102***b* is pressed for the first time, the switch **102***b* establishes contact between points C and D of the electric circuitry and transfers the electric current to the energy converter **109** through points D and G of the electric circuitry. When the switch **102***b* is engaged between the points C and D, the pump **101** operates in low speed. The energy converter **109** converts the electric current, for example, direct current from the flexible energy storage device **126** to alternating current that is fed to the pump **101**. Pressing the switch **102***a* in the first position establishes contact between points J and K of the electric circuitry and activates the pump mode. During the pump mode, the pump **101** draws the fluid **201**, for example, fresh air from the ambient environment, through the vents **112** exemplarily illustrated in FIG. **18**A, and pumps the fluid **201** into the cavity **111** of the footwear **110** through the feed pipe **104** and the diffusing member **105** of the fluid diffuser **103** exemplarily illustrated in FIG. **18**B.

Pressing the switch **102***a* in the second position establishes contact between points J and L of the electric circuitry and activates the exhaust mode. During the exhaust mode, the pump **101** draws fluid **201**, for example, warm air from the cavity **111** of the footwear **110**, through the diffusing member **105**, and pumps the fluid **201** through the feed pipe **104** and the vents **112** to the ambient environment as exemplarily illustrated in FIGS. **19**A-**19**B. When the switch **102***b* is pressed for the second time, the switch **102***b* establishes contact between points C and E of the electric circuitry. The electric current passes through points E and H of the electric circuitry to the pump **101** through the energy converter **109** and the pump **101** operates at a medium speed when the switch **102***b* is in contact with the points C and E of the electric circuitry. When the switch **102***b* is pressed for the third time, the switch **102***b* establishes contact between points C and F of the electric circuitry. The electric current passes through the points F and Ito the pump **101** through the energy converter **109** and the pump **101** operates at a high speed when the switch **102***b* is in contact with the points F and I of the electric circuitry. When the switch **102***c* is pressed for the second time, the contact between the points A and M is disconnected and the pump **101** stops since no electric current flows in the electric circuit.

The foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the ventilation apparatus **100** and the method disclosed herein. While the ventilation apparatus **100** and the method disclosed herein have been described with reference to various embodiments, it is understood that the words, which have been used herein, are words of description and illustration, rather than words of limitation. Furthermore, although the ventilation apparatus **100** and the method have been described herein with reference to particular means, materials, and embodiments, the ventilation apparatus **100** and the method disclosed herein are not intended to be limited to the particulars disclosed herein; rather, the ventilation apparatus **100** and the method disclosed herein extend to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims. Those skilled in the art, having the benefit of the teachings of this specification, may effect numerous modifications thereto and changes may be made without departing from the scope and spirit of the ventilation apparatus **100** and the method disclosed herein in their aspects.

I claim:

1. An article of footwear with a ventilation apparatus, comprising:

said ventilation apparatus comprising a set of parts attached to said footwear, said set of parts comprising:

at least one flexible energy storage device positioned at one or more of a plurality of preconfigured locations of said footwear, said at least one flexible energy storage device configured to flexibly conform to varying contours of said footwear, said at least one flexible energy storage device further configured to store electrical energy;

an electric pump disposed on an ankle section of said footwear;

a switching unit disposed on said ankle section of said footwear, said switching unit in electric communication with said at least one flexible energy storage device and said electric pump, said switching unit selectively changing modes of operation of said electric pump, said modes of operation comprising:

a pump mode for pumping fluid from an ambient environment external to said footwear into a cavity of said footwear when said electric pump receives said electrical energy from said at least one flexible energy storage device via said switching unit; and

an exhaust mode for exhausting said fluid from said cavity of said footwear to said ambient environment external to said footwear when said electric pump receives said electrical energy from said at least one flexible energy storage device via said switching unit; and

a fluid diffuser comprising:

a diffusing member positioned within said cavity of said footwear and operably connected to said electric pump in said ankle section through a feed pipe; and

said feed pipe connected to and extending from said electric pump in said ankle section into said diffusing member, said feed pipe positioned within said footwear proximal to an inner surface of said footwear, wherein said feed pipe and said diffusing member transfer said fluid from said ambient environment external to said footwear to said cavity of said footwear during said pump mode, and wherein said feed pipe and said diffusing member transfer said fluid in said cavity of said footwear to said ambient environment external to said footwear during said exhaust mode, for ventilating said footwear.

2. The article of footwear with the ventilation apparatus of claim **1**, wherein said at least one flexible energy storage device comprises one or more substantially thin electric power layers that flexibly conform to said varying contours of said footwear and sustain deforming forces that arise during usage of said footwear.

3. The article of footwear with the ventilation apparatus of claim 1, wherein said at least one flexible energy storage device is rechargeable and usable over extended periods of time.

4. The article of footwear with the ventilation apparatus of claim 1, wherein said preconfigured locations for accommodating said at least one flexible energy storage device comprise a location between an inner rear surface and an outer rear surface of said footwear and a location on an outer surface of said footwear.

5. The article of footwear with the ventilation apparatus of claim 1, wherein said diffusing member is positioned and attached proximal to a front end of said footwear in said cavity of said footwear, and wherein said diffusing member comprises one or more openings for allowing said fluid pumped from said electric pump through said feed pipe to be transferred into said cavity of said footwear during said pump mode and for allowing said fluid in said cavity of said footwear to be transferred through said feed pipe to said ambient environment external to said footwear during said exhaust mode, for ventilating said footwear.

6. The article of footwear with the ventilation apparatus of claim 1, further comprising an energy converter, in electric communication with said at least one flexible energy storage device, said switching unit, and said electric pump, for converting direct current received from said at least one flexible energy storage device to an alternating current to be supplied to said electric pump via said switching unit to actuate said electric pump.

7. The article of footwear with the ventilation apparatus of claim 1, wherein said modes of operation of said electric pump further comprise a termination mode for terminating said operation of said electric pump.

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