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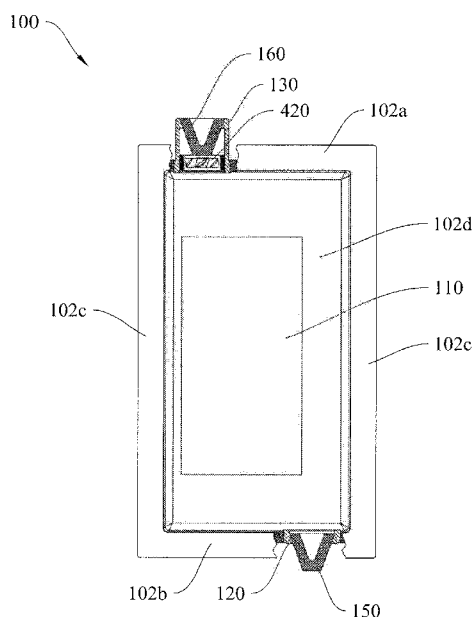


FIGURE 4

(57) Abstract: Enclosures for use in hazardous areas include sintered filters for thermal management. The enclosures include an opening to which a filter holder housing and sintered filter are coupled. The enclosures can also include a second opening to which a vent or a second filter holder housing and sintered filter are coupled. The internal temperature of the enclosures can be actively managed by such a system because air within the enclosure can be displaced to and from the atmosphere through the sintered filters. Air from the atmosphere enters the enclosure via the second opening and exits the enclosure via the first opening.

EXPLOSION-PROOF ENCLOSURES WITH ACTIVE THERMAL MANAGEMENT USING SINTERED ELEMENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is related to U.S. Patent Application Number 12/466,249, titled "Explosion-Proof Enclosures with Active Thermal Management by Heat Exchange" and filed on May 14, 2009, in the name of Joseph Michael Manahan *et al*, the entire disclosure of which is hereby fully incorporated herein by reference.

TECHNICAL FIELD

[0002] The invention relates generally to explosion-proof enclosures, and more particularly, to explosion-proof enclosures having active thermal management capabilities using sintered materials.

BACKGROUND

[0003] Automation equipment can be used to preserve the life of devices such as motors and pumps by improving device performance. However, the installation of automation equipment in hazardous or explosive environments typically has been avoided due to the high heat generated by components of the automation equipment, which could result in an explosion. Hazardous area requirements dictate that such equipment must be sealed from the surrounding atmosphere to fully contain any possible sources of ignition within the enclosure, thus preventing propagation of an explosion.

[0004] The automation equipment could potentially be housed in an explosion-proof enclosure. Currently, explosion-proof enclosures rely on conductive heat transfer for dissipating heat produced by equipment within the enclosure. However, these enclosures do not adequately dissipate the heat produced by the automation equipment within and thus could cause a decrease in the life of the equipment or lead to an explosion within the enclosure. As a result, automation equipment is typically installed outside the boundaries of the hazardous area and long electrical cables are run to the devices within the hazardous area. Several disadvantages to this configuration exist. For example, this configuration results in lack of control at the device, as well as an increase in installation, and/or maintenance costs.

[0005] Therefore, a need exists in the art for an explosion-proof enclosure automation and other for equipment that can provide active thermal management in a hazardous area.

SUMMARY

[0006] The present invention can satisfy the above-described need by providing enclosures having sintered filters for use in hazardous areas. As used herein, the term “sintered filter” refers to any sintered element having channels that allow flow of air therethrough. Some sintered filters are thermally conductive and have the ability to remove some heat energy from a flame passing therethrough, and thus can “arrest” a flame passing therethrough. In other words, some sintered filters can prevent flame transmission by removing one element (heat) of the combustion triangle (oxygen, fuel, and heat).

[0007] The enclosures of the present invention include an opening to which a sintered filter system is coupled. In some aspects, the enclosures include another opening to which a vent or another sintered filter system is coupled.

[0008] The sintered filter systems typically include a filter holder and a sintered filter positioned within. The filter holders can be cylindrically-shaped, rectangular-shaped, or tapered. The sintered filters can be any shape. In some aspects, the sintered filters can be cylindrically-shaped, rectangular-shaped, or be shaped similar to an elliptic paraboloid. In some aspects, the sintered filters can be bolted to the enclosure without the use of a filter holder. The sintered filters can include channels that have a flame path of about one inch and a pore size of about 38.1 microns. In certain aspects, the sintered filters can include channels that have a pore size of about 101.6 microns.

[0009] The enclosures also can include at least one fan positioned proximate to one or both of the sintered filter systems. The fan can be controlled by a control system having a sensor and a controller. In one aspect of the invention, the fan forces air out of one of the sintered filter systems. As a result, atmospheric air is forced into the enclosure through the other sintered filter systems. In some aspects, the atmospheric air can be chilled air or warmed air for improved performance depending on ambient conditions. In another aspect of the invention, the fan pulls air into the enclosure via one of the sintered filter systems and air is forced out through the other sintered filter system.

[0010] In certain aspects of the invention, the enclosures can include a heating element for heating the air within the enclosures. The heating element can be controlled by a control system having a sensor and a controller.

[0011] These and other aspects, objects, and features of the invention will become apparent to those having ordinary skill in the art upon consideration of the following detailed description of exemplary embodiments exemplifying the best mode for carrying out the invention as presently perceived.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Figure 1 is a front view of an explosion-proof enclosure with the cover removed according to an exemplary embodiment.

[0013] Figure 2 is a top perspective view of the explosion-proof enclosure shown in Figure 1 according to an exemplary embodiment.

[0014] Figure 3 is a bottom perspective view of the explosion-proof enclosure shown in Figure 1 according to an exemplary embodiment.

[0015] Figure 4 is a cross-sectional view of the explosion-proof enclosure shown in Figure 1 according to an exemplary embodiment.

[0016] Figure 5 is a cross-sectional view of a sintered filter that can be used in conjunction with the explosion-proof enclosure shown in Figure 1 according to an exemplary embodiment.

[0017] Figure 6 is a cross-sectional view of a sintered filter that can be used in conjunction with the explosion-proof enclosure shown in Figure 1 according to an alternative exemplary embodiment.

[0018] Figure 7 is a sectional view of an explosion-proof enclosure according to an alternative exemplary embodiment.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0019] The application discloses enclosures having active thermal management capabilities. The enclosures include a sintered material that provides a vent to the atmosphere. The enclosures can be used for both general purposes and in hazardous areas.

[0020] The present invention may be better understood by reading the following description of non-limiting embodiments with reference to the attached drawings wherein like parts of each of the figures are identified by the same reference characters.

[0021] Figures 1-3 are front, top perspective, and bottom perspective views of an explosion-proof enclosure 100 with a cover (not shown) removed according to an exemplary embodiment. The enclosure 100 includes a rectangular housing 102. The housing 102

includes a top wall 102a, a bottom wall 102b, two side walls 102c, a rear wall 102d, and a cavity 102e. The housing 102 also includes a flange 102f extending orthogonally from the top, bottom, and two side walls 102a, 102b, 102c. In certain embodiments, the housing 102 is constructed from aluminum and is a NEMA 7 compliant enclosure for indoor or outdoor use in hazardous locations classified as Class I, Groups A, B, C, or D.

[0022] The enclosure 100 also includes automation equipment 110 positioned within the cavity 102e and coupled to the rear wall 102d. In alternative embodiments, the automation equipment 110 can be coupled to the top wall 102a, the bottom wall 102b, or one of the side walls 102c. The automation equipment 110 produces heat within the enclosure 100 which should be dissipated to maintain a desired temperature within the enclosure 100. In certain embodiments, the automation equipment 110 may include a controller, such as a variable frequency drive (VFD) that controls the frequency of electrical power supplied to an external device, such as a pump or a motor (not shown). In certain embodiments, the automation equipment 110 may also include a transformer, a programmable logic controller (PLC), and/or a line reactor.

[0023] The enclosure 100 also includes a filter holder 120 coupled to the housing 102. The filter holder 120 may be coupled to the housing 102 by any suitable means that can maintain the hazardous rating integrity of the enclosure 100, such as by mating threads or by bolting a flange (not shown) on the filter holder 120 to the housing 102. The filter holder 120 houses a sintered filter 150. In certain embodiments, the filter holder 120 and the sintered filter 150 are two separate pieces. In certain embodiments, the sintered filter 150 is sealed within the filter holder 120. In certain alternative embodiments, the filter holder 120 and the sintered filter 150 are integrated into a single sintered filter system. The filter holder 120 extends outwardly from the bottom wall 102b and has a variable sectional area from an end adjacent to the enclosure 102 to an opposite end. For example, the filter holder 120 can be tapered as shown in Figure 1, 3, and 4. In certain alternative embodiments, the filter holder 120 has a constant sectional area. The size and shape of the filter holder 120 and the filter 150 can be configured based on the amount of air flow desired.

[0024] The enclosure 100 further includes another filter holder 130 coupled to the housing 102. The filter holder 130 may be coupled to the housing 102 by any suitable means that can maintain the hazardous rating integrity of the enclosure 100, such as by mating threads or by bolting a flange (not shown) on the filter holder 130 to the housing 102. The filter holder 130 houses a sintered filter 160. In certain embodiments, the filter holder 130 and the sintered filter 160 are two separate pieces. In certain embodiments, the sintered filter

160 is sealed within the filter holder 130. In certain alternative embodiments, the filter holder 130 and the sintered filter 160 are integrated into a single sintered filter system. The filter holder 130 extends outwardly from the top wall 102a and has a constant sectional area. In certain embodiments, the filter holder 130 is cylindrically-shaped as shown in Figures 1, 2, and 4. In certain alternative embodiments, the filter holder 130 has a variable sectional area from an end adjacent to the enclosure 102 to an opposite end. The size and shape of the filter holder 130 and the filter 160 can be configured based on the amount of air flow desired.

[0025] Figure 4 is a cross-sectional view of the explosion-proof enclosure 100 according to an exemplary embodiment. The filter holder 120 includes a sintered filter 150 positioned therein and the filter holder 130 includes a sintered filter 160 positioned therein. The sintered filters 150, 160 can be sealed within the filter holders 120, 130 to maintain the hazardous rating integrity of the enclosure 100. The exemplary sintered filters 150, 160 are shaped substantially similar to an elliptic paraboloid. The sintered filters 150, 160 have a thickness that is substantially uniform throughout. In certain embodiments, the sintered filters 150, 160 have a thickness of about one inch. The thickness of the sintered filters 150, 160 can vary as long as the path length of the apertures, or channels, within (described in detail with respect to Figure 6) is approximately one inch.

[0026] The filter holder 130 also includes a fan 420 positioned within the housing 102 and proximate to the sintered filter 160. The fan 420 can be powered by an internal power source, such as a battery (not shown), or receive power from a source (not shown) external to the enclosure 100. The fan 420 forces heated air from within the housing 102 through the sintered filter 160 to the atmosphere. The displacement of air from the enclosure 100 to the atmosphere by the fan 420 also forces cooled air from the atmosphere into the housing 102 via the sintered filter 150. The cooled air from the atmosphere enters the housing 102, is heated by the heat produced from the automation equipment 110, and exits through the sintered filter 160.

[0027] In certain alternative embodiments, the fan 420 may be positioned proximate the sintered filter 150 and force cooled air into the housing 102 from the atmosphere and thus result in a displacement of hot air via sintered filter 160. In another embodiment, the fan 420 may be proximate the sintered filter 160 while a second fan (not shown) may be included and proximate the sintered filter 150. In yet another embodiment, the fan 420 may be located outside of the housing 102 on either side of filters 150, 160. In yet another embodiment, the fan 420 may not be present. The warm air inside of the enclosure 100 rises and exits through the filter 160, thus drawing cool air from the atmosphere into the enclosure 100 via filter 150.

One having ordinary skill in the art will recognize that any number of configurations having a fan are possible.

[0028] In certain embodiments, the enclosure 100 may include a control system 450 for monitoring and controlling a cooling element, such as the fan 420. In alternative embodiments, the control system 450 monitors and controls a heating element. The control system 450 generally includes a sensor (not shown) that is coupled to a controller (not shown) that controls the heating or cooling element. The sensor actively or passively monitors conditions within the enclosure 100. Based on the conditions within the enclosure 100, the controller can turn on or off the heating or cooling element. For example, the sensor may be a temperature gauge that senses the temperature within the enclosure 100. When the sensor indicates that the temperature within the enclosure 100 is too high, the controller turns on the fan 420. Similarly, when the sensor indicates that the temperature within the enclosure 100 is low, the controller can turn on a heating element to heat the air within the enclosure 100. In some embodiments, the control system 450 cycles on and off passively. For example, the control system 450 can cycle such that the heating or cooling element is active for ten minutes every thirty minutes. In certain embodiments, the control system 450 includes a sensor capable of detecting humidity changes within the enclosure 100. If the sensor detects that the relative humidity within the enclosure 100 is too high, the control system 450 can turn on the fan 420 to facilitate air displacement from within the enclosure 100 to the exterior of the enclosure 100. In certain other embodiments, the control system 450 includes a sensor capable of determining whether an explosion has occurred by detecting a rapid temperature or pressure change. Upon detection of an internal explosion, the sensor communicates the state change to the controller which communicates the state change to a local indicator (not shown) or wirelessly to a remote location. One having ordinary skill in the art will recognize that the control system 450 can be programmed any number of ways to meet specifications of a given area and include any number or type of sensors to determine various states within the enclosure 100. In certain embodiments, the control system 450 is controlled wirelessly by a user in a remote location.

[0029] Figure 5 is a sectional view of a sintered filter 500 that can be used as sintered filters 150, 160 according to an exemplary embodiment. The sintered filter 500 has a substantially parabolic cross-section. The sintered filter 500 includes substantially linear channels 510 extending therethrough. The channels 510 have a length of about one inch and a pore size of about 38.1 microns. In certain alternative embodiments, the channels 510 have a pore size of about 101.6 microns. The sintered filter 500 has a thickness T1 of about one

inch. In certain embodiments, the sintered filters 500 can withstand at least 560 pounds per square inch (psi) without fracturing or distorting.

[0030] Figure 6 is a sectional view of a sintered filter 600 that can be used as sintered filters 150, 160 according to an exemplary embodiment. The sintered filter 600 has a substantially parabolic cross-section. The sintered filter 600 includes channels 610 randomly extending therethrough. Each channel 610 has a length of about one inch and a pore size of about 38.1 microns. As such, the sintered filter 600 has a thickness T2 that may be less than about one inch. In certain alternative embodiments, each channel 610 has a pore size of about 101.6 microns. In certain embodiments, the sintered filter 600 can withstand at least 560 pounds per square inch (psi) without fracturing or distorting.

[0031] In alternative embodiments, sintered filters of the present invention may have channels that follow a curved, parabolic, helical, or other suitable path. Generally, the sintered filters of the present invention are designed based on controlling size and geometry of free volumes within the sintered filters, in other words, controlling pore size, and relating this pore size to the channels length. The sintered filters of the present invention may have any shape. The shape dictates the amount of airflow therethrough, and the directly correlates to the cooling performance of the sintered filters. A person having ordinary skill in the art and the benefit of this disclosure will recognize that the sintered filters of the present invention may include a number of channels having varying configurations to meet hazardous location requirements.

[0032] The sintered filters 500, 600 can be fabricated from any material that can withstand the dynamic effects of explosions without permanent distortion or damage. Suitable examples of sinter materials include, but are not limited to, ceramics, copper, glass, aluminum, stainless steel, other metal alloys such as austenitic nickel-based superalloys, reactive materials such as titanium, and thermally conductive polymers. The sintered filters 500, 600 are designed to allow air flow therethrough. In certain embodiments, the sintered filters 500, 600 are fabricated from a thermally conductive material and have a sufficient channel configuration (e.g. length, diameter) to arrest a flame so as to contain any explosion within the housing 102.

[0033] In an exemplary embodiment, the sintered filters 500, 600 can be produced using rapid prototyping, and more particularly, rapid manufacturing. As used herein, the terms “rapid prototyping” and “rapid manufacturing” refer to any technique related to the automated construction of physical objects using solid freeform fabrication. A particular time frame for fabrication is not implied by the terms. Suitable methods of manufacturing the

exemplary sintered filters 500, 600 include, but are not limited to, Laser Engineered Net Shaping TM (LENS), or laser fusing, developed by Sandia National Laboratories, and Selective Laser Sintering TM (SLS) developed by 3D Systems, Inc. Fuse deposition techniques, combined with computational fluid dynamics, can allow accurate depositing of materials to create a sintered filter such that the creation of channels within the sintered filter can be controlled. The size and shape of these channels can be controlled as desired to produce a desired length and pore size for each flame path to adequately suppress a flame while providing the desired airflow therethrough.

[0034] The sintered filters of the present invention also can be produced by pressing together sinter material, such as small bronze balls about 200 microns in diameter or stainless steel flakes, in a die to form a substantially circular, square, or rectangular component. The component is then heated to a temperature below the actual melting point of the material but at a high enough temperature to allow the sinter particles to fuse together. The sinter particles fuse together in the areas where they are in contact with each other. Ultimately, the fused sinter particles form a matrix of channels within the component, thus forming a sintered element.

[0035] Figure 7 is a cross-sectional view of an explosion-proof enclosure 700 according to an alternative exemplary embodiment. The enclosure 700 differs from the enclosure 100 in that the enclosure 700 utilizes cylindrical-shaped sintered filters 750, 760 instead of filters 150, 160, and is ducted to prevent water from entering the enclosure 700. The enclosure 700 includes a housing 702 similar to the housing 102 of the enclosure 100. The housing 702 includes a top wall 702a, a bottom wall 702b, two side walls 702c, and a rear wall 702d. The enclosure 700 also includes automation equipment 110 positioned within the housing 702 and coupled to the rear wall 702d.

[0036] The enclosure 700 includes a filter holder 720 coupled to the housing 702. The filter holder 720 may be coupled to the housing 702 by any suitable means to maintain a seal. The filter holder 720 houses a sintered filter 750, further described below. The filter holder 720 extends outwardly from the bottom wall 702b and has a constant cross-sectional area. In certain embodiments, the filter holder 720 is cylindrically-shaped as shown. In certain alternative embodiments, the filter holder 720 has a variable cross-sectional area.

[0037] The enclosure 700 further includes another filter holder 730 coupled to the housing 702. The filter holder 730 may be coupled to the housing 702 by any suitable means that can maintain the hazardous rating integrity of the enclosure 100. The filter holder 730 houses a sintered filter 760, further described below. The filter holder 730 extends outwardly

from the top wall 702a and has a constant sectional area. In certain embodiments, the filter holder 730 is cylindrically-shaped as shown in Figure 7. In certain alternative embodiments, the filter holder 730 has a variable sectional area from an end adjacent to the enclosure 700 to an opposite end.

[0038] The sintered filters 750, 760 are substantially cylindrically-shaped. The sintered filters 750, 760 have a thickness that is substantially uniform throughout. In certain embodiments, the sintered filters 750, 760 have a thickness of about one inch. In certain embodiments, the thickness of the sintered filters 750, 760 is based on the flame arresting properties desired. The thickness of the sintered filters 750, 760 can vary as long as the path length of the apertures within is sufficient to dissipate the desired amount of heat. In certain embodiments, the path length of the apertures within is about one inch.

[0039] The filter holder 730 also includes a fan 420 proximate to the sintered filter 160 and positioned on the exterior of the housing 702. The fan 420 pulls heated air from within the housing 702 through the sintered filter 750 to the atmosphere. The displacement of air from the enclosure 700 to the atmosphere by the fan 420 also draws cooled air from the atmosphere into the housing 702 via the sintered filter 760.

[0040] In certain alternative embodiments, the fan 420 may be positioned proximate the sintered filter 760 and force cooled air into the housing 702 from the atmosphere and thus result in a displacement of hot air via sintered filter 750. In another embodiment, the fan 420 may be proximate the sintered filter 760 while a second fan (not shown) may be included and proximate the sintered filter 750. In yet another embodiment, the fan 420 may be located inside of the housing 702 on either side of filters 750, 760. In yet another embodiment, the fan 420 may not be present. The warm air inside of the enclosure 700 rises and exits through the filter 760, thus drawing cool air from the atmosphere into the enclosure 700 via filter 750. One having ordinary skill in the art will recognize that any number of configurations having a fan are possible.

[0041] In certain embodiments, the enclosure 700 includes a cylindrical tubing 770 coupled to filter holder 730, and is a NEMA 3, 4, or 9 compliant enclosure. The tubing 770 includes a bend 770b which aids in preventing water from entering the enclosure 700. The enclosure further includes a cylindrical tubing 780 coupled to filter holder 720. In certain alternative embodiments, the tubing 770, 780 can be coupled directly to the sintered filters 760, 750, respectively. The tubing 770, 780 provide ducting for the enclosure 700. In certain exemplary embodiments, the tubing 770, 780 are constructed from plastics, rubber, metals

such as aluminum, brass, and stainless steel, corrosion-free materials, or plated or painted materials.

[0042] Therefore, the present invention is well adapted to attain the ends and advantages mentioned, as well as those that are inherent therein. The particular exemplary embodiments disclosed above are illustrative only, as the present invention may be modified and practiced in different but equivalent manners apparent to a person having ordinary skill in the art and the benefit of the teachings herein. Having described some exemplary embodiments of the present invention, the use of alternate sintered filter configurations having channels related to length and pore size is within the purview of those in the art. Additionally, while the present application discusses elliptic paraboloid and cylindrically-shaped sintered filters, it is understood that a number of other geometric configurations, such as rectangular-shaped, may be used based on the air displacement properties desired and using the teachings described herein. In addition, the exemplary embodiments of the present invention may be used to actively displace cold air from within the enclosures to the atmosphere. Furthermore, while the present application discusses the inclusion of two sintered filters in an enclosure, it is understood that the enclosures may include a single sintered filter, or multiple sintered filters. In embodiments where a single sintered filter is included, a breather, or a drain, can be included to displace any condensation that accumulates within the enclosure. While numerous changes to the invention may be made by a person having ordinary skill in the art, such changes are encompassed within the spirit of this invention as defined by the appended claims. Furthermore, the details of construction or design shown herein do not limit the invention, other than as described in the claims below. It is therefore evident that the particular exemplary embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the present invention. The terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee.

What is claimed is:

1. An enclosure, comprising:
a housing having a first opening; and
a first sintered filter coupled to the first opening, wherein the first sintered filter allows air to pass therethrough.
2. The enclosure of claim 1, wherein the sintered filter comprises a thermally conductive material, and is capable of arresting a flame exiting the housing.
3. The enclosure of claim 1, further comprising a first filter holder, wherein the first sintered filter is positioned within the first filter holder.
4. The enclosure of claim 3, wherein the first filter holder is cylindrical-shaped and the first sintered filter is an elliptic paraboloid.
5. The enclosure of claim 1, further comprising a first fan positioned proximate the first sintered filter.
6. The enclosure of claim 5, further comprising a control system coupled to the first fan.
7. The enclosure of claim 1, further comprising a first tubing coupled to the first opening.
8. The enclosure of claim 1, further comprising a second opening in the housing.
9. The enclosure of claim 8, further comprising a second tubing coupled to the second opening.
10. The enclosure of claim 8, further comprising a second sintered filter coupled to the second opening, the second opening positioned on a wall different from the first opening.
11. The enclosure of claim 10, further comprising a second filter holder, wherein the second sintered filter is positioned within the second filter holder, and wherein the second filter holder is tapered.
12. The enclosure of claim 10, wherein the second sintered filter is an elliptic paraboloid.

13. The enclosure of claim 10, further comprising a second fan positioned proximate the second sintered filter.

14. The enclosure of claim 13, further comprising a control system coupled to the second fan.

15. An explosion-proof enclosure, comprising:
 - a housing having a first opening and a second opening, wherein the housing is configured for use in a hazardous area; and
 - a first air displacement system coupled to the first opening, wherein the first air displacement system allows displacement of air from within the housing to an exterior of the housing.
16. The enclosure of claim 15, wherein the first opening is positioned on a different side of the housing as the second opening.
17. The enclosure of claim 15, further comprising a fan positioned inside the housing proximate the first air displacement system or in an interior portion of the first air displacement on a side away from the housing.
18. The enclosure of claim 15, further comprising a fan positioned proximate the second opening inside the housing or in an interior portion of the second opening on a side away from the housing.
19. The enclosure of claim 15, wherein the first air displacement system comprises a first filter holder coupled to the housing about the first opening and a first sintered filter positioned within the first filter holder and sealed to the housing.
20. The enclosure of claim 15, wherein the second opening comprises a vent.
21. The enclosure of claim 15, further comprising a second air displacement system coupled to the second opening, wherein the second air displacement system allows air to pass therethrough.
22. The enclosure of claim 21, wherein the second air displacement system comprises a second filter holder coupled to the housing about the second opening and a second sintered filter positioned within the second filter holder and sealed to the housing.
23. The enclosure of claim 15, further comprising a heating or cooling element.
24. The enclosure of claim 23, further comprising a control system coupled the heating or cooling element.

25. An explosion-proof enclosure having active thermal management capabilities, comprising:

a housing having a first opening and a second opening;

a sintered filter system coupled to the first opening and sealed to the housing, wherein the sintered filter system allows air to pass therethrough;

an air displacement system coupled to the second opening and sealed to the housing, wherein the air displacement system allows air to pass therethrough;

a control system comprising a sensor and a controller, wherein the sensor is a temperature gauge; and

a heating or cooling element coupled to the controller and positioned inside the housing, wherein the heating or cooling element is operable by the control system.

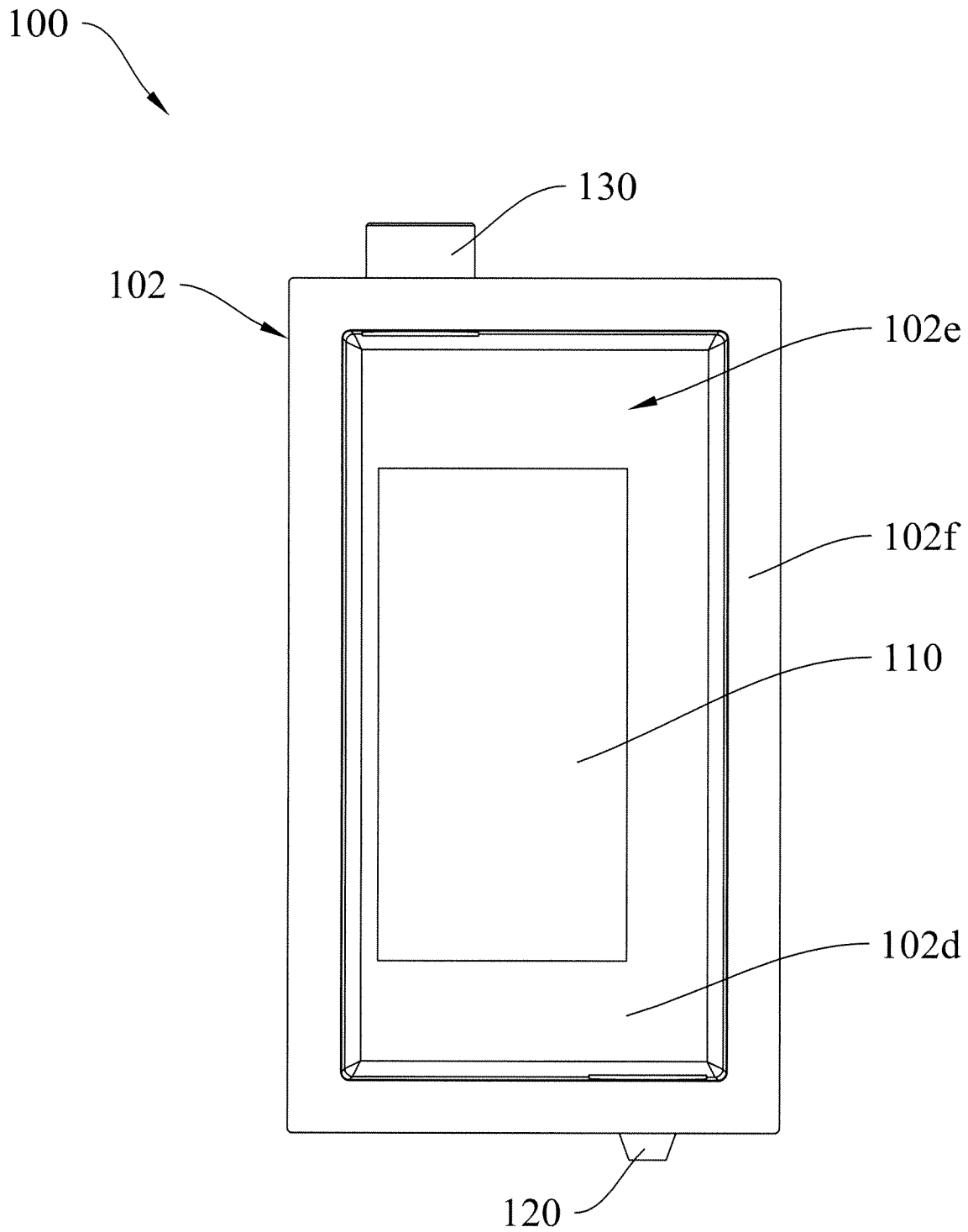


FIGURE 1

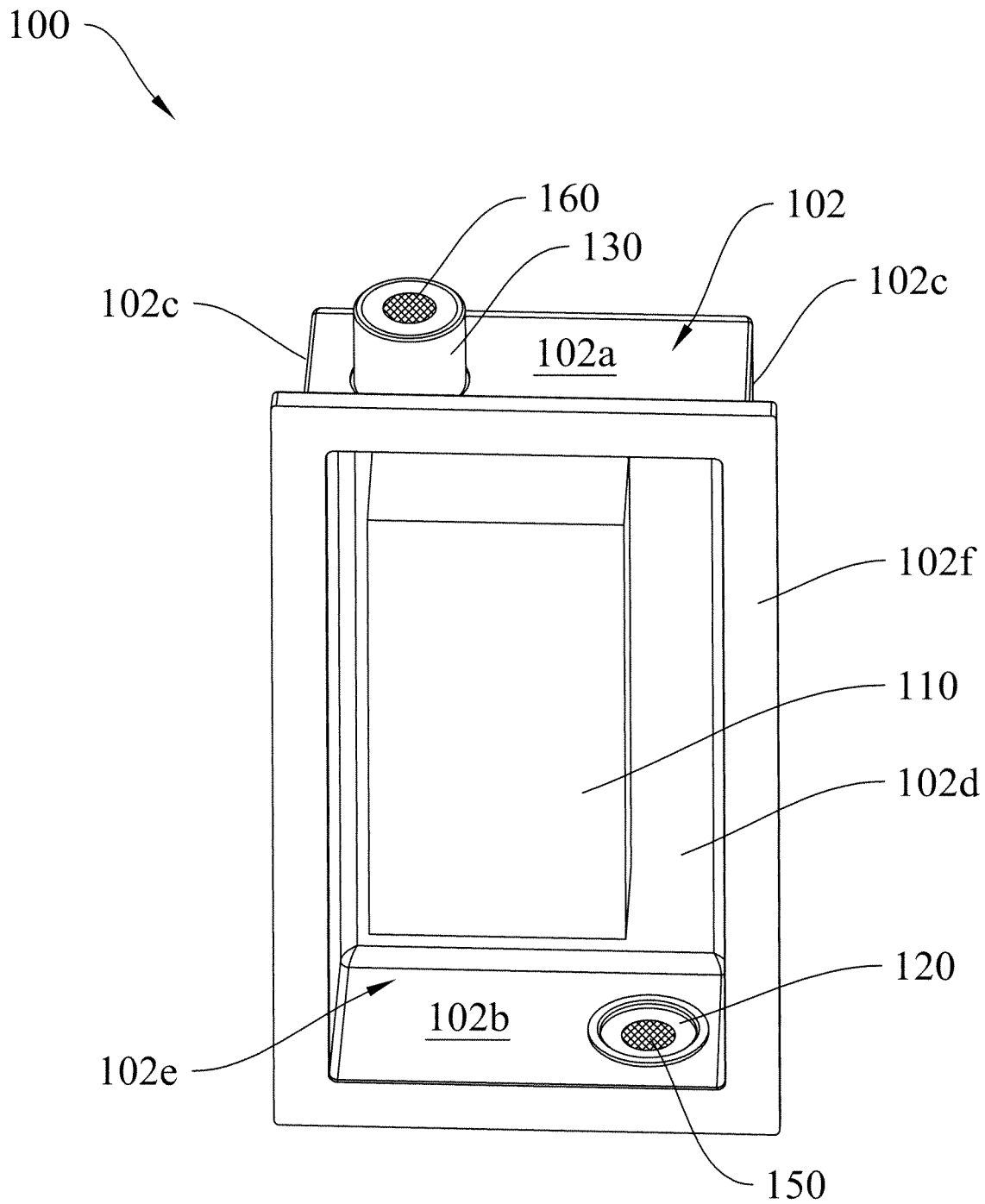


FIGURE 2

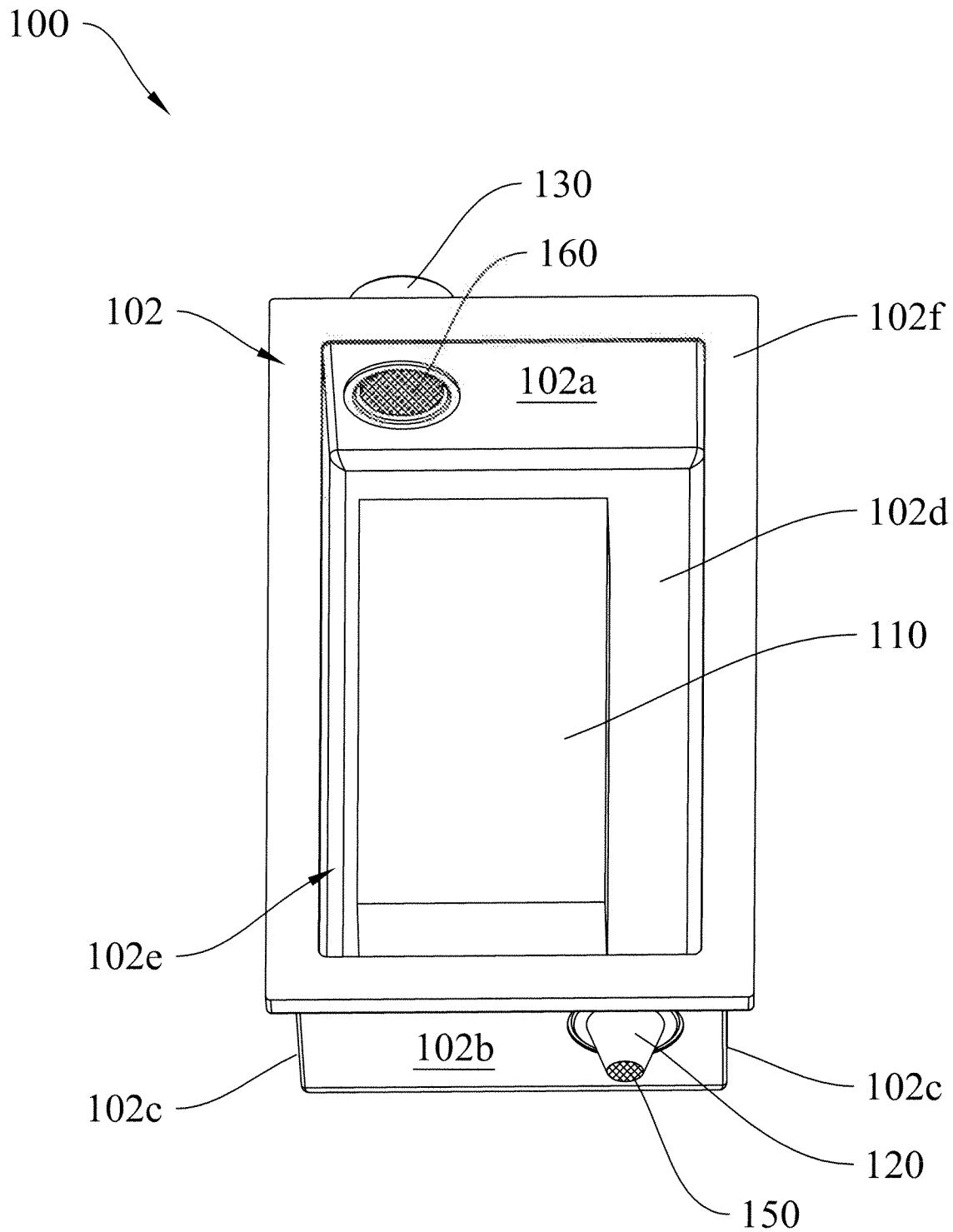


FIGURE 3

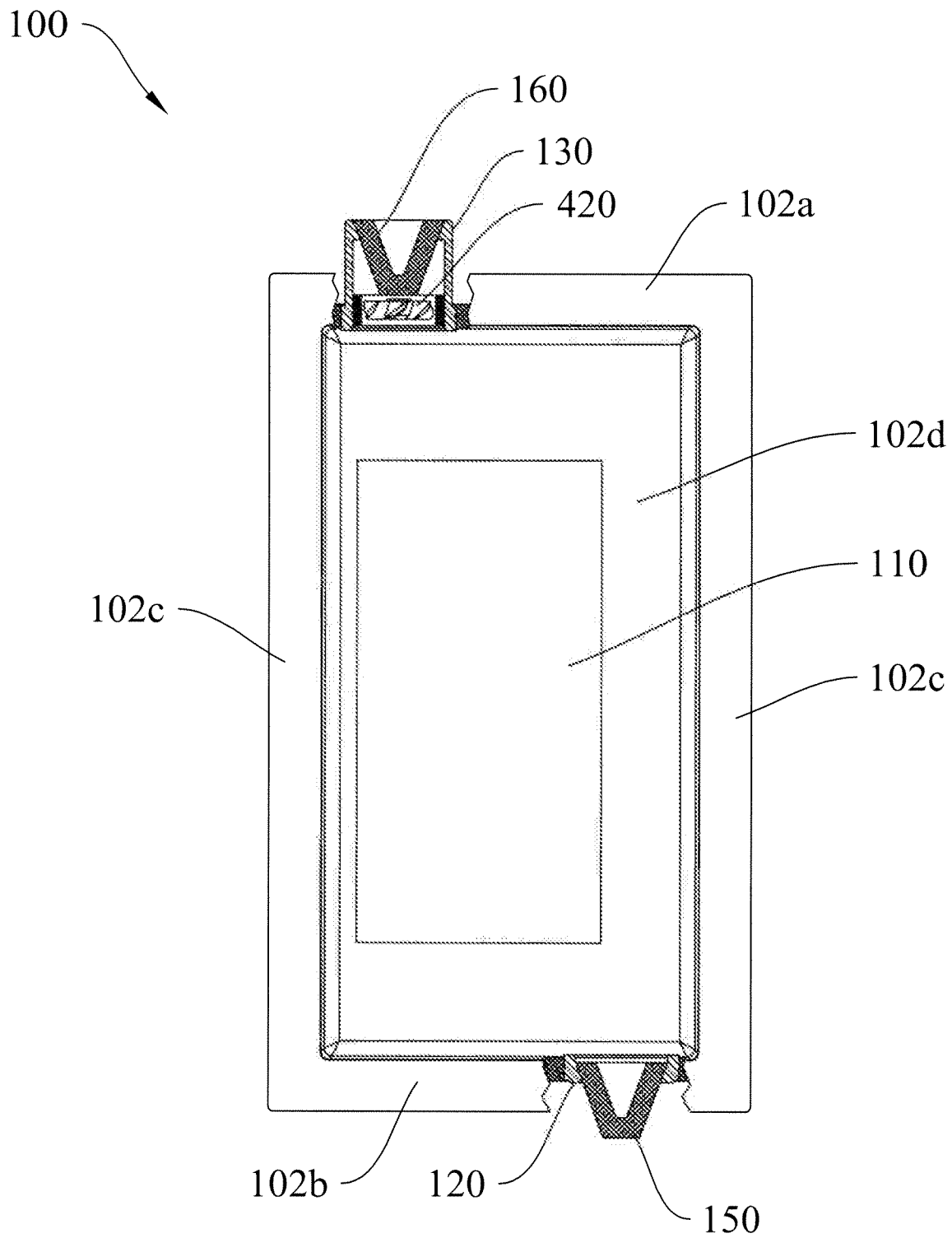


FIGURE 4

500

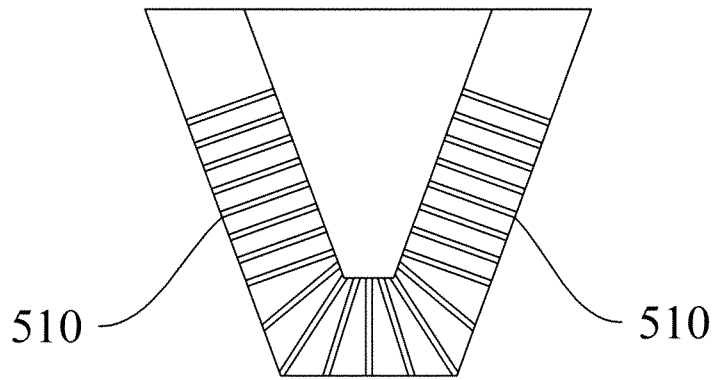


FIGURE 5

600

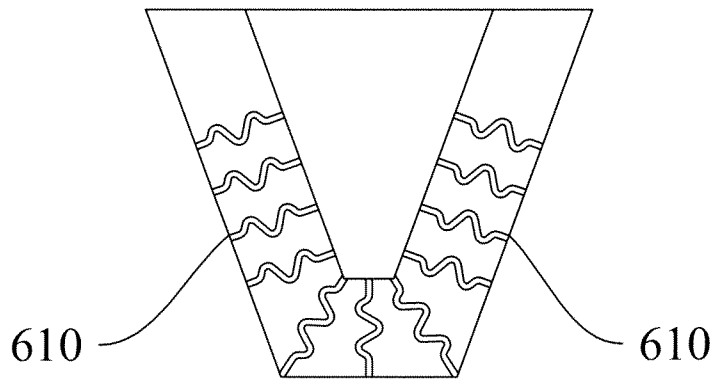


FIGURE 6

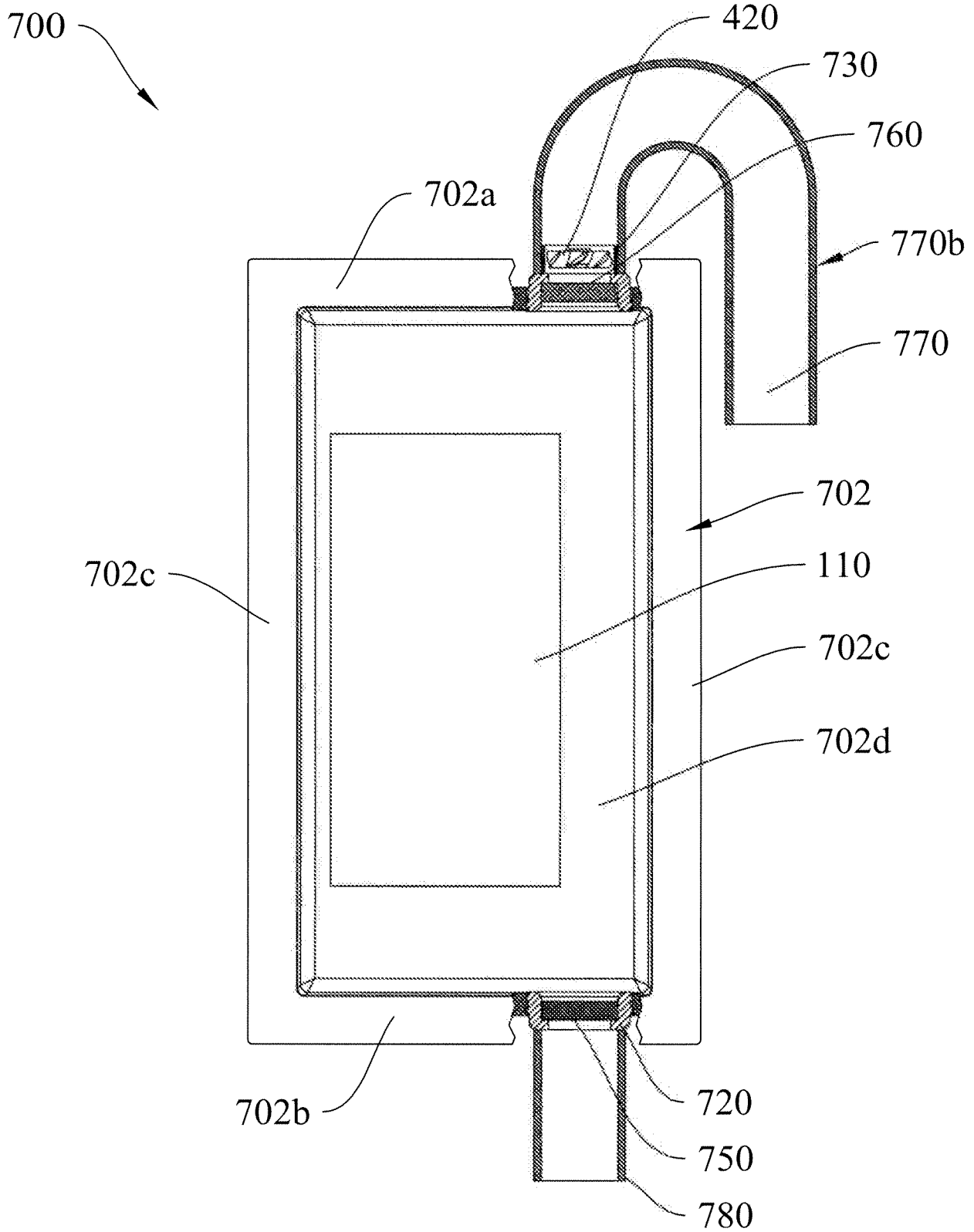


FIGURE 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/032961

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B65D 25/00 (2010.01)

USPC - 225/367.1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - B65D 23/00, 25/00 (2010.01)

USPC - 225/200, 367.1, 370

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase, Google Patents, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 6,469,303 B1 (SUN et al) 22 October 2002 (22.10.2002) entire document	1-4, 7-12 — 5-6, 13-25
Y	US 6,953,491 B2 (GOYETCHE) 11 October 2005 (11.10.2005) entire document	5-6, 13-25
A	US 4,484,690 A (NASH) 27 November 1984 (27.11.1984) entire document	1-25
A	US 2007/0119452 A1 (SCHUBERT) 31 May 2007 (31.05.2007) entire document	1-25

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search

24 June 2010

Date of mailing of the international search report

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