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Oxygen-activated heat releasing enclosure

Abstract

An oxygen-activated heat releasing enclosure includes an insulated shell with at least a first cutout portion, a second cutout portion, and a sealable opening that opens to a cavity of the oxygen-activated heat releasing enclosure. A transparent window, disposed within the first cutout portion, allows contents within the cavity to be visible from outside of the cavity. A heat releasing member, disposed within the second cutout portion, includes a powder chamber containing an oxygen-activated heat releasing powder. The powder chamber is formed by (i) an oxygen permeable membrane that allows oxygen to pass through the oxygen permeable membrane into the powder chamber and (ii) a thermally conductive membrane disposed between the oxygen permeable membrane and the transparent window. The oxygen-activated heat releasing enclosure also includes a sealing strip for sealing the sealable opening.

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Background/Summary

RELATED APPLICATIONS (1) This application is a non-provisional patent application of and claims priority to U.S. Provisional Application No. 63/094,713, filed 21 Oct. 2020, incorporated herein by reference.

FIELD OF THE INVENTION
(1) The present invention relates to an oxygen-activated heat releasing enclosure, and more particularly relates to an oxygen-activated heat releasing enclosure for heating a fluid container, such as a blood bag.
BACKGROUND
(2) When delivering fluids to a person intravenously, blood is often warmed from a storage temperature (e.g., 1-6° C.) to body temperature (e.g., 36-38° C.) so as to prevent hypothermia, acidosis and/or coagulopathy from occurring in the recipient of the fluids. Existing blood warmers have one or more shortcomings. Some warmers are expensive (costing hundreds or thousands of dollars), are bulky and/or require an electrical outlet for operation. Other warmers may inadvertently contaminate the blood with heavy metals or other impurities. Described herein is a heat releasing enclosure that can be used to warm blood (or other fluids) while avoiding the above-mentioned deficiencies of currently available blood warmers.
SUMMARY OF THE INVENTION
(3) In accordance with one embodiment of the invention, an oxygen-activated heat releasing enclosure may include an insulated shell with at least a first cutout portion, a second cutout portion, and a sealable opening that opens to a cavity of the oxygen-activated heat releasing enclosure. A transparent window, disposed within the first cutout portion, may allow contents within the cavity to be visible from outside of the cavity. A heat releasing member, disposed within the second cutout portion, may include a powder chamber containing an oxygen-activated heat releasing powder. The powder chamber may be formed by (i) an oxygen permeable membrane that allows oxygen to pass through the oxygen permeable membrane into the powder chamber and (ii) a thermally conductive membrane disposed between the oxygen permeable membrane and the transparent window. The oxygen-activated heat releasing enclosure may also include a sealing strip for sealing the sealable opening.
(4) In accordance with one embodiment of the invention, a fluid heating system may include a heat releasing enclosure. The heat releasing enclosure may include an insulated shell comprising at least a first cutout portion, a second cutout portion, a first and second opening that lead to a cavity of the heat releasing enclosure. A transparent window may be disposed within the first cutout portion. A heat releasing member, disposed within the second cutout portion, may comprise a powder chamber containing an oxygen-activated heat releasing powder. The powder chamber may be formed by (i) an oxygen permeable membrane that allows oxygen to pass through the oxygen

permeable membrane into the powder chamber and (ii) a thermally conductive membrane. The fluid heating system may also include a fluid receiving conduit that passes through the first opening, a fluid dispensing conduit that passes through the second opening, and a fluid container disposed within the cavity of the heat releasing enclosure. The fluid container may include an inlet that is fluidly connected to the fluid receiving conduit and an outlet that is fluidly connected to the fluid dispensing conduit.
(5) These and other embodiments of the invention are more fully described in association with the drawings below.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) The invention is now described, by way of example and without limiting the scope of the invention, with reference to the accompanying drawings which illustrate embodiments of it, in which:
(2) FIG. **1**A depicts a front view of a heat releasing enclosure, in accordance with one embodiment of the invention.
(3) FIG. **1**B depicts a back view of the heat releasing enclosure of FIG. **1**A, in accordance with one embodiment of the invention.
(4) FIG. **1**C depicts an oxygen impermeable sheet being peeled away from the heat releasing enclosure of FIG. **1**A, in accordance with one embodiment of the invention.
(5) FIG. **2**A depicts a perspective cross-sectional view of the heat releasing enclosure along line I-I of FIG. **1**A, in accordance with one embodiment of the invention.
(6) FIG. **2**B depicts an alternative embodiment of the heat releasing enclosure, in which multiple heat releasing members are employed, in accordance with one embodiment of the invention.
(7) FIG. **3** depicts, in dashed line, an electrically powered heating element that is disposed within a heat releasing enclosure, in accordance with one embodiment of the invention.
(8) FIG. **4**A depicts a front view of a heat releasing enclosure with a fluid container (e.g., a blood bag) being inserted into a cavity thereof, in accordance with one embodiment of the invention.
(9) FIG. **4**B depicts a front view of a heat releasing enclosure with a fluid container fully inserted therein, in accordance with one embodiment of the invention.
(10) FIG. **4**C depicts a back view of a heat releasing enclosure with a fluid container fully inserted therein, and further depicts an oxygen impermeable sheet being peeled away from the heat releasing enclosure, in accordance with one embodiment of the invention.
(11) FIG. **4**D depicts a front view of a heat releasing enclosure, in which the heat releasing enclosure (with the fluid container inserted therein) is mounted on a hanging mechanism, in accordance with one embodiment of the invention.
(12) FIGS. **4**E-**4**H illustrate an alternative method and mechanism for sealing the heat releasing enclosure, in accordance with one embodiment of the invention.
(13) FIG. **5**A depicts a first method of dispensing fluid from a heated fluid container, in which a person uses his/her hands to apply pressure to a heat releasing enclosure, in accordance with one embodiment of the invention.
(14) FIG. **5**B depicts a second method of dispensing fluid from a heated fluid container, in which an elastic band, which tightly encircles the heat releasing enclosure, is used to apply pressure to a heat releasing enclosure, in accordance with one embodiment of the invention.
(15) FIGS. **5**C and **5**D illustrate additional details regarding how the elastic band is attached to the heat releasing enclosure, in accordance with one embodiment of the invention.
(16) FIG. **5**E depicts a third method of dispensing fluid from a heated fluid container, in which a pump is used to pump fluid from the heated fluid container, in accordance with one embodiment of

the invention.
(17) FIG. **6**A depicts a front view of a fluid heating system configured to receive a fluid, warm the fluid and then dispense the warmed fluid, in accordance with one embodiment of the invention.
(18) FIG. **6**B depicts a perspective cross-sectional view of the fluid heating system along line II-II of FIG. **6**A, in accordance with one embodiment of the invention.
(19) FIG. **6**C depicts a front view of an alternative embodiment of the fluid heating system of FIG. **6**A, in which the fluid heating system is configured to simultaneously receive fluid from a plurality of fluid containers, in accordance with one embodiment of the invention.
DETAILED DESCRIPTION OF THE INVENTION
(20) In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration specific embodiments in which the invention may be practiced. It is understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention. Descriptions associated with any one of the figures may be applied to different figures containing like or similar components/steps.
(21) FIG. **1**A depicts a front view of heat releasing enclosure **100**. Heat releasing enclosure **100** may include insulated shell **102**, which may be constructed from a light weight material, such as foil that is padded with a layer of bubble wrap or other insulating material and/or coated with a heat reflecting film (e.g., polyimide). Insulated shell **102** (in combination with other components) may enclose cavity **202** (visible in the perspective cross-sectional view of FIG. **2**A), which may be accessed through opening **104**.
(22) Sealing strip **106** may be used to seal opening **104** in a manner similar to how an envelope is sealed, in which two surfaces are pressed together to form a seal. The seal may be a permanent seal, such that once the two surfaces are pressed together, they may not be separated again without tearing one or more of the surfaces. Alternatively, the seal may be a temporary seal, such that once the two surfaces are pressed together, they may be pulled apart without destroying or deforming the two surfaces. A temporary seal may be formed using an adhesive, such as that used in painter's tape or a Post-it®. Alternatively, a temporary seal may be formed using a fastener, such as a Velcro® fastener, a Ziploc® press and seal fastener, a zipper, buttons, etc. If not already apparent, the use of dashed lines to illustrate sealing strip **106** indicates that the sealing strip may not be visible in the front view of heat releasing enclosure **100**. Rather, sealing strip **106** may be located on an inner surface of insulated shell **102** (i.e., surface that faces cavity **202**) that is adjacent to opening **104**.
(23) Heat releasing enclosure **100** may include transparent window **108**, which allows the contents within cavity **202** to be visible from outside of cavity **202**. Transparent window **108** may be formed using a clear plastic sheet. As should be apparent, transparent window **108** may be disposed within a cutout of insulated shell **102** with shape/dimensions substantially similar to those of transparent window **108**. While transparent window **108** has been depicted so that almost the entirety of cavity **202** is visible from outside of the cavity, the size of transparent window **108** may be decreased for increased heat insulation. FIG. **2**B depicts an alternative embodiment with reduced dimensions of transparent window **108**.
(24) Insulated shell **102** may also include hole **110** (or other component that allows heat releasing enclosure **100** to be mounted on a stand or wall) along a peripheral portion of insulated shell **102**. Hole **110** may be used to hang heat releasing enclosure on a hook (or other hanging mechanism), as shown in FIG. **4**D. Preferably, hole **110** does not penetrate into cavity **202** so as to minimize heat loss from cavity **202**.
(25) FIG. **1**B depicts a back view of heat releasing enclosure **100**. Heat releasing enclosure **100** may include tab **114** (or “pull tab”) for peeling oxygen impermeable sheet **116** away from heat releasing enclosure **100** (as later depicted in FIG. **1**C). Oxygen impermeable sheet **116** is present prior to the “activation” of heat releasing enclosure **100**, and prevents oxygen from activating a heat releasing powder within heat releasing enclosure **100**. The process of activating heat releasing

enclosure **100** will be discussed below in FIG. **1**C.

(26) Heat releasing enclosure **100** may include temperature indicator **118** (e.g., a digital temperature indicator) which may indicate a temperature measured by temperature sensor **119** that is disposed within cavity **202**. If not already apparent, the use of dashed line indicates that temperature sensor **119** and the wires that communicatively couple temperature sensor **119** to temperature indicator **118** and/or temperature alarm **117** may not be visible in the back view of heat releasing enclosure **100**. Typically, when in use, temperature sensor **119** contacts a fluid container within cavity **202**, so temperature sensor **119** approximately measures the temperature of the fluid contained within the fluid container. However, as the temperature of the fluid container may not be exactly equal to the temperature of the fluid within the fluid container (e.g., due to insulative properties of the fluid container), temperature indicator **118** may only indicate an approximate temperature (rather than an exact temperature) of the fluid within the fluid container. While not depicted, it is also possible for a color changing thermometer strip to perform the functions of both temperature indicator **118** and temperature sensor **119**. Such a color changing thermometer strip may be located on a surface within cavity **202** that is visible through transparent window **108**.

(27) Temperature sensor **119** may also be communicatively coupled to temperature alarm **117** that transmits an alarm signal if the temperature measured by temperature sensor **119** deviates outside of a desired range (e.g., 95-105° F.). The alarm signal may be a visual alarm, such as for example the display of a particular color of light (e.g., red light), the display of light in a particular fashion (e.g., flashing light), etc. Alternatively, or in addition, the alarm signal may be transmitted using sound. If the temperature of heat releasing enclosure **100** exceeds the desired range, opening **104** may be unsealed so as to release heat from the cavity **202**. If the temperature of heat releasing enclosure **100** falls below the desired range, additional heat sources (as will be later described) may be activated within heat releasing enclosure **100** to raise the temperature back within the desired range. If additional heat sources are not available, the temperature falling below the desired range may indicate that the useful lifetime of heat releasing enclosure **100** has been reached.

(28) FIG. **1**C depicts a process of activating heat releasing enclosure **100** by peeling oxygen impermeable sheet **116** away from heat releasing enclosure **100**. The removal of oxygen impermeable sheet **116** allows oxygen (and other constituents of air) to penetrate oxygen permeable membrane **120** (e.g., made of Tyvek® manufactured by DuPont de Nemours, Inc.™ of Wilmington, DE). The oxygen from air then exothermically reacts with a heat releasing powder within heat releasing enclosure **100**, causing heat to be released within cavity **202**. The location of the heat releasing powder is described in more detail in FIG. **2**A. If not already apparent, oxygen permeable membrane **120** may be located within another cutout of insulated shell **102**. The shape/dimensions of oxygen permeable membrane **120** may substantially match the shape/dimensions of the corresponding cutout of insulated shell **102**.

(29) Prior to the separation of oxygen impermeable sheet **116** from heat releasing enclosure **100**, oxygen impermeable sheet **116** may be secured to insulated shell **102** and/or to oxygen permeable membrane **120** by a weakly bonding adhesive. As a result, oxygen impermeable sheet **116** may be peeled away from heat releasing enclosure **100** without tearing oxygen permeable membrane **120**. The dimensions of oxygen impermeable sheet **116** may substantially equal (or be slightly larger) than the dimensions of oxygen permeable membrane **120** in order to prevent air from contacting any portion of oxygen permeable membrane **120**. In another embodiment, it is also possible for oxygen impermeable sheet **116** to be formed by a portion of insulated shell **102** (i.e., this embodiment assumes that insulated shell **102** is oxygen impermeable) with perforations all along the perimeter of oxygen impermeable sheet **116**. In such an embodiment, tab **114** may be used to tear off a portion of insulated shell **102** so as to expose oxygen permeable membrane **120**.

(30) FIG. **2**A depicts a perspective cross-sectional view of heat releasing enclosure **100** along line I-I of FIG. **1**A. Visible in the perspective cross-sectional view is cavity **202**, which is formed by the combination of insulated shell **102**, transparent window **108**, and heat releasing member **212**. As

will be described in FIGS. **4**A and **4**B below, a fluid container (e.g., a blood bag) may be placed in cavity **202** when heat releasing enclosure **100** is in use.

(31) Heat releasing member **212** includes powder chamber **204** which is formed in the space between oxygen permeable membrane **120** and thermally conductive membrane **208**. Powder chamber **204** may contain a heat releasing powder **206** that includes a mixture of iron particles, salt, vermiculite and activated carbon (e.g., charcoal). When oxygen reacts with the iron particles, the iron particles are transformed into iron oxide, and at the same time, heat is released. Salt is used as a catalyst to speed up the reaction of iron with oxygen. In operation, heat is transferred to the fluid container primarily through the heat transfer mechanism of conduction, in which heat passes from thermally conductive membrane **208** directly to the fluid container, or from thermally conductive membrane **208** to air inside cavity **202** and from the air to the fluid container.

(32) If not already apparent, thermally conductive membrane **208** may also be oxygen impermeable, so that oxygen inside cavity **202** does not penetrate thermally conductive membrane **208** and prematurely activate heat releasing powder **206**. In some embodiments, it is possible that the temperature of heat releasing powder **206**, once activated, exceeds that of the desired temperature range within cavity **202**. In such cases, the thermal conductivity of thermally conductive membrane **208** may need to be chosen to have a lower value, so that the temperature within cavity **202** increases more gradually. In some embodiments, if heat releasing member **212** is "scalding hot", it may be necessary to place a piece of insulative material between heat releasing member **212** and the fluid container so as to prevent heat releasing member **212** from overheating portions of the fluid bag.

(33) FIG. **2**B depicts heat releasing enclosure **210**, in which multiple heat releasing members are employed. In addition to heat releasing member **212***a* (which is similar to heat releasing member **212** of FIG. **2**A), heat releasing enclosure **210** includes heat releasing member **212***b*. While not depicted in FIG. **2**B, it is understood that prior to activation, an oxygen impermeable sheet (similar to that depicted in FIGS. **1**B and **1**C) may cover oxygen permeable membranes **120***a* and **120***b* to prevent the premature activation of heat releasing members **212***a* and **212***b*. During use, one or more of heat releasing members **212***a* and **212***b* may be activated at the same time or in a staggered manner (i.e., one after another). For instance, heat releasing member **212***a* may be activated first, and once the heat output from heat releasing member **212***a* starts to decrease, heat releasing member **212***b* may then be activated in order to sustain the heat output. Due to the presence of heat releasing member **212***b*, transparent window **108** of heat releasing enclosure **210** has reduced dimensions, as compared to transparent window **108** of heat releasing enclosure **100**. While two heat releasing members are illustrated in FIG. **2**B, it is understood that two or more two heat releasing members may be present in a single heat releasing enclosure.

(34) FIG. **3** depicts an optional electrically powered heating element **304** of heat releasing enclosure **300** that may be included in addition to heat releasing member **212**. Heating element **304** is depicted in dashed line because it is present within heat releasing enclosure **300** and may not be visible in either the front or back view of heat releasing enclosure **300**. (It is understood that FIG. **3** corresponds to the back view of heat releasing enclosure **300**; the front view of heat releasing enclosure **300** is substantially similar to that depicted in FIG. **1**A, so it is not shown for conciseness.) In one embodiment, heating element **304** may be located adjacent to thermally conductive membrane **208**. More specifically, heating element **304** may be located on the surface of thermally conductive membrane **208** facing cavity **202**, or may be located on the surface of thermally conductive membrane **208** facing away from cavity **202**. In the latter case, heating element **304** may be located within powder chamber **204**. It is also possible for heating element **304** to be embedded within thermally conductive membrane **208** (very much like how a heating element is embedded within an electric blanket).

(35) Battery **302** may be used to power heating element **304**. To reduce the number of components (and hence the cost of heat releasing enclosure **100**), the pulling of tab **114** may simultaneously

activate heat releasing member **212** as well as electrically connect battery **302** to heating element **304**. For instance, prior to activation, a nonconductive membrane may separate one of the contacts of battery **302** from heating element **304**. In addition to peeling away oxygen impermeable sheet **116**, the pulling of tab **114** may simultaneously pull away the nonconductive membrane causing heating element **304** to be powered by battery **302**. While not depicted, it is also possible for an on/off switch to be used to turn on/off heating element **304**. In one use case, heat releasing member **212** may initially be used to heat cavity **202**. However, as the heat output from heat releasing member **212** starts to decrease, heating element **304** can be turned on so as to maintain the desired temperature within cavity **202**.

(36) FIGS. **4**A-**4**D depict a step-by-step process that illustrates how heat releasing enclosure **100** may be used to warm fluid contained within a fluid container (e.g., blood bag, IV bag) prior to the fluid being delivered to a patient. FIG. **4**A depicts a front view of heat releasing enclosure **100** with fluid container **400** (e.g., an intravenous bag, a blood bag) being inserted through opening **104** into cavity **202** of heat releasing enclosure **100**. Fluid **406** (e.g., water, normal saline, Ringer's lactate solution, red blood cells, plasma, albumin, volume expanders and fresh whole blood, etc.) may be contained within fluid container **400**. Fluid container **400** may be fluidly connected to fluid dispensing conduit **402** with valve **404** for regulating the flow of fluid through fluid dispensing conduit **402**. As shown in FIG. **4**A, heat releasing enclosure **100** may be sized so that fluid container **400** fits snugly within cavity **202**.

(37) FIG. **4**B depicts a front view of heat releasing enclosure **100** with fluid container **400** fully inserted therein. Once fluid container **400** has been fully inserted, sealing strip **106** may be used to seal cavity **202** (e.g., by pressing sealing strip **106** against opening flap **403** of heat releasing enclosure **100**). The seal created by sealing strip **106** serves two purposes. First, it prevents heat loss from cavity **202** once heat releasing member **212** has been activated. Second, it prevents fluid container **400** from falling out from heat releasing enclosure **100** when heat releasing enclosure **100** is inverted and hung on a hanging mechanism (as will be described in FIG. **4**D). While most of opening **104** is sealed by sealing strip **106**, it is noted that a small portion of opening **104** remains unsealed so as to permit fluid dispensing conduit **402** to protrude out of opening **104**.

(38) FIG. **4**C depicts a back view of heat releasing enclosure **100** with fluid container **400** fully inserted therein, and further depicts oxygen impermeable sheet **116** being peeled away to expose oxygen permeable membrane **120** to air. Once oxygen impermeable sheet **116** is peeled away, the fluid that is housed in heat releasing enclosure **100** starts to warm. To speed up the exothermic oxidation process, the air surrounding heat releasing enclosure **100** may be fanned (e.g., with a fan or with a person's hand). Once the fluid within fluid container **400** has reached the desired temperature, the warmed fluid may be delivered to a patient. If desired, hole **110** may be used to hang heat releasing enclosure **100** on a hanging mechanism **408** (e.g., a hook), as depicted in FIG. **4**D. It is noted that the precise sequence of steps may be varied. For instance, it is also possible to first activate the heat releasing enclosure (as shown FIG. **4**C) before inserting fluid container **400** into heat releasing enclosure **100** (as shown in FIG. **4**A).

(39) FIGS. **4**E-**4**H depicts an alternative method and mechanism to seal heat releasing enclosure **100**. FIG. **4**E depicts a front view of heat releasing enclosure **100** with sealing flaps **410***a* and **410***b* which may be folded down and pressed against sealing strips **412***a/b* in order to seal cavity **202** of heat releasing enclosure **100**. In contrast to sealing strip **106**, sealing strips **412***a/b* may be located and be visible on the outer surface of insulated shell **102**. Sealing flaps **410***a/b* may be spaced apart by gap **411** to allow for fluid dispensing conduit **402** to protrude from cavity **202** of heat releasing enclosure **100** (as will be more clearly shown in FIGS. **4**G and **4**H).

(40) In one embodiment, sealing strips **412***a/b* may be sticky strips that are exposed by peeling away a protecting film (not depicted). Alternatively, sealing strips **412***a/b* may be composed of one-half of a Velcro™ fastener (i.e., either the velvet surface or the surface with tiny-hooks that affixes onto the velvet surface). In the case of a Velcro™ fastener, the other half of the Velcro™ fastener

(not depicted) would be located on sealing flaps **410***a/b*. FIG. **4**F depicts a back view of heating releasing enclosure **100** in which fold line **414** may be visible. When the sealing operation is performed, sealing flaps **410***a/b* may be folded with respect to fold line **414**. FIG. **4**G depicts heat releasing enclosure **100** with a fluid container **400** inserted therein. FIG. **4**H depicts the heat releasing enclosure **100** after sealing flaps **410***a/b* have been folded downwards and pressed onto sealing strips **412***a/b*. As previously mentioned, gap **411** between sealing flaps **410***a/b* allows fluid dispensing conduit **402** to protrude out from cavity of **202** of heat releasing enclosure **100**.
(41) FIG. **5**A depicts a first method of dispensing fluid from heated fluid container **400**, in which a person uses his/her hands **500** to apply pressure to heat releasing enclosure **100**. The use of a person's hands to manually dispense the fluid from the heated fluid container may be less than optimal, but may be all that is available in certain circumstances (e.g., in a combat zone).
(42) FIG. **5**B depicts a second method of dispensing fluid from the heated fluid container **400**, in which an integrated elastic band **502** (i.e., an elastic band that is integrated with heat releasing enclosure **100**) is used to apply pressure to heat releasing enclosure **100**. In one embodiment, elastic band **502** may be an Esmarch® bandage. In operation, oxygen impermeable sheet **116** is first peeled away, before elastic band **502** is tightly wound around heat releasing enclosure **100**, causing pressure to be applied to heat releasing enclosure **100**, and in turn, to heated fluid container **400**. Perforations **504** may be present in elastic band **502** so as to allow air to penetrate through elastic band **502** and contact oxygen permeable membrane **120**. The use of elastic band **502** may also be less than optimal as the pressure applied to fluid container **400** may decrease over time, which may cause the rate at which fluid is dispensed to decrease over time. However, the use of elastic band **502** may be preferable to manually squeezing fluid from heated fluid container **400** (as in FIG. **5**A) in an environment where there is a shortage of medical professionals (e.g., in a combat zone). If there is only one medic available to treat a wounded soldier, the medic may use elastic band **502** to dispense a fluid (e.g., blood) from heated fluid container **400**, which frees the medic's hands to perform other lifesaving tasks (e.g., intubation).
(43) FIGS. **5**C and **5**D depict additional details regarding how elastic band **502** may be secured to insulated shell **102** of heat releasing enclosure **100**. FIG. **5**C depicts a back view of heat releasing enclosure **100** in which a first end of elastic band **502** may be permanently secured (e.g., by means of glue, sewing, etc.) or releasably secured (e.g., by a Velcro™ fastener) to first attaching area **506***a* on insulated shell **102**. FIG. **5**D depicts a front view of heat releasing enclosure **100** in which the second end of elastic band **502** may be releasably secured by a medic to second attaching area **506***b* on insulated shell **102**. The attachment means associated with second attaching area **506***b* may be a Velcro™ fastener, hooks, buttons, etc. For simplicity of illustration, the “wrapping” of the elastic band is shown in FIGS. **5**C and **5**D without a fluid container in the heat releasing enclosure, but it is understood that in the typical operation, a fluid container will be disposed in the heat releasing enclosure prior to the wrapping of the elastic band. If not already apparent, the non-stretched length, l, of elastic band **502** may be less than twice the width, w, of heat releasing enclosure **100** so that securing the second end of elastic band **502** to second attachment area **506***b* requires elastic band **502** to be stretched, which in turn applies pressure to heated fluid container **400**. In other words, elastic band **502** is wrapped around a periphery of insulated shell **102** in a taut manner.
(44) It is noted that when a medic takes heat releasing enclosure **100** out of a sterile package, the first end of elastic band **502** may already be secured to first attaching area **506***a*. Such “pre-assembly” prevents elastic band **502** from being accidentally dropped and lost on the floor/ground, as might otherwise occur in the chaotic and high pressure environment of a combat zone. It is also noted that elastic band **502** is an optional feature, as it might not be needed in all use cases, such as the use case described in FIG. **5**E below.
(45) FIG. **5**E depicts a third method of dispensing fluid from the heated fluid container **400**, in which pump **506** is used to pump fluid from heated fluid container **400**. Pump **506** may be battery powered (or powered by an electrical outlet) and may dispense fluid **406** from heated fluid

container **400** at a constant rate. In some instances, pump **506** is also configured to heat fluid **406**, so heat releasing enclosure **100** may serve to "pre-warm" the fluid from the original storage temperature to a mid-point temperature, before the heating mechanism of pump **506** is used to further warm the fluid from the mid-point temperature to the final desired temperature. The pre-warming of the fluid using heat releasing enclosure **100**, thus, is able to shorten the amount of time taken to warm the fluid from the original storage temperature to the final desired temperature. The third method of dispensing fluid may be more common in a hospital setting where pump **506** and an electrical source to power pump **506** are readily available.

(46) FIG. **6**A depicts a front view of fluid heating system **600** that is configured to receive a fluid, warm the fluid, and dispense the warmed fluid. In contrast to the embodiments depicted in the figures so far, fluid is transferred from fluid container **400** (i.e., a blood bag from a blood bank) to fluid container **602** that is located within a heat releasing enclosure similar to heat releasing enclosure **100**. Fluid container **602** may have dimensions larger than those of fluid container **400** so that the surface area of fluid container **602** is larger than that of fluid container **400**. A larger surface area permits more contact area between heat releasing member **212** and the fluid container **602** (as compared to heat releasing member **212** and fluid container **400**), which in turn increases the rate at which fluid can be warmed or heated.

(47) The construction of the heat releasing enclosure of fluid heating system **600** may be substantially similar to that of heat releasing enclosure **100**, except for an additional opening **611** to allow for the passage of fluid dispensing conduit **610**. Fluid container **602** may include inlet **604** that is fluidly connected to fluid receiving conduit **612**. Fluid may be transferred from fluid container **400** into fluid container **602** through fluid receiving conduit **612**. Conduit connectors **614** and **616** may be used to couple fluid receiving conduit **612** of fluid container **602** to fluid dispensing conduit **402** of fluid container **400**. Fluid container **602** may also include outlet **606** that is fluidly connected to fluid dispensing conduit **610**. A valve **608** may be present in fluid dispensing conduit **610** to control the flow of fluid out of fluid container **602**.

(48) FIG. **6**B depicts a perspective cross-sectional view of fluid heating system **600** along line II-II of FIG. **6**A. As shown, fluid container **602** may be disposed within cavity **202** of the heat releasing enclosure. One side of fluid container **602** may contact thermally conductive membrane **208** of heat releasing member **212** for increased heat transfer. As previously described, it is also possible for an insulating sheet (not depicted) to be disposed between thermally conductive membrane **208** and fluid container **602** so as to prevent heat releasing member **212** from over-heating certain portions of the fluid within fluid container **602**.

(49) FIG. **6**C depicts a front view of fluid heating system **620**, which is a variant of fluid heating system **600** depicted in FIG. **6**A. In fluid heating system **620**, fluid container **622** contains a plurality of inlets **604***a*-**604***c*, allowing fluid from multiple fluid containers **400***a*-**400***c* to be simultaneously delivered into fluid container **622**. While three inlets are depicted in FIG. **6**C, it is understood that two or more inlets may be present in practice. Inlet **604***a* is fluidly connected to fluid receiving conduit **612***a*, which is configured to receive fluid from fluid container **400***a*. Inlet **604***b* is fluidly connected to fluid receiving conduit **612***b*, which is configured to receive fluid from fluid container **400***b*. Similarly, inlet **604***c* is fluidly connected to fluid receiving conduit **612***c*, which is configured to receive fluid from fluid container **400***c*. Fluid heating system **620** illustrates another advantage of using a larger fluid container **622** (i.e., larger than that of a 500 cc or 1000 cc fluid container from a blood bank), in that the fluid from several fluid containers **400***a*-**400***c* can be warmed at the same time using a single heat releasing enclosure.

(50) While the discussion so far has described the heat releasing enclosure for the primary purpose of heating a fluid, other uses are possible. For instance, heat releasing enclosure **100** may be used as a heat pack for preventing hypothermia and/or thawing an initial or more severe frost-bit injury. It is noted that care should always be taken to avoid direct contact of skin with heat releasing member **212**, which could result in burns. Instead, skin should be covered with a barrier (e.g.,

clothes, gloves, socks, etc.) before placing the body part near heat releasing member **212**. If a body part (e.g., hands, feet, fingers, toes, etc.) fits within cavity **202**, the body part may be inserted within cavity **202**. If a body part (e.g., groin, axilla) does not fit within cavity **202**, the body part may be placed adjacent to oxygen permeable membrane **120**. While not previously mentioned, heat is also released from heat releasing member **212** through oxygen permeable membrane **120**, so a body part need not be placed within cavity **202** in order for that body part to be warmed.
(51) Another use for heat releasing enclosure **100** is to warm small mission critical equipment (e.g., portable pulse oximeter, a portable end-tidal CO.sub.2 monitor, digital thermometer, etc.) while operating in a cold environment (e.g., in the arctic, high mountains, etc.).
(52) Thus, an oxygen-activated heat releasing enclosure has been described. It is to be understood that the above-description is intended to be illustrative, and not restrictive. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

Claims

1. An oxygen-activated heat releasing enclosure, comprising: an insulated shell comprising at least a first cutout portion, a second cutout portion, and a sealable opening that opens to a cavity of the oxygen-activated heat releasing enclosure; a transparent window disposed within the first cutout portion, the transparent window allowing contents within the cavity to be visible from outside of the cavity; a heat releasing member disposed within the second cutout portion, the heat releasing member comprising a powder chamber containing an oxygen-activated heat releasing powder, the powder chamber formed by (i) an oxygen permeable membrane that allows oxygen to pass through the oxygen permeable membrane into the powder chamber and (ii) a thermally conductive membrane disposed between the oxygen permeable membrane and the transparent window; and a sealing strip for sealing the sealable opening.
2. The oxygen-activated heat releasing enclosure of claim 1, wherein the insulated shell includes a hole for receiving a hanging mechanism.
3. The oxygen-activated heat releasing enclosure of claim 1, wherein the cavity is configured to receive a container of fluid.
4. The oxygen-activated heat releasing enclosure of claim 3, further comprising an elastic band that is integrated with the oxygen-activated heat releasing enclosure, wherein the elastic band, when wrapped around the insulated shell, is configured to dispense a fluid contained in the container of fluid.
5. The oxygen-activated heat releasing enclosure of claim 3, further comprising a temperature indicator, configured to indicate an approximate temperature of a fluid contained within the container of fluid.
6. The oxygen-activated heat releasing enclosure of claim 3, further comprising a temperature alarm configured to transmit an alarm when an approximate temperature of a fluid contained within the container of fluid exceeds a threshold.
7. The oxygen-activated heat releasing enclosure of claim 1, further comprising an oxygen impermeable sheet that is attached to the oxygen permeable membrane prior to activation of the oxygen-activated heat releasing enclosure.
8. The oxygen-activated heat releasing enclosure of claim 7, further comprising: a battery; an electrically powered heating element; and a pull tab attached to the oxygen impermeable sheet and a non-conductive sheet separating the electrically powered heating element from a terminal of the battery, such that pulling of the pull tab simultaneously peels the oxygen impermeable sheet and electrically couples the electrically powered heating element with the battery.
9. The oxygen-activated heat releasing enclosure of claim 1, further comprising an electrically

powered heating element.
10. A fluid heating system, comprising: a heat releasing enclosure, comprising: an insulated shell comprising at least a first cutout portion, a second cutout portion, and a first and second opening that lead to a cavity of the heat releasing enclosure; a transparent window disposed within the first cutout portion; and a heat releasing member disposed within the second cutout portion, wherein the heat releasing member comprises a powder chamber containing an oxygen-activated heat releasing powder, the powder chamber formed by (i) an oxygen permeable membrane that allows oxygen to pass through the oxygen permeable membrane into the powder chamber and (ii) a thermally conductive membrane; and a first fluid receiving conduit that passes through the first opening; a fluid dispensing conduit that passes through the second opening; and a fluid container disposed within the cavity of the heat releasing enclosure, the fluid container comprising a first inlet that is fluidly connected to the first fluid receiving conduit and an outlet that is fluidly connected to the fluid dispensing conduit.
11. The fluid heating system of claim 10, further comprising: a second fluid receiving conduit that passes through the first opening, wherein the fluid container further comprises a second inlet that is fluidly connected to the second fluid receiving conduit.