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(54) **COLD WEATHER SUIT WITH VAPOR BARRIER AND HEAT RECOVERY**

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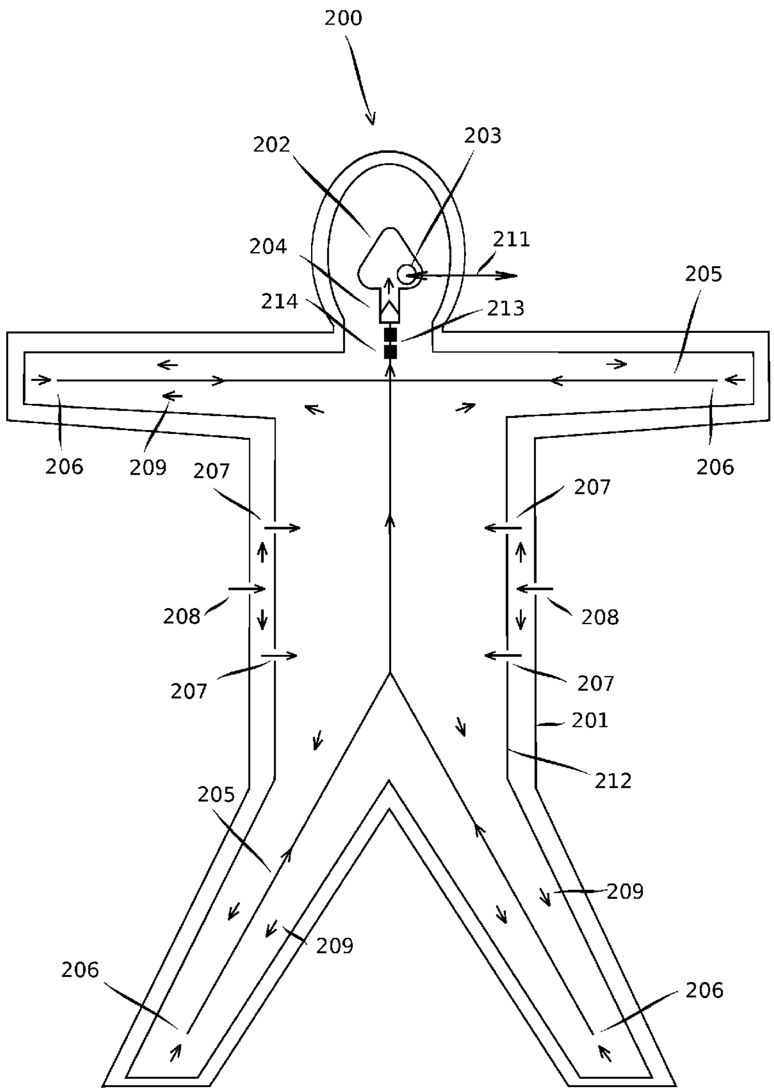
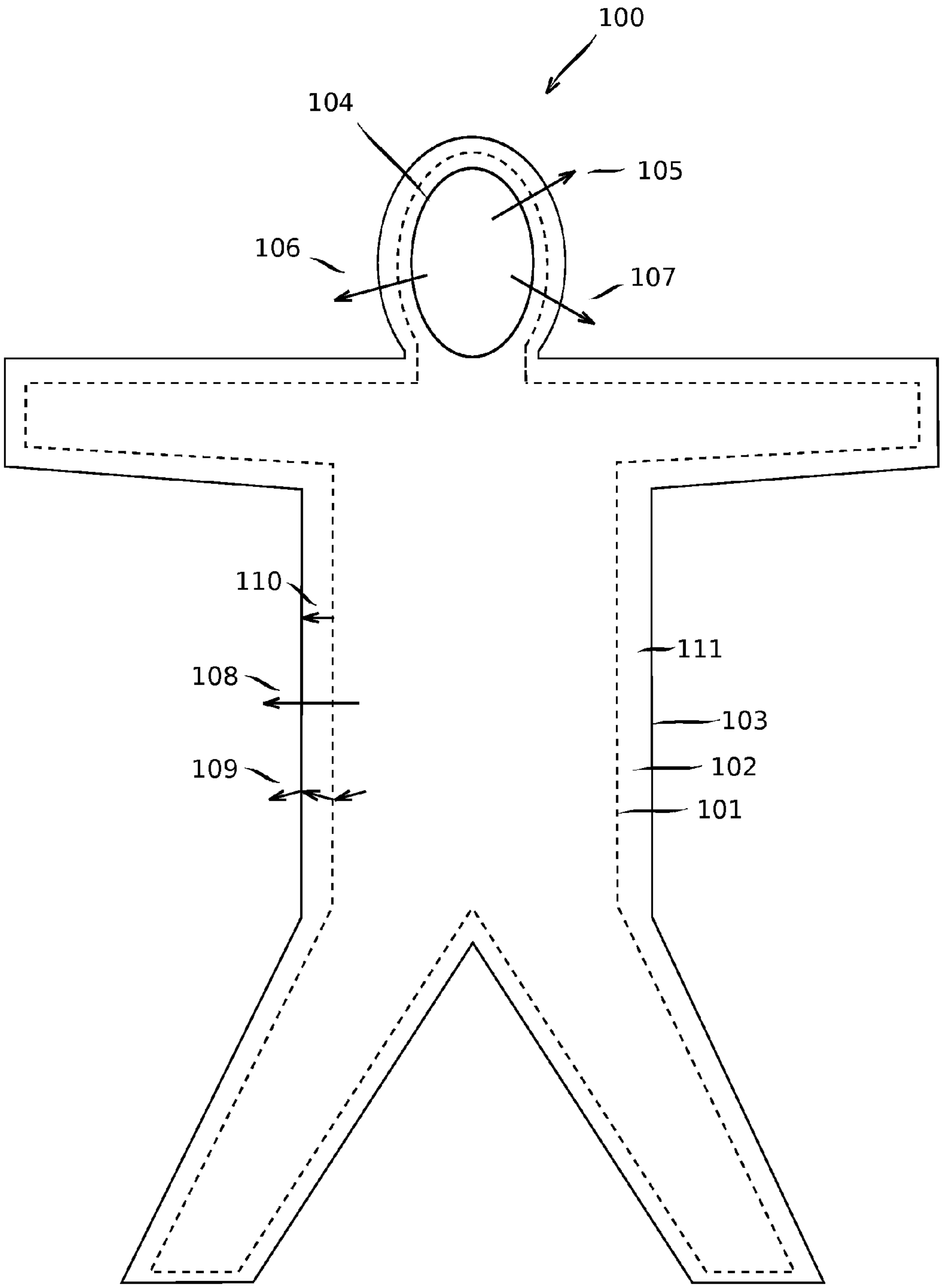
(57) **ABSTRACT**

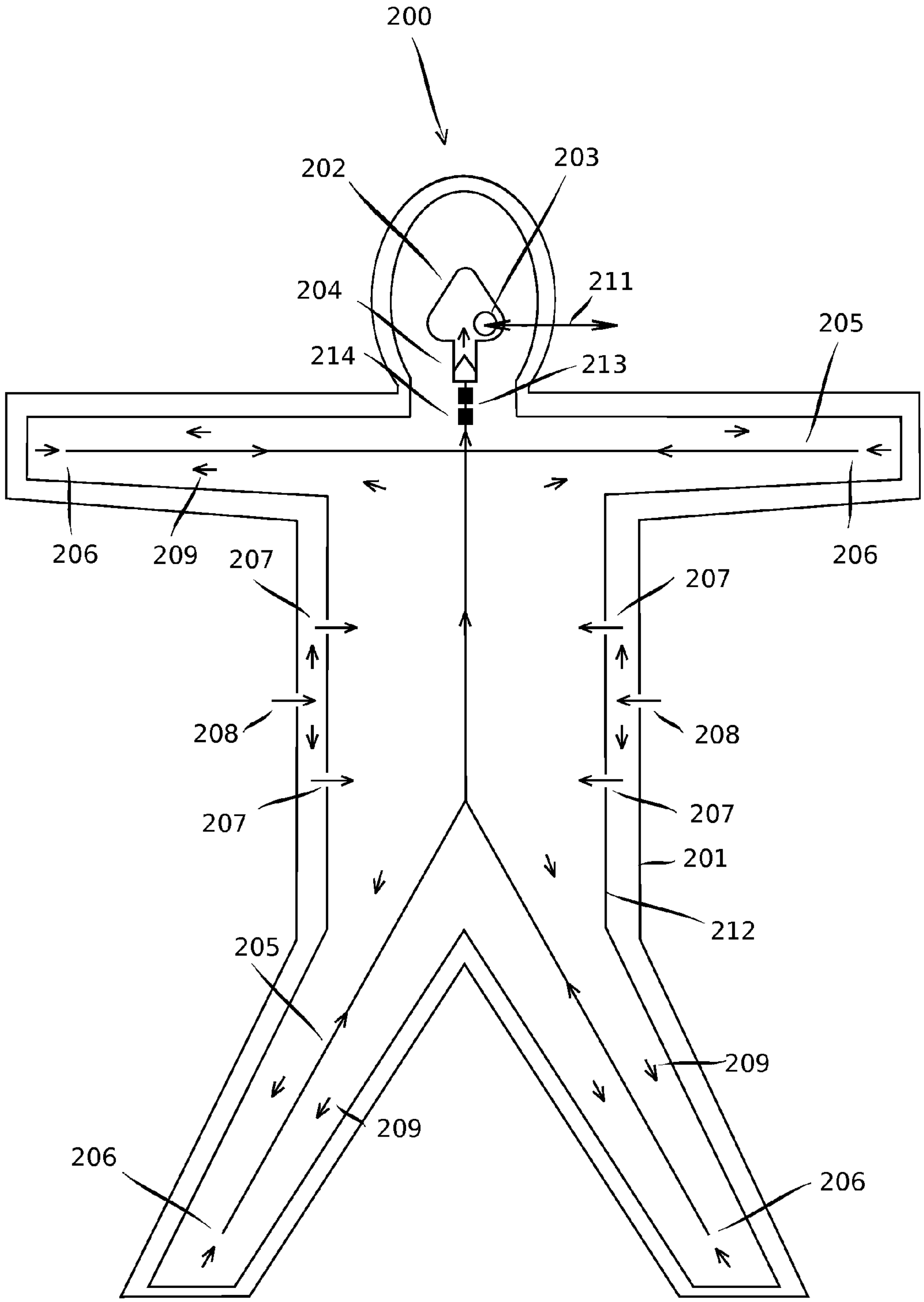
In a first embodiment, a gas-impermeable vapor barrier inner layer of a cold weather suit prevents condensation of body moisture in outer layers, thus preventing degradation of outer-layer insulating value. Body moisture vapor is collected by a network of tubes inside the inner layer, and fed through a one-way valve into a facemask, where it is added to inhaled air. Heat of vaporization of body moisture, and body heat lost to air convection, is thus recovered by displacing a like amount of heat of vaporization of moisture, and heat added to exhaled air, respectively, that would have been added by the lungs. The basic system can be further improved by additional gas-impermeable insulating layers, and by providing a coupling to detach the facemask from the tube network, so that the remaining tube network is inconspicuous within the suit. In a second embodiment, a heat exchanger also recovers heat, and heat of condensation, from exhaled air and uses it to pre-warm air entering the suit to be inhaled.





- PRIOR ART -

FIG. 1


200
202
203
204
211
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206

FIG. 2

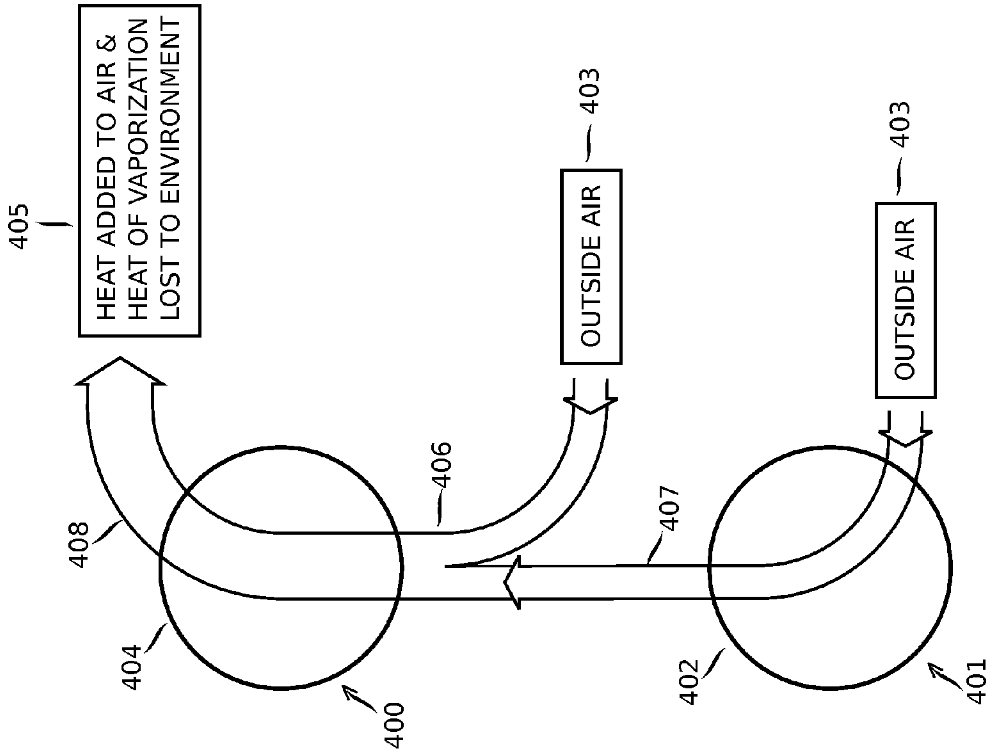

FIG. 4

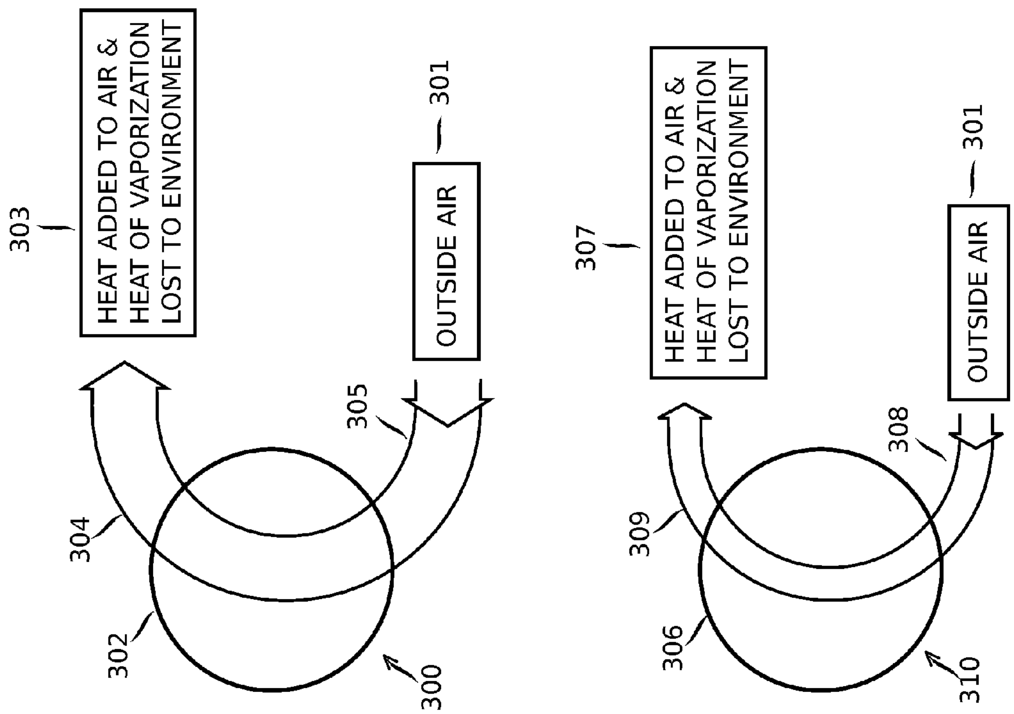

FIG. 3 - PRIOR ART -

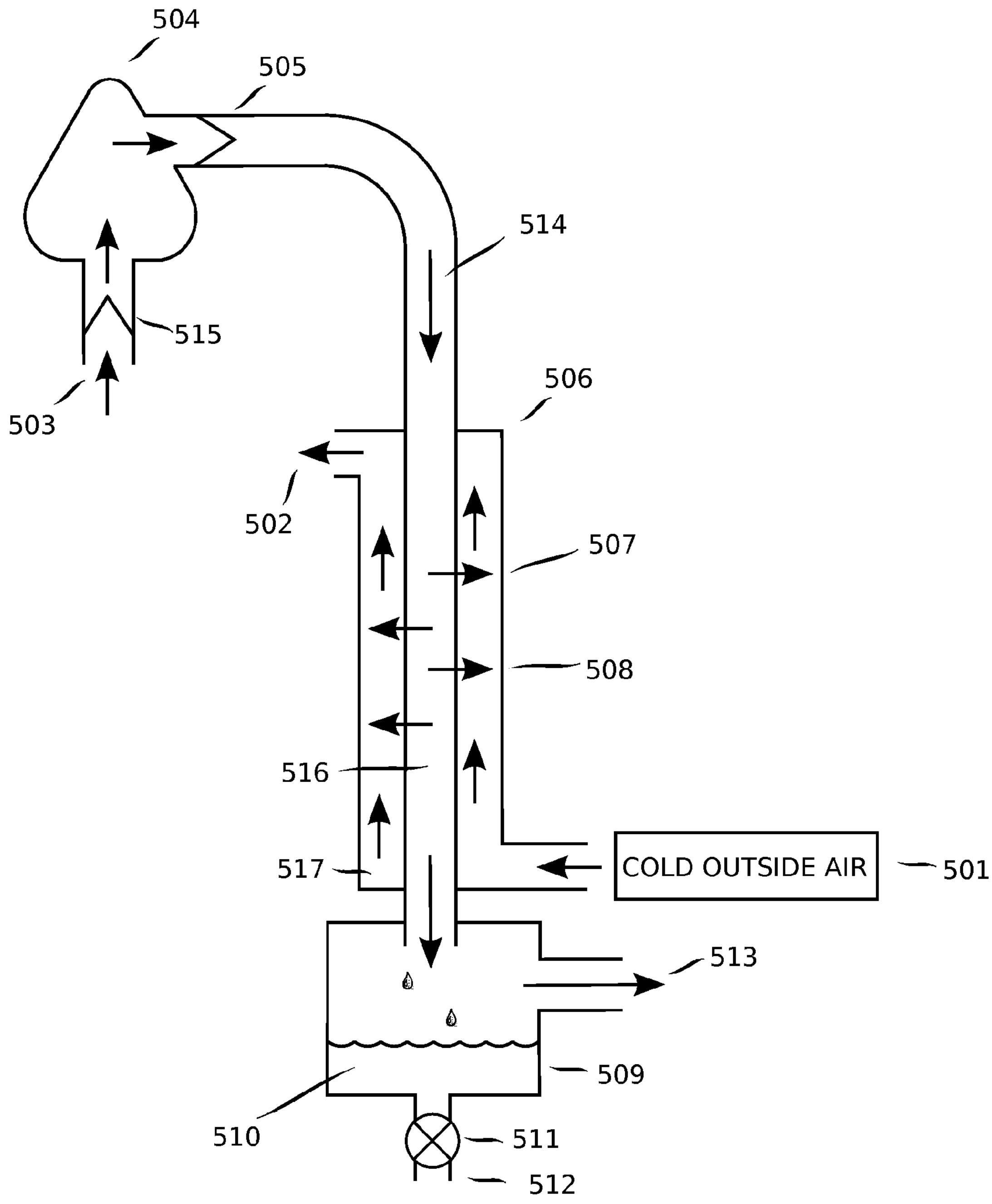
504
505
514
515
503
506
502
507
508
516
517
COLD OUTSIDE AIR
501
513
509
510
511
512

FIG. 5

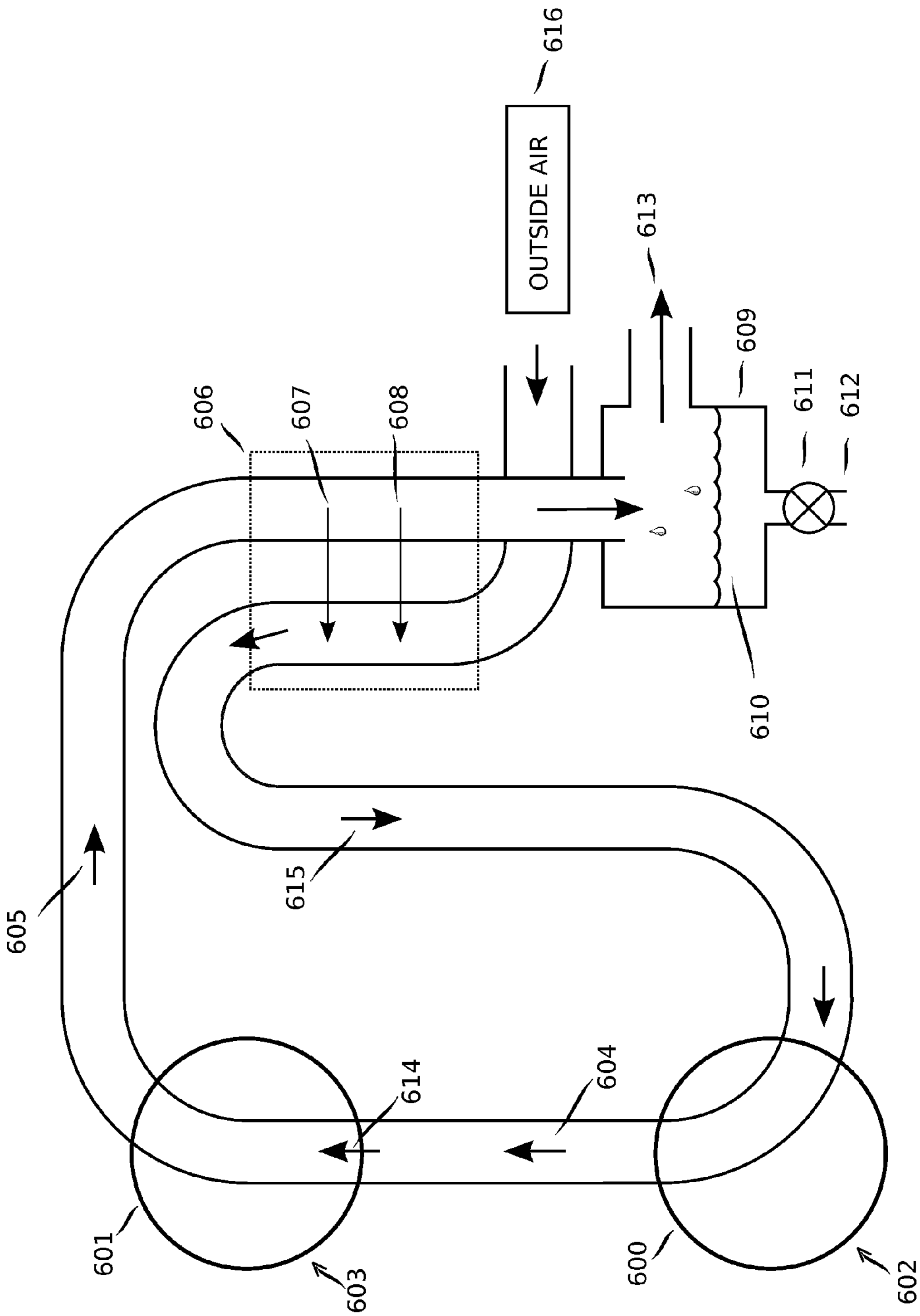
OUTSIDE AIR
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616

FIG. 6

COLD WEATHER SUIT WITH VAPOR BARRIER AND HEAT RECOVERY

BACKGROUND

[0001] Body heat is lost to the environment through the mechanisms of air convection, conduction, heat of vaporization, and radiation.

[0002] Air convection is the transfer of heat by means of airflow. Airflow caused by an external agent, such as a pump or the wind, is called forced convection. If the movement is due to density differences of the air itself, such as hot air rising, it is called free convection. Clothing serves to reduce heat loss by blocking both kinds of air convection.

[0003] Heat conduction occurs when materials at different temperatures are in physical contact. The amount of heat flow is proportional to the temperature difference times the thermal conductivity of the material. Thermal conductivities vary widely depending on the substance. In particular, the thermal conductivity of a fabric or insulation fill or other porous material is greatly increased by being wet.

[0004] To change from liquid to gas at constant temperature, water must absorb a great deal of heat, which is called heat of vaporization. When water vapor condenses back to a liquid, this same amount of heat is released as heat of condensation. Thus water evaporating from a body transfers heat from the body to the resulting water vapor. Water vapor condensing onto an object transfers heat from the water to the object. Heat of vaporization can subsequently be transported by convection. Associated with a given body of air is its dew point, which is the temperature below which the moisture in the air condenses. When air comes into contact with a surface that is cooler than the air's dew point, condensation will form on the surface. Thus when air travels through layers of a garment toward a cold exterior, water condensation will form at the point where the temperature of the layer is less than the dew point of the air.

[0005] Radiation transfers heat by electromagnetic waves. Two bodies coupled in radiation contact will converge towards a common temperature. The coupling is enhanced if the surface of a body is black, which enhances the ability to both transmit and absorb radiation. A white or reflective surface, by contrast, serves to insulate a body against radiation transfer. Likewise the more reflective barriers between two bodies, the more radiation heat transfer is reduced. At ordinary temperatures most radiation heat transfer is at infrared wavelengths, so that additional reflective barriers beyond one provide additional radiative insulation, even though the space between layers may be dark at visible wavelengths. For example the James Webb telescope will be cooled to −370 degrees Fahrenheit by a 5 layer reflective shield interposed between the telescope and the Earth, Moon and Sun. A material that is substantially transparent or translucent to radiation, such as fiberglass or down insulation, does not reduce radiation heat transfer.

[0006] Moisture is a central problem in designing a suit for extremely cold weather. Body moisture can accumulate and condense within the suit, soaking the fabric and degrading its insulating value. In very cold conditions moisture can even freeze within the suit. On the other hand, if body moisture is allowed to escape, then its heat of vaporization is lost, along with the body heat that was added to the air carrying the moisture. Likewise water vapor in exhaled breath represents a loss of the water's heat of vaporization, as well as the heat added to the exhaled air itself.

[0007] The designer of a cold weather suit faces two sometimes-conflicting goals:

[0008] 1. Retaining body heat.

[0009] 2. Getting rid of body moisture.

[0010] An ordinary cold weather suit **100** is represented in FIG. **1**. The suit may contain multiple fabric layers comprising an innermost layer **101**, outermost layer **103**, and fill insulation **102**, such as goose down or synthetic insulation, between fabric layers. The wearer's face **104** is uncovered to some extent to allow vision and respiration. The suit loses body heat by the following mechanisms:

[0011] 1. Heat of radiation **105** is lost from the exposed face through the face opening **104**.

[0012] 2. Heat lost by convection in exhaled breath **106** contains two components: the heat added to the inhaled air, and the heat of vaporization of the water vapor added by the lungs.

[0013] 3. Heat is lost by convection **107** from the exposed face.

[0014] 4. Body heat is lost by convection **108** through permeable fabric and permeable fill insulation layers, especially when the wind blows. Again, this has two components—the heat added to the air, and the heat of vaporization of body moisture carried in the air.

[0015] 5. Heat of radiation **109** is lost through translucent fill material. Even though the space between suit layers may be dark in the visible part of the spectrum, heat radiation takes place in the infrared part of the spectrum, where material at ordinary temperatures transmits and absorbs light. To the extent that insulating fill material is translucent or transparent, there is a net flux of heat radiation from the hotter inner layers **101** to the cooler outer layers **103**.

[0016] 6. Body heat is lost by conduction **110** through the material of the suit. This heat loss is greatly increased **111** when the material is dampened by moisture condensation. In addition, fill insulation, especially goose down, suffers loft loss when wet.

[0017] Several efforts have been made to reduce these heat losses. A vapor barrier as an inner layer has been used as a way of preventing outer layers from being dampened by body moisture (U.S. Pat. No. 6,319,864 and Andrew Skurka The Ultimate Hiker's Guide, 2012, National Geographic Society, pp. 56-60). Although this has the significant advantage of preserving the insulating quality of the outer layers, the moisture buildup beneath this inner layer requires periodic venting, so that heat added to the air and the heat of vaporization of body moisture is still lost.

[0018] Several types of air-to-air heat exchangers have been proposed (U.S. Pat. No. 4,150,671, U.S. Pat. No. 6,807,964) for recovering heat by transferring it from exhaled air to inhaled air. Heat exchangers for therapeutic medical use have also been developed for transferring moisture as well as heat from exhaled air to inhaled air. For example, US-2008/0283053 FIG. 13 shows a heat exchanger in which heat and moisture travel across a paper tube wall.

[0019] U.S. Pat. No. 5,029,572 and U.S. Pat. No. 7,958,888 propose a tube that carries exhaled air into the suit. This only worsens the concentration of moisture in the suit, thus reducing its insulation value.

[0020] U.S. Pat. No. 4,768,235 and U.S. Pat. No. 4,441,494 propose warming air to be inhaled, as it travels through a tube positioned between the body and the suit. This transfers heat from the body to the air before it is inhaled, but does not reduce net heat loss to the environment, because the heat conserved by breathing the warmed air is offset by heat lost in warming the air.

[0021] U.S. Pat. No. 5,063,923 proposes a network of tubes carrying air from inside a suit to a mouthpiece to be inhaled, and also carrying exhaled air to the suit. The suit comprises insulation between an impermeable outer layer and a permeable inner layer. The intakes to the network of tubes are positioned between the inner and outer layer, so that body moisture travels through the insulation, dampening it, before entering the network of tubes.

[0022] This review of the prior art shows the need for a cold weather garment that

- **[0023]** 1. Avoids the deterioration of insulation from condensation of body moisture.
- **[0024]** 2. Recovers body heat.
- **[0025]** 3. Recovers heat from warm exhaled air.
- **[0026]** 4. Recovers heat of condensation from body moisture and from moisture in exhaled air.

SUMMARY

First Embodiment

[0027] In accordance with a first embodiment of the current invention, a cold weather garment comprises a vapor barrier inner layer, optionally one or more insulating outer layers, a facemask covering nose and mouth, a two-way port going between the facemask and the exterior, and a one-way inlet valve allowing air to enter the facemask from a network of tubes positioned inside the inner layer. The network of tubes extends from the facemask to four openings at the ends of the arms and legs to convey air to the facemask. The vapor barrier inner layer is impermeable to penetration by gas, including water vapor, except that the region of the inner layer around the midsection has a limited number of holes, with a limited total area, that allow a limited inward flow equal to the flow that goes to the facemask through the network of tubes.

[0028] When the wearer exhales, the breath travels through the two-way port to the exterior, but the exhaled air causes a slight rise in pressure within the facemask, closing the one-way inlet valve, so that no flow takes place between the facemask and the tube network during exhalation. When the wearer inhales, the slight drop in air pressure within the facemask causes the one-way inlet valve to open and air to flow from the tube network into the facemask. Air flows into the facemask not only from the tube network, but also through the two-way port. The two-way port is sized to afford low-effort breathing, but with activation of the one-way inlet valve, so that while some air flows into the facemask from the tube network during inhalation, there is no flow between the facemask and the tube network during exhalation. The tube network is sized to allow a flow of air that is sufficient to carry enough body moisture as water vapor, to prevent accumulation of liquid water within the inner layer.

[0029] In order to supply air to the ends of the tube at the ends of the arms and legs, a flow of air travels from the exterior through the midsection holes into the space between the wearer's body and the inner layer, and down the arm sleeves and pant legs to enter the four ends of the tubes, thus flushing out humid air with dry air. There might be leakage through the inner layer at the site of zippers or seams or other breaks in the inner layer. If this leakage is sufficiently large, midsection holes may be unnecessary. The flow established by this configuration flushes the entire space between the wearer and the inner layer, with no dead spots where moisture can accumulate. This flow, along with the vapor barrier inner layer, has the benefit of keeping the outer insulating layers completely free of body moisture, thus preventing degradation of their insulating value. A second advantage is that the heat added to the air by the skin, instead of being lost to the exterior environment, is recovered by breathing it into the lungs, where it displaces a like amount of heat that would otherwise be added by the lungs. A third advantage is that the heat of vaporization of body moisture, instead of being lost to the exterior environment, is recovered by breathing it into the lungs, where the moisture displaces a like amount of moisture that would otherwise be vaporized in the lungs.

Second Embodiment

[0030] A second embodiment of the current invention will now be summarized by contrast to the first embodiment. The main difference is the addition of a condensing heat exchanger, which recovers heat from exhaled air as well as heat of condensation from exhaled moisture, transferring the heat back into air going into the suit and ultimately being inhaled. The heat exchanger has two chambers—a cold chamber for the incoming outside air, and a warm chamber for the outgoing exhaled air. The heat exchanger does not allow the two flows to mingle, but only allows heat to flow from the exhaled air to the outside air. Whereas in the first embodiment a 2-way port allowed air to both enter and leave the facemask, the second embodiment replaces the 2-way port with a one-way port that only allows exhaled air to leave the facemask but does not allow air into the facemask. By segregating the inhaled air from the exhaled air in this way, the two flows can be run through the condensing heat exchanger. The tube network and the one-way inlet valve to the mask are now sized large enough to provide all of the inhaled air, whereas in the first embodiment they carried a smaller flow only adequate enough to evacuate moisture from inside the suit.

[0031] Moisture condensing within the condensing heat exchanger is collected in a condensate tank and periodically discarded.

[0032] The airflow within the suit can be summarized as follows: Cold outside air flows into the cold chamber of the heat exchanger and receives heat from the warm chamber before traveling into the interior of the suit. Air within the suit travels to the four limb extremities, where it enters the tube network. The tube network carries this air to the facemask, where it is inhaled. Exhaled air travels through the warm chamber of the heat exchanger, where it gives up heat and heat of condensation, and is then exhausted to the outside as cooled and dehumidified air.

DRAWINGS

Figures

[0033] FIG. **1** (prior art) shows the various avenues by which body heat escapes from a conventional cold weather suit.

[0034] FIG. **2** shows features of the first embodiment of the current invention

[0035] FIG. **3** (prior art) shows heat convection flows in a conventional cold weather suit.

[0036] FIG. **4** shows heat convection flows in the first embodiment of the current invention.

[0037] FIG. **5** shows the heat exchanger and its connection to the facemask in the second embodiment.

[0038] FIG. **6** shows heat flows in the second embodiment of the current invention.

DRAWINGS - REFERENCE NUMERALS	
FIG. 1	
100 Conventional cold-weather suit	
101 inner layer	102 insulation fill
103 outer layer	104 face opening
105 radiation from face	106 heat loss from breath
107 convection from face	108 convection heat loss
109 radiation heat loss	110 conduction heat loss
111 insulation degraded by body moisture condensation	
FIG. 2	
200 cold-weather suit	201 outer layer
202 facemask	203 two-way port
204 one-way inlet valve	205 tube network
206 tube network input ports	207 inner layer air inlet
208 outer layer air inlet	209 air travel to extremities
211 inhalation and exhalation through two-way port	
212 inner layer vapor barrier	213 coupler
214 tube network output port	
FIG. 3	
300 heat added by lungs	301 outside air
302 lungs	303 heat lost to environment from lungs
304 exhaled air	305 inhaled air
306 skin	307 heat lost to environment from skin
308 air convection to skin	309 air convection from skin
310 heat added by skin	
FIG. 4	
400 heat added by lungs	401 heat added by skin
402 skin	403 outside air
404 lungs	405 heat lost to environment from lungs
406 inhaled air	407 heat added to outside air from skin
408 exhaled air	
FIG. 5	
501 outside air	502 pre-warmed outside air
503 inhaled air	504 facemask
505 one-way outlet valve	506 condensing heat exchanger
507 heat flows	508 heat of condensation flows
509 condensate tank	510 condensate
511 condensate outlet valve	512 condensate outlet
513 cooled exhaled air	514 exhaled air
515 one-way inlet valve	516 warm chamber
517 cold chamber	
FIG. 6	
600 skin	601 lungs
602 heat added by skin	603 heat added by lungs
604 air carried by tube network	605 exhaled air
606 heat exchanger	607 heat flows
608 heat of condensation flows	609 condensate tank
610 condensate	611 condensate outlet valve
612 condensate outlet	613 cooled exhaled air
614 inhaled air	615 pre-warmed air
616 outside air	

DETAILED DESCRIPTION

First Embodiment

[0039] FIG. **2** illustrates the first embodiment of the invention in schematic cross section. A cold weather suit **200** comprises a vapor barrier inner layer **212** and one or more insulating outer layers **201**. A facemask **202** covers the wearer's nose and mouth, and a two-way port **203** allows air to travel between the facemask and the exterior. Inhalation and exhalation **211** takes place through the two-way port. A one-way inlet valve **204** allows air to enter the facemask from a network of tubes **205** positioned inside the inner layer, but prevents air from flowing in the opposite direction, from the facemask to the network of tubes. One-way valves in breathing apparatuses are well known (see for example US-2006/0231091, US-2004/0084048, and 2009/0188505, FIGS. 26 and 27, label 164). The network of tubes extends from the facemask **202** through a coupler **213** to four openings **206** at the ends of the arms and legs. The network of tubes conveys air from the four extremities to the facemask. The coupler **213** allows the facemask **202** and one-way inlet valve **204** to be uncoupled from the garment and stored elsewhere, while the rest of the tube network **205** remains inconspicuously hidden inside the suit.

[0040] The vapor barrier inner layer is impermeable to penetration by gas, including water vapor, except that the region of the inner layer around the midsection has a limited number of holes **207**, with a limited total area, that allow a limited inward flow equal to the flow that goes to the facemask through the network of tubes. The insulating outer layers **201** also have midsection holes **208**, which do not necessarily align with the holes **207** in the vapor barrier inner layer. In order to supply air to the ends of the tube at the ends of the arms and legs, a flow of air **209** travels from the exterior through the midsection holes **208** and **207** into the space between the wearer's body and the inner layer, and down the arm sleeves and pant legs to enter the four ends of the tubes **206**, thus flushing humid air out and replacing it with dry air. The inner layer vapor barrier **212** has the benefit of keeping the outer insulating layers completely free of body moisture, thus preventing degradation of its insulating value. The tube network **205** not only prevents the accumulation of body moisture underneath the vapor barrier, but also recovers its heat of vaporization by providing it to be inhaled. The outer layers **201** may optionally be impermeable to penetration by gas, like the inner layer. Both the inner layer **212** and the outer layers **201** may be reflective, in order to reduce heat loss by radiation transmitted or absorbed by these layers.

[0041] The flow of air **209** is small compared to the flow of exhaled and inhaled air **211**, and is even small compared to the air convection through a conventional suit. The body does lose heat to this air, but this heat is recovered by virtue of the fact that the flow is inhaled into the lungs. The heat added by the body to the air reduces, by a like amount, the amount of heat that the lungs add to the exhaled air. In effect, there is no net loss of heat due to the heating of this air by the body.

[0042] A second advantage is that the heat of vaporization of body moisture is recovered by breathing it into the lungs, where it reduces by a like amount the moisture that would otherwise be vaporized in the lungs. By increasing the amount of moisture in inhaled air, the lungs add correspondingly less water to the exhaled air, to bring it up to the dew point of the exhaled breath, and thus will lose less heat to vaporization. In effect, no net heat of vaporization is lost by the evaporation of body moisture.

[0043] FIG. **3** illustrates convection heat flow in a conventional cold weather suit. The essential characteristic is that heat flow **310** from the skin **306** and heat flow from the lungs **300** are independent from each other and are not coupled. Outside air **301** is inhaled **305** into the lungs **302** and heat **300** is added to the exhaled air **304** both as heating of the inhaled air, and as heat of vaporization. This heat is lost to the environment (**303**).

[0044] Likewise, outside air **301** travels by convection **308** to the skin **306** and heat **310** is added both as heating of the air, and as heat of vaporization of body moisture, which travels by convection **309** and is lost to the exterior environment (**307**). When the air containing body moisture travels through the insulating layers on its way to the environment, it will condense when it reaches a layer that is colder than the dew point of the air. This condensation degrades the thermal resistance of the insulating layers and can even freeze to ice.

[0045] By contrast, in the current invention (FIG. **4**) the heat **401** added by the skin **402** to the outside air **403**, and the heat of vaporization of body moisture, is not lost to the environment, but rather is added (**407**) to the air **406** inhaled into the lungs. By heating and humidifying the inhaled air, the heat **400** that the lungs **404** must add to the exhaled breath **408** is correspondingly reduced. In effect, the heat normally lost by the skin heating and humidifying the outside air, is largely eliminated. Both the conventional cold weather suit and the current invention give off heat (**303** and **405**, respectively) in the exhaled breath (**304** and **408** respectively), but the current invention largely avoids loss of heat by convection from the body.

[0046] In the conventional cold weather suit, the outer layers must be gas-permeable to prevent moisture from becoming trapped and accumulating inside. However the current invention removes this requirement, by getting rid of body moisture by other means. Thus the current invention enables the outer layers **201**, in addition to the inner layer **212**, to be gas-impermeable. This has the advantage of blocking heat that would otherwise be lost by convection through these outer layers. Like the inner layer, the outer layers must still have a limited number of holes in the midsection, or be slightly permeable to gas, to allow a small one-way flow of air into the suit.

Second Embodiment

[0047] The fact that the wearer is already wearing a facemask opens up the possibility of capturing separately the flows of inhaled and exhaled air, and putting them into thermal contact within a heat exchanger, so that heat is sent back into the suit instead out to the environment. This second embodiment will be described in terms of differences between it and the first embodiment.

[0048] The second embodiment transfers heat from exhaled air to inhaled air by means of a condensing heat exchanger. FIG. **5** shows how this is accomplished. The condensing heat exchanger **506** contains two chambers that are in thermal contact to each other. The cold chamber **517** warms cold outside air **501** so that it is carried into the suit as pre-warmed air **502**. Since this pre-warmed air **502** is supplied to the interior of the suit, the inlet holes **207** and **208** of the first embodiment are not necessary. The warm chamber **516** carries exhaled air **514** from the facemask **504** to the outside, where it is exhausted **513** after being cooled and dehumidified. Heat of the warm exhaled air **507**, and heat of condensation of the exhaled moisture **508** flow from the warm chamber **516** to the cold chamber **517**.

[0049] As the exhaled air is cooled below its dew point, condensation forms within the warm chamber **516** and is collected as condensate **510** in a condensate tank **509**. Provision can be made for draining the condensate through a condensate outlet valve **511** and condensate outlet **512**.

[0050] As in the first embodiment, the tube network **205** carries air from the four extremities to the facemask **504** through a one-way inlet valve **515**. However now this tube network **205** and one-way inlet valve **515** must be made larger to carry the entire flow of inhaled air **503**. Exhaled air **514** travels from the facemask **504** through a one-way valve **505** and is carried to the condensing heat exchanger.

[0051] FIG. **6** shows the heat flows of the system. Outside air **616** enters the condensing heat exchanger **606** and receives heat **607** from the warm exhaled air and heat of condensation **608** from condensing moisture in exhaled air. Thus pre-warmed, the air **615** is carried inside the suit. As it travels to the four extremities, this air receives more heat **602** from the skin **600**. The tube network **205** carries the air **604** to the facemask **504** and inhaled **614** into the lungs **601** where heat **603** is added both as heat to the air and as heat of vaporization in moisture. Exhaled air **605** travels to the heat exchanger **606**. As the exhaled air is cooled below its dew point in the heat exchanger, moisture condenses and is collected in a condensate tank **609**. The condensate **610** can be drained through a condensate outlet valve **611** and condensate outlet **612**.

[0052] Since an opening around the face is no longer necessary in the current invention for breathing, the face no longer has to be exposed to the cold outside air—the suit can be made to extend over the lower part of the face, reducing the heat of convection and radiation that is lost in a conventional cold weather suit. The only part of the body that must be visible is the eyes, which can be protected by goggles.

[0053] Looking back at the conventional cold weather suit in FIG. **1**, and comparing it with the second embodiment in FIG. **6**, we can see how the current invention reduces or eliminates many of the avenues of heat loss in a cold weather suit. The outer insulation layers are not soaked by condensed body moisture, and thus retain their insulating capability. Heat lost by conduction from the body is reduced because the insulating layers are kept free of condensation, thus preserving their insulating ability. Heat lost by convection from the body is virtually eliminated because the layers can be made impermeable to gas. Heat added by the skin to the air, and heat of vaporization of body moisture, is recovered by the heat exchanger and recycled back into the suit. Heat lost by the conventional winter suit in exhaled air is to a great extent recovered in the heat exchanger. Heat lost by convection and radiation from the face is reduced because the suit can be made to cover the mouth area.

[0054] By increasing the insulating efficiency, the current invention allows the wearer to remain comfortable in colder temperatures, as compared to what can be achieved in a conventional cold weather suit.

What is claimed is:

1. A cold weather garment to be worn by a person in an environment, said cold weather garment comprising:

an inner layer comprised of a material that is impermeable to gas, including water vapor, the inner layer comprising
- a right arm sleeve,
- a left arm sleeve,
- a right pant leg,
- a left pant leg, and
- a torso section;

a tube network situated between the inner layer and the person, said tube network comprising
- an output port,
- a plurality of input ports comprising
  - an input port situated at the end of the right arm sleeve,
  - an input port situated at the end of the left arm sleeve,
  - an input port situated at the end of the right pant leg, and
  - an input port situated at the end of the left pant leg;
- wherein the tube network is configured to allow a first flow of air from a space between the person and the inner layer into the plurality of input ports and thence through the tube network to the output port; and

a facemask to be worn over the nose and mouth of the person, said facemask comprising a one-way inlet valve connected between the output port of the tube network and the facemask, said one-way inlet valve being configured to allow air to pass from the output port of the tube network to the facemask but not allow air to pass from the facemask to the output port of the tube network.

2. The cold weather garment of claim **1**, further comprising

a two-way port that is configured to allow air from the environment to enter the facemask to be inhaled and to allow exhaled air to exit the facemask to the environment,

a plurality of holes in the torso section that are adequate to carry a second flow of air from outside the inner layer to inside the inner layer at a rate equal to the first flow of air.

3. The cold weather garment of claim **2**, further compromising one or more outer layers impermeable to gas, including water vapor, said outer layers being situated on the outside of the inner layer and containing a plurality of holes adequate to carry a third flow of air at a rate equal to the first flow of air.

4. The cold weather garment of claim **2**, wherein said one-way inlet valve is connected to said output port of said tube network by a coupling configured to allow the one-way inlet valve and facemask to be disconnected from the tube network.

5. The cold weather garment of claim **1**, further comprising

a condensing heat exchanger that comprises a warm chamber, a cold chamber, a warm chamber inlet, a warm chamber outlet, a cold chamber inlet, and a cold chamber outlet;

a condensate tank that is configured to collect water condensing within the warm chamber; and

a one-way outlet valve that is configured to allow exhaled air to flow from the facemask to the warm chamber inlet, from whence it flows through the warm chamber and out through the warm chamber outlet to the environment;

wherein the cold chamber is configured to allow outside air to flow into the cold chamber inlet and through the cold chamber, where it receives heat from the warm chamber, from which it travels as pre-warmed air out of the cold chamber outlet into the space between the person and the inner layer.

6. The cold weather garment of claim **5**, further compromising one or more outer layers impermeable to gas, including water vapor, said outer layers being situated on the outside of the inner layer.

7. The cold weather garment of claim **5**, wherein said one-way inlet valve is connected to said output port of said tube network by a coupling configured to allow the one-way inlet valve, facemask and condensing heat exchanger to be disconnected from the tube network.

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