ABSTRACT

A lightweight, gas-filled, highly insulative material is incorporated into an article of outdoor gear or apparel (e.g., a camping pad). The insulative material has a layered cellular structure that can be filled with an insulative gas (e.g., air or argon). The insulative material includes two or more layers of cells, which improves insulation (compared to a single layer) by reducing convection for a given thickness. Increasing the thickness without substantially increasing convection results in a better insulator and an improvement in the ability to retain heat.
THIN INSULATIVE MATERIAL WITH LAYERED GAS-FILLED CELLULAR STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATIONS


BACKGROUND OF THE INVENTION

[0002] 1. The Field of the Invention
[0003] The present invention is in the field of thermal insulation materials. More particularly, the present invention relates to layered gas filled thermal insulation. 2. The Relevant Technology
[0004] Thermal insulators have long been important for human survival and comfort in cold climates. The primary function of any thermal insulator is to reduce heat loss (i.e., heat transfer) from a heat source to a cold sink. There are three forms of heat transfer: convection, conduction, and radiation.
[0005] Heat loss through convective mixing of gases is caused by the tendency of a gas to form a rotational mixing pattern between a warm (i.e., less dense) region and a cooler (i.e., more dense) region. In a convection cycle, warmed gas is constantly exchanged for cooler gas. One of the primary ways in which thermal insulators work is through suppressing convection by trapping or confining a volume of a gas within the insulative material. For example, one of the reasons that a fiber-filled parakeet feels warm is that the air near the pet’s skin is warmed by body heat and the fibers act to prevent or at least slow convective mixing of the warmed layer of the air with the cold air outside.
[0006] Conduction involves heat flow through a material from hot to cold in the form of direct interaction of atoms and molecules. For example, the phenomenon of conduction is one of the reasons why a thin layer of insulation does not insulate as well as a thicker layer.
[0007] Radiation involves direct net energy transfer between surfaces at different temperatures in the form of infrared radiation. Radiation is suppressed by using materials that reflect infrared radiation. For example, the glass surface of a vacuum flask is coated with silver to reflect radiation and prevent heat loss through the vacuum region.
[0008] Different thermal insulators prevent heat loss through convection, conduction, and radiation in different ways. For example, fiber-based thermal insulators like polyester fiber fill or fiberglass insulation utilize fairly low conductivity fibers in a stack or batt with a volume of air trapped or confined amongst the fibers. Furthermore, conduction is reduced by the random orientation of the fibers across the stack or batt, and radiative heat loss is somewhat reduced because the radiation is scattered as it passes through the fibers.
[0009] Another example class of thermal insulators includes closed cell structures, such as foams or microspheres. Closed cell structures are generally comprised of a polymer matrix with many small, mostly closed cavities. As with fiber-based insulations, these insulators conserve heat by trapping a volume of air in and amongst the cells. In fact, convection is effectively eliminated inside the small, closed cells. Furthermore, conduction is reduced by using low conductivity materials, and radiation is low because the cells are typically very small and there is little temperature difference between cavity walls and hence low driving force for radiative heat transfer.

[0010] Essentially all thermal insulators present a tradeoff between insulative value (i.e., prevention of convection, conduction, and radiation), bulk, and cost. For example, because of the bulkiness of fiber- or foam-based insulation, achieving a sufficient degree of insulation for a given set of conditions can be difficult without also making the article too bulky for practical use. It should also be appreciated that adding additional fiber- or foam-based insulation inevitably adds weight. Such insulative materials are also static in that the amount of insulative material cannot be changed or adjusted as the user’s needs change. For example, if a person is wearing a fiber filled parka or sleeping in a fiber filled sleeping bag, the amount of insulation cannot be increased or decreased as environmental or activity conditions change.

[0011] In addition, many typical insulative materials produce toxic and/or environmentally damaging byproducts in the process of manufacture. For example, the manufacturing process for many thermal insulators such as polyester fibers or foams produces CFCs and/or greenhouse gases. Many typical thermal insulators also continue to outgas toxic chemicals long after their manufacture. For example, fiberglass insulation is typically manufactured with formaldehyde compounds that continue to outgas long after the insulation is placed in a wall or other structure. And many typical insulators, such as fiberglass or polyester fiber fill, produce loose fibers that can be harmful if they are inhaled.

BRIEF SUMMARY OF THE INVENTION

[0012] The present invention is directed to a lightweight, gas-filled, highly insulative material incorporated into an article of outdoor gear or apparel (e.g., a sleeping pad for camping). The insulative material has a layered cellular structure that can be filled with an insulative gas (e.g., air or argon). The two or more layers of cells improve insulation (compared to a single layer) by reducing convection for a given thickness. Increasing the thickness without substantially increasing convection results in a better insulator and an improvement in the ability to retain heat.

[0013] In one embodiment, insulation with two or more layers also allows the seams created from the individual cells to be sealed to improve insulation. Insulated seams may be achieved by offsetting or overlapping the cells of one layer with the seams of the underlying layer. Insulating the seams of the cellular structure can have a substantial impact on increasing the insulative value of the material.

[0014] In one embodiment, the present invention is directed to a layered insulative material that includes first and second gas impermeable layers joined together to form a chamber having a cell structure and including a plurality of cells that are in fluid communication. One or more interior layers of material are positioned within the chamber between the first and second gas impermeable layers. The one or more interior layers divide the chamber into the plurality of cells. The plurality of cells form a first layer of cells above a second layer of cells. The insulative material also includes a valve mechanism coupled to the insulative material that allows the insulative material to be inflated or deflated.
In one embodiment, the first and second gas impermeable layers may include a woven material. To make the woven material gas impermeable a laminate may be applied to the surface thereof. In one embodiment, the gas impermeable laminate material may be selected from the group including polyethylene, polypropylene, polyurethane, urethane, silicone rubber, latex rubber, polytetrafluoroethylene (PTFE), expanded PTFE, butyl rubber, and/or Mylar.

In another embodiment, the cell structure of the present invention may be used to insulate outdoor gear. Example outdoor apparel items include but are not limited to, coats, parkas, jackets, vests, gloves, mittens, hats, liners, waders, snow boots, work boots, ski boots, and snowboard boots. In another embodiment, the cell structure of the present invention may be used to insulate outdoor gear. Example outdoor apparel items include, but are not limited to, tents, sleeping bags, bivouac bags, and sleeping pads.

The novel insulative materials of the invention may be particularly advantageous for use with sleeping pads. Thus, in one embodiment, a sleeping pad incorporating a layered insulative material is provided. The sleeping pad includes a sleeping surface sized and configured to support a person. The sleeping pad includes a layered insulative material including first and second gas impermeable layers joined together to form a chamber having a cell structure comprising a plurality of cells that are in fluid communication. The sleeping pad also includes one or more interior layers of material positioned within the chamber between the first and second gas impermeable layers, the one or more interior layers dividing the chamber into the plurality of cells, wherein the plurality of cells form a first layer of cells above a second layer of cells. The sleeping pad also includes a valve mechanism coupled to the insulative material and configured to allow inflation and deflation of the plurality of cells of the first and second layers of cells.

In one embodiment, the sleeping pad can include woven materials that are laminated to provide gas impermeability. The layered cells of the sleeping pad may also be offset or overlapping such that seams in the different layers of cells overlap with one another to reduce heat transfer.

These and other objects and features of the present invention will become more fully apparent from the following description and appended claims, or may be learned by the practice of the invention as set forth hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a schematic of single insulating gas cell having X, Y, and Z dimensions, a gas reservoir, and a valve;

FIG. 2 illustrates an arrangement of a plurality of insulating gas cells as in FIG. 1 that are in fluid connection with one another and with a gas reservoir;

FIG. 3 illustrates an alternate arrangement of a plurality of insulating gas cells that are in fluid connection with one another;

FIG. 4 illustrates yet another alternate arrangement of a plurality of insulating gas cells that are in fluid connection with one another;

FIG. 5 illustrates even yet another alternate arrangement of a plurality of insulating gas cells that are in fluid connection with one another;

FIG. 6 illustrates a side cross-sectional view of a plurality of insulating cells divided by an intermediate layer;

FIG. 7 illustrates an offset arrangement of a plurality of insulating cells;

FIG. 8 illustrates a side cross-sectional views of a layered insulating material with an offset arrangement;

FIG. 9 illustrates a side cross-sectional view of a layered insulating material with the layers offset arrangement;

FIG. 10 illustrates a spheroidal cell arrangement of a layered insulating material;

FIG. 11 illustrates a sleeping pad incorporating a layered insulating material;

FIG. 12 illustrates a wearable item incorporating the layered insulating material of FIG. 8;

FIG. 13 illustrates a front cross-sectional view of an air bladder having an open cell foam core; and

FIG. 14 illustrates an inflation system for inflating a layered insulating material.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present disclosure is directed to a lightweight, gas-filled, highly insulative material incorporated into an article of outdoor gear or apparel (e.g., a camping pad). The insulative material has a layered cellular structure that can be filled with an insulative gas (e.g., air or argon). The insulative material includes two or more layers of cells, which improves insulation (compared to a single layer) by reducing convection for a given thickness. Increasing the thickness without substantially increasing convection results in a better insulator and an improvement in the ability to retain heat.

I. Design of an Insulative Gas Cell

FIG. 1 illustrates a schematic of single insulating gas cell 10 having X, Y, and Z dimensions. In a lightweight, gas-filled, highly insulative article that depends on the insulating properties of dry gases, the selection of X, Y, and Z dimensions are selected to reduce heat transfer by means of convection.

Convecive heat transfer consists of both forced and natural convection. Forced convection is due to the induced movement of the gas in the gas-filled cell. For example, in the case of a gas-filled cell that is incorporated into a garment, forced convection can be caused by movement of the wearer. Natural convection is a rotational flow pattern of gas caused by the temperature differential between warm and cool regions of the cell and gas buoyancy.

For example, in a gas filled insulating cell 10 like the one depicted in FIG. 1, the gas adjacent to the cell 10 surface nearest to a source of heat is typically at a higher temperature and lower density than the gas at the surface of the cell closest to atmospheric conditions. The hotter gas will rise and the cooler gas will replace the hotter gas thus setting off convective mixing of the gas within the cell 10. This will increase the heat transfer through the cell 10, which is undesirable for insulation. For both natural and forced convection, heat transfer is enhanced as the length of the free flowing path of the gas is increased. This is because convective mixing of the gas is allowed to more fully develop in these free flowing paths and thus heat transfer by convection is increased. This means that increasing the XYZ dimensions of the cell 10 depicted in FIG. 1 will tend to increase the tendency of convection coils to form inside the cell 10, which increases heat loss.
In one embodiment of the present invention, the cell 10 structure is specifically designed to reduce both free and forced convection of the gas inside the cell 10. Free and forced convection are minimized by choosing cell volume and dimensions that break up the free flow path of the gas inside the cell 10 and thus reduce convective mixing or rotational motion of the gas in the cell 10. In one embodiment of the present invention, a heat transfer model was developed that allows one to predict preferred cell dimensions (i.e., X, Y, and Z dimensions) in order to minimize natural convection and increase the insulating capabilities of the cell 10. These preferred cell dimensions for natural convection will also reduce heat transfer due to forced convection.

The model is developed by using both the Rayleigh value and the Nusselt number to predict the convective coefficient for the cell 10 under static conditions (i.e., natural convection and no forced convection). The Rayleigh value is a correlation between the buoyancy and viscous forces of the gas inside the cell 10. Large Rayleigh values are indicative of very buoyant flows leading to increased convection in the cell. Large Rayleigh values would be typical of convective mixing or rotational motion of the gas in large free flowing paths. The Rayleigh value can be expressed as the following for the geometry used for the cell structure.

$$R_{\text{ray}} = \frac{gB(T_h - T_0)d^3}{v^2}$$

Equation 1, $g$ represents gravity, $B$ is the expansion coefficient for the gas, $d$ is the thickness of the cell structure when inflated with the gas, $P_r$ is the Prandtl number, $v$ is the kinematic viscosity of the gas, $T_h - T_0$ is the temperature difference between the inner and outer walls of the cell 10. For purposes of this invention, the Rayleigh value is calculated using a value of $37^\circ$ C. for $T_h$ and $-40^\circ$ C. for $T_0$.

The Rayleigh value is used in turn to predict the Nusselt number, which quantifies convective heat transfer from the surfaces of the cell 10. The Nusselt number is then used to calculate the total heat transfer through the cell 10. Empirical correlations for the average Nusselt number for natural convection in enclosures were used to determine the Nusselt number based on the Rayleigh value and cell geometry. The Rayleigh value is significantly influenced by the thickness (i.e., the Z dimension depicted in FIG. 1) of the cell 10 and also the temperature difference between the inner and outer wall of the cell 10. Increasing the thickness will increase the free flowing path of the gas. When either the cell thickness or the temperature difference is increased than the Rayleigh value is increased which also causes the Nusselt number to increase. Equation 2 shows that as the Nusselt number is increased the total heat transfer in the cell is also increased.

$$Q = hN_{\text{ray}}(T_h - T_0)$$

Equation 2 also shows that the heat transfer through the cell 10 is also dependent on the facial area of the cell 10 (i.e., A = X Y). As the facial area is increased, the heat transfer through the cell 10 is also increased. The equation for heat transfer also shows the importance of the thermal conductivity value, $k$, of the gas used in the cell structure. The smaller the thermal conductivity of the gas the lower the total heat transfer through the cell structure. Thermal conductivity of the gas is a function of the gas type (i.e., some gases are better insulators than others), the moisture content of the gas (i.e., increased water content increases the thermal conductivity of the gas), and on the temperature.

One will appreciate from the above discussion that there is an interplay between heat loss through convection, as primarily influenced by cell thickness, and heat loss through conduction, as primarily influenced by the facial area of the cell, along with the thickness of the cell. In one embodiment, this interplay is balanced leading to a preferred range for dimensions of the cell 10. That is, as the cell 10 thickness is increased heat transfer through convection is decreased. Nevertheless, there is a point of diminishing returns due to the fact that convective mixing or rotational motion increases as the cell 10 thickness is increased. Increased convective mixing and loss of insulation value is seen as an increase in the Rayleigh value for the cell 10. That is, as the thickness of the cell 10 is increased, there is a point where the increase in heat transfer due to convection is greater than the decrease in heat transfer due to conduction. After this point there is no longer a need to increase the thickness because no benefit in reducing heat transfer can be obtained.

Through use of this theoretical model, it was determined the preferred dimensions for minimal heat transfer through the cell 10 occur at a preferred Rayleigh value less than 300,000. More preferably, the Rayleigh value of the cell is in a range from about 50,000 to about 275,000. Most preferably, the Rayleigh value of the cell is in a range from about 125,000 to about 250,000. Rayleigh values greater than 300,000 will cause the insulating cell to perform less optimally due to convective heat transfer. This will reduce the effectiveness of the gas cell 10 as an insulator.

In one embodiment, the present invention includes a gas-filled, highly insulating cell 10. The cell 10 includes a first sheet of a gas impermeable material and a second sheet of a gas impermeable material joined together to form a cell 10. In one embodiment of the present invention, the cell 10 depicted in FIG. 1 is attached to a dry gas reservoir 12 and a valve mechanism 16 configured to allow the dry insulating gas to be introduced into and removed from the cell 10. Additionally, the cell 10, the gas reservoir 12, and the valve mechanism are connected to the cell 10 by means of a gas line 14. As was explained more fully in the preceding paragraphs, the volume and XYZ dimensions of the cell are chosen such that free and forced convective mixing of gas inside the cell is minimized.

In one embodiment, the cell 10 includes a dry insulating gas disposed within the cell 10. The identity of the insulating gas is an important factor in determining the insulating properties of the cell 10. In general, dry gases insulate better than moist gases, monatomic gases insulate better than diatomic or polyatomic gases, and heavy, viscous gases insulate better than lighter, less viscous gases. Preferably, the gas disposed within the cell 10 has a moisture content less than about 4% by weight. More preferably, the gas disposed within the cell 10 has a moisture content less than about 2% by weight. Most preferably, the gas disposed within the cell 10 has a moisture content less than about 1% by weight. The insulating gas can be selected from the group consisting of atmospheric air, argon, krypton, xenon, carbon dioxide, sulfur hexafluoride, and combinations thereof.
In one embodiment, the preferred Rayleigh value for the cell 10 is less than 300,000. More preferably, the Rayleigh value of the cell is in a range from about 50,000 to about 275,000. Most preferably, the Rayleigh value of the cell is in a range from about 125,000 to about 250,000. Based on a preferred Rayleigh value of less than 300,000, preferred X, Y, and Z dimensions for the cell 10 depicted in FIG. 1 were determined. Preferably, the cell volume is less than about 300 cm$^3$ with XYZ dimensions of less than about 7 cm by about 14 cm by about 3 cm. More preferably, the cell volume is less than about 145 cm$^3$ with XYZ dimensions of less than about 4 cm by about 12 cm by about 3 cm. Most preferably, the cell volume is less than about 100 cm$^3$ with XYZ dimensions of less than about 4 cm by about 8 cm by about 3 cm. These dimensions minimize heat transfer due to both forced and natural convection.

II. Insulative Material Having Cellular Structure

In one embodiment of the present invention, a plurality of insulative cells as depicted in FIG. 1 are grouped together to form an insulative cell structure. FIGS. 2-10 depict various arrangements of the plurality of cells 10 that form a cell structure.

With reference to FIG. 2, the cell structure 20 comprises a first sheet of a gas impermeable material and a second sheet of a gas impermeable material that are joined together to form a chamber there between. The chamber is subdivided into a cellular structure comprising a plurality cells 10. The first and second sheets are bonded together such that there are open sections that form the cells 10. In between the cells, there are regions 29 where the first and second sheets are bonded together leaving essentially no open space between the first and second sheets.

In one embodiment, the cells 10 are in fluid communication with one another. In the cellular structure depicted in FIG. 2, the cells 10 are in fluid communication with one another via short connector tubes 26 and 28 that allow gas to flow between cells 10. It should be mentioned, however, that the connector tubes 26 and 28 do not enhance convection within the cells 10. That is, the connector tubes 26 and 28 are sufficiently small and they are placed such that convection currents do not form between adjacent cells 10.

In one embodiment, a dry insulating gas is disposed within the plurality of cells 10. The identity of the insulating gas is an important factor in determining the insulative properties of the insulative article 20. In general, dry gases insulate better than moist gases, monatomic gases insulate better than diatomic or polyatomic gases, and heavy, viscous gases insulate better than lighter, less viscous gases. Preferably, the gas disposed within the cells 10 has a moisture content less than about 4 percent by weight. More preferably, the gas disposed within the cells 10 has a moisture content less than about 2 percent by weight. Most preferably, the gas disposed within the cells 10 has a moisture content less than about 1 percent by weight. The insulating gas is selected from the group consisting of atmospheric air, argon, krypton, xenon, carbon dioxide, sulfur hexafluoride, and combinations thereof.

The insulative article 20 depicted in FIG. 2 is depicted as it may be attached to a dry gas reservoir 12 and a valve mechanism 16 configured to allow the dry insulating gas to be introduced into and removed from the cells 10 comprising the insulative article 20. The insulative article 20 is connected to the gas reservoir 12, and the valve mechanism 16 via a gas line 14. The connector tubes 26 and 28 depicted in FIG. 2 allow gas introduced into one cell 10 to fill all cells 10 in the insulative article 20.

As was explained more fully in the preceding section, the volume and X dimension 22, Y dimension 24, and Z dimension (not shown) of the cells 10 are chosen such that free and forced convective mixing of gas inside the cell is minimized. Minimizing free and forced convection of the gas inside the plurality of cells 10 increases the insulative efficiency of the insulative article 20. In one embodiment, the preferred Rayleigh value for the each of the plurality of cells 10 is less than about 500,000. More preferably, the Rayleigh value of the cell is in a range from about 50,000 to about 275,000. Most preferably, the Rayleigh value of the cell is in a range from about 125,000 to about 250,000. Based on a preferred Rayleigh value of less than about 300,000, preferred dimensions for each of the plurality of cells 10 depicted in FIG. 2 were determined. Preferably, the cell volume is less than about 300 cm$^3$ with XYZ dimensions of about 7 cm by about 14 cm by about 3 cm. More preferably, the cell volume is less than about 145 cm$^3$ with XYZ dimensions of about 4 cm by about 12 cm by about 3 cm. Most preferably, the cell volume is less than about 100 cm$^3$ with XYZ dimensions of about 4 cm by about 8 cm by about 3 cm. In one embodiment, the cell volume may be in a range from about 0.25 cm$^3$ to about 2000 cm$^3$, more specifically in a range from about 0.25 cm$^3$ to about 1000 cm$^3$, and even more specifically in a range from about 2 cm$^3$ to about 300 cm$^3$. These dimensions minimize heat transfer due to both forced and natural convection.

In one embodiment, the first and second sheets of material that form the plurality of cells 10 that comprise the insulative article 20 are comprised of a fabric, such as nylon, polyester, or spandex, bonded to a gas impermeable material. Examples of suitable gas impermeable materials include, but are not limited to, polyethylene, polypropylene, polyurethane, urethane, silicone rubber, latex rubber, polytetrafluoroethylene (PTFE), expanded PTFE, butyl rubber, and Mylar.

FIG. 3 depicts an alternate arrangement of a plurality of cells 10 to form an insulative article 30. The cells 10 are formed as open space between two layers of gas impermeable material that are joined together to form a plurality of cells 10. Joined regions 36 are formed between the cells 10. In one embodiment, the cells 10 may be arranged in a zigzag fashion with adjacent cells 10 arranged at substantially right angles relative to one another. Each cell 10 has an X dimension 32, a Y dimension 34, and a Z dimension (not shown). The Y dimension 34 is depicted in part by an imaginary line that extends into the adjacent cell. The cell is bounded by the dotted lines because gas atoms traveling through the center of the cell have a free motion that is essentially bounded by these dimensions since most the gas atoms bouncing off the walls will stay within this space. For purposes of this invention, the plurality of cells can be partially open so long as the cells are at angles that limit direct flow. In one embodiment the opening in the cell has a surface that is less than about 20% of the surface area of the cell walls, more preferably less than about 10%, and most preferably less than about 5 percent.

As in the previous examples, the dimensions of each of the cells 10 are chosen such that heat loss through convection is reduced or minimized. Even though the cells are connected, the formation of convection currents that lead to heat loss are minimized because the right angles break up the free flow path of any convection currents that may form. That is, rotational convection currents generally cannot form around
Heat loss through convection is minimized if the Rayleigh value for the each of the plurality of cells 10 is preferably less than about 300,000. More preferably, the Rayleigh value of the cell is in a range from about 50,000 to about 275,000. Most preferably, the Rayleigh value of the cell is in a range from about 125,000 to about 250,000. Based on a preferred Rayleigh value of less than about 300,000, preferred dimensions for each of the plurality of cells 10 depicted in FIG. 3 were determined. Preferably, the cell volume is less than about 300 cm³ with XYZ dimensions of about 7 cm by about 14 cm by about 3 cm. More preferably, the cell volume is less than about 145 cm³ with XYZ dimensions of about 4 cm by about 12 cm by about 3 cm. Most preferably, the cell volume is less than about 100 cm³ with XYZ dimensions of about 4 cm by about 8 cm by about 3 cm. These dimensions minimize heat transfer due to both forced and natural convection.

FIG. 4 depicts another alternate arrangement of a plurality of cells 10 to form an insulating article 40. The arrangement is similar to the arrangement depicted in FIG. 2. The cells 10 are formed as open space between two sheets of gas impermeable material that are bonded together to form a plurality of cells 10. Bonded regions 49 are formed between the cells 10. The cells are in fluid communication with one another via connector tubes (46 and 48) between the cells.

As in previous examples, each of the plurality of cells 10 have an X dimension 42, a Y dimension 44, and a Z dimension (not shown). The XYZ dimensions are chosen according to the preferred Rayleigh value of less than 300,000 so as to minimize heat loss through convection of the gas within the cells 10.

FIG. 5 depicts another alternate arrangement of a plurality of cells 10 to form an insulating article 50. The arrangement is similar to the arrangement depicted in FIG. 3. The cells 10 are formed as open space between two sheets of gas impermeable material that are bonded together to form a plurality of cells 10. Bonded regions 58 are formed between the cells 10. The cells are in fluid communication with one another via connector tubes 56 between the cells.

As in previous examples, each of the plurality of cells 10 have an X dimension 52, a Y dimension 54, and a Z dimension (not shown). The XYZ dimensions are chosen according to the preferred Rayleigh value of less than 300,000 so as to minimize heat loss through convection of the gas within the cells 10.

In one embodiment, the insulating articles depicted in FIGS. 2-10 may be used to insulate outdoor apparel. Exemplary outdoor apparel items include, but are not limited to, coats, parkas, jackets, vests, gloves, mittens, hats, liners, and boots.

In one embodiment, the insulating articles depicted in FIGS. 2-10 may be used to insulate outdoor gear. Exemplary outdoor gear items include, but are not limited to, tents, sleeping bags, bivouac bags, and sleeping pads.

III. Methods for Making an Insulative Article

A method for manufacturing a lightweight, gas-filled, highly insulative material can include all or portion of the following steps: (1) providing a first sheet of a gas impermeable material and a second sheet of a gas impermeable material; (2) welding the first and second sheets of gas impermeable material together to form a chamber having a cell structure comprising a plurality of cells that are in fluid communication; (3) providing a valve mechanism configured to allow an insulating gas to be introduced into and removed from the plurality of cells; and (4) filling the plurality of cells with a dry insulating gas selected from the group consisting of argon, krypton, xenon, carbon dioxide, sulfur hexafluoride, and combinations thereof. In an alternative embodiment, dry atmospheric air can also be used, although the foregoing dry gases are preferred. Preferably, the insulating gas used to fill the plurality of cells has a moisture content less than about 4 percent by weight. More preferably, the insulating gas used to fill the plurality of cells has a moisture content less than about 2 percent by weight. Most preferably, the insulating gas used to fill the plurality of cells has a moisture content less than about 1 percent by weight.

In one embodiment, the first and second sheets that form the cellular structure comprise a fabric, such as nylon, polyester, or spandex, bonded or laminated to a gas impermeable material. Preferably the materials used to form the insulative material are flexible such that the insulative material can be wearable or useable next to a person's body. Examples of suitable gas impermeable materials include, but are not limited to, polyethylene, polypropylene, polyurethane, urethane, silicone rubber, latex rubber, polytetrafluoroethylene (PTFE), expanded PTFE, butyl rubber, and Mylar. In one embodiment, a portion of the bladder can also be formed of a Kevlar material and/or a laminated Kevlar material. The lamination can be any gas impermeable material or composition.

Exemplary techniques for joining the first and second sheets of gas impermeable material together to form a chamber having a cell structure comprising a plurality of cells that are in fluid communication include, but are not limited to, ultrasonic welding, laser welding, stamp heat welding, hot plate welding, gluing, taping, sewing, and other fabric joining techniques known by those having skill in the art, such as, but not limited to weaving, including one piece woven fabrics. For example, the repeating patterns of cells, examples of which are depicted in FIGS. 2-10, can be formed by joining two sheets of gas impermeable fabric together with an ultrasonic welding drum or a hot plate welding drum that is machined to impress the pattern into the sheets of fabric. Alternatively, the two sheets can be woven together as one piece and sealed to form chambers using techniques known in the art of making airbags.

Exemplary techniques to welding the first and second sheets of gas impermeable material together to form a chamber having a cell structure comprising a plurality of cells that are in fluid communication include, but are not limited to, ultrasonic welding, laser welding, stamp heat welding, hot plate welding, gluing, taping, sewing, and other fabric joining techniques known by those having skill in the art. For example, the repeating patterns of cells, examples of which are depicted in FIGS. 2-10, can be formed by welding two sheets of gas impermeable fabric together with an ultrasonic welding drum or a hot plate welding drum that is machined to impress the pattern into the sheets of fabric.

Heat loss through the article is lessened if convective mixing of the gas in the plurality of cells is minimized. In turn convective mixing of the gas in the plurality of cells is minimized if the dimensions are such that the Rayleigh value, which is a function of the cell dimensions, is below about 300,000. In one embodiment of the present invention, the method further comprises choosing a volume and cell dimensions for each of the plurality of cells such that the Rayleigh value of each of the plurality of cells is less than about 300,
Based on a preferred Rayleigh value of less than about 300,000, preferred dimensions for each of the plurality of cells 10 depicted in FIG. 3 were determined. Preferably, the cell volume is less than about 300 cm³ with XYZ dimensions of about 7 cm by about 14 cm by about 3 cm. More preferably, the cell volume is less than about 145 cm³ with XYZ dimensions of about 4 cm by about 12 cm by about 3 cm. Most preferably, the cell volume is less than about 100 cm³ with XYZ dimensions of about 4 cm by about 8 cm by about 3 cm. These dimensions minimize heat transfer due to both forced and natural convection.

In one embodiment, the method disclosed herein further includes incorporating the insulative material into an article of outdoor apparel and/or outdoor gear. Example articles of outdoor apparel and/or outdoor gear include, but are not limited to, coats, parkas, jackets, vests, pants, gloves, mittens, hats, liners, snow boots, work boots, ski boots, snowboard boots, tents, sleeping bags, bivouac bags, and sleeping pads. The insulative material can be an integral component of the article of outdoor gear or apparel. For example, the insulative material can form part of the wall of a jacket or ski pant. The insulative material can be used to make a hat where all or part of the hat is the insulative material with a cellular structure. The insulative material can be a liner in a sleeping bag or it can be sewn such that the insulative material is a permanent component of the sleeping bag. The liner can be used as the fabric portion of the wall of a tent. The insulative material can be used in the floor of the tent to provide a barrier between a person and the ground. In addition, the insulative material can be used as a sleeping pad to provide insulated separation between a person and the ground.

Alternatively, the insulative material can be overlaid or attached as a liner to the article of outdoor gear or apparel. In this case, the insulative material can be attached using a zipper, snaps, hook and loop fastener (i.e., Velcro), or any other suitable connection means. In one embodiment, the insulative material can be incorporated into a vest or jacket that can zip into the shell of a coat. This mechanism allows the insulative material to be selectively used or removed depending on weather conditions.

FIG. 6 illustrates an insulative laminate that may include cells, such as the cells 10 described hereinabove. The cells 10 are formed by an upper layer 62 and a lower layer 64 secured to one another at seams 66 to form cells having the shapes illustrated in FIGS. 2 through 5.

In order to further reduce convection for a cell size having a given size in the XY plane, an inner layer 68 may be positioned between the upper layer 62 and lower layer 64 in order to form cells 10a and 10b having reduced volume. In some embodiments, the inner layer 68 is gas permeable, whereas in others it is gas impermeable. The inner layer 68 may also be insulative in order to further increase the insulative properties of the article 60. In one embodiment, the inner layer 168 is a closed cell foam or an open celled foam. Open celled foam can be used where the insulative article is to be compressed (e.g., for storage). The open celled foam allows the insulative gas to flow out of the foam cells when the bladder is being deflated and the article compressed. In a preferred embodiment, the inner layer 68 is formed of an insulative synthetic fiber such as THINSULATE™, PRIMALOFT™, or the like. The inner layer 68 inhibits convection between the cells thereby reducing heat transfer. As with other embodiments described herein, an insulative gas, such as argon may be injected into or released from the cells 10.

The inner layer 68 may be secured to the upper layer 62 and 64 by the seams 66. The seams 66 may be formed according to the methods described hereinabove. In some embodiments, where the seams 66 are formed by ultrasonic, or other, welding techniques, the upper layer 62 and lower layer 64 may permeate the inner layer 68 in order to secure to one another and the inner layer 68.

In another embodiment of an insulative laminate material 70 is illustrated in FIGS. 7 through 10. In the embodiments of FIGS. 7 through 10, the cells 10 are formed by an upper gas impermeable layer 71 and a lower gas impermeable layer 73 that form the air chamber. A plurality of interior or middle layers 74 divide the space between impermeable layers 71 and 73 to form an upper layer of cells 10a and a lower layer of cells 10b. Interior layers 74 are attached to upper layer 71 at wall 76, which forms a seam between cells 10a of upper layer 71. Interior layers 74 are also attached at walls 80, which form a seam between cells 10b. While the seams 76 and 80 are shown as spanning a relatively large area of a cell, those skilled in the art will recognize that the walls 76 and 80 can have any length depending on the technique used to join the interior layers. In one embodiment, the seams can be as narrow as the thickness of the material of interior layers 74. Interior layers 74 may or may not be gas impermeable since these layers are within the air chamber formed by joining gas impermeable layers 71 and 73.

In FIG. 8, the walls 80 (i.e., the seams of the layer of cells 10b) are at least partially offset from the walls 76 (i.e., the seam of the layer of cells 10a). The article 70 of FIGS. 7 and 8 may be formed using any technique including laminating, weaving, welding, adhesives, stitching, and the like.

In one embodiment, article 70 may be manufactured using a spacer and a fabric welding technique. In this embodiment, middle layer 74 is first secured to upper layer 71. Next a spacer is positioned in the upper layer of cells 10a and lower layer 73 is welded to the layer of cells 10a at a location other than the seam, so as to create an overlap with the cells and the seams. The spacer can then be removed from cells 10a. The use of the spacer prevents wall 80 from being welded to wall 72, thereby preserving the first layer of cells during formation of the second layer of cells. This embodiment is advantageous for forming gas-impermeable interior layers 74.

In an alternative embodiment, layers 71, 73 and interior layers 74 can be joined together and then laminated to make layers 71 and 73 gas impermeable. For example, layers 71, 73 and 74 can be woven and then laminated using lamination techniques known in the art. In one embodiment, layers 71 and 73 may be made gas impermeable by laminating with a material selected from the group including polyethylene, polypropylene, polyurethane, urethane, silicone rubber, latex rubber, polytetrafluoroethylene (PTFE), expanded PTFE, butyl rubber, and/or Mylar and/or materials that provide a similar functionality.

Yet another alternative embodiment is described with reference to FIG. 9 in which an interior layer 74a is a single continuous layer. In FIG. 9, the layered laminate material 70 may be formed by coupling an upper layer 71a to an intermediate or interior layer 74a to form seams 76a. The lower layer 73a may then be coupled to the intermediate layer 74a by means of an adhesive or other fastening means. The seams 76a are preferably offset from the seams 80a as in the embodiment described with respect to FIG. 8. As with other embodiments described herein, an insulative gas, such as argon may be injected into or released from the cells 10a.
and/or 10b. The present invention includes insulative materials with any number of layers having cells and or subcells formed therein. In addition, all or some of the layers may be offset or patterned so as to position the insulative portion of the cells of one layer above the seams of another layer.

The configuration of the cells in FIGS. 8 and 9 can be achieved for the arrangement of cells illustrated in FIGS. 2 through 5 and/or any other arrangement of cells where the cells can be layered. Moreover, the cells do not need to have a rectangular shape. In some embodiments, the cells can be polygonal and/or spheroidal. FIG. 10 illustrates a portion of an insulative material 150 that includes spheroidal shaped cells. An upper layer of cells 152 is disposed above a lower layer of cells 154. The spheroidal cells 152 are offset from spheroidal cells 154 such that the seams of the cells in the layers are insulated by the adjacent layer 152 or 154. In one embodiment, spheroidal cells 152 and 154 have a cross section similar to FIG. 8.

The cells of the insulative layer can also vary in size in certain regions of the insulative material. The various sizes can be selected to maximize insulation where insulation is most needed and minimize the volume of gas for other locations where insulation is not as important. In one embodiment, the insulative material can include regions configured to provide increased insulation (relative to other regions of the insulative material) for certain body parts of a person.

For example, the insulative material can be configured to provide increased insulation to regions of the body, excluding, but not limited to, a head region, a shoulder region, a hip region, or a calf region of a person's body or a subportion of any of these regions.

The increased insulation can be provided by increasing the thickness of the insulative material. In one embodiment, the thickness can be in a range from about 0.5 cm to about 20 cm, more preferably about 1 cm to about 10 cm, and most preferably about 1.5 cm to about 5 cm. In one embodiment, the difference in the thickness between the differently sized cells in different regions of the insulative material is in a range from about 1.1 to about 20 times the thickness, more specifically about 1.2 to about 10 times the thickness, and even more specifically about 1.3 to about 5 times the thickness.

FIG. 11 illustrates an example of an article of outdoor gear or apparel incorporating cells with different thicknesses in different regions of the insulative material. FIG. 11 illustrates a sleeping pad 110 having a surface sized and configured to support a person lying thereon. For example, the sleeping pad 110 may include a cell structure suitable for withstanding pressures needed to support a person weighing between 20 kg to 120 kg. The sleeping pad 110 may have a width in a range from 40 cm to 100 cm, more specifically 60 cm to 80 centimeters, a length in a range from 140 cm to about 250 cm, more specifically 170 to 200 centimeters, and a height (i.e., thickness) in a range from 1 cm to about 20 cm, more specifically 3 cm to 10 centimeters.

Sleeping pad 110 has a head portion 112, a torso portion 114 and a lower extremity portion 116. Each portion, 112, 114, and 116 may include regions configured to provide increased or decreased insulation depending on the relative importance of the region. For example, in one embodiment, increased insulation can be provided by head region 118, shoulder region 120, hip region 122, and calf region 124. Regions 118, 120, and 124 are positioned and configured to engage the head, shoulders, hips, and calf, respectively of a person lying on sleeping pad 110. Moreover, sleeping pad 110 includes lesser insulated regions 126, 128, 130, and 132. In a preferred embodiment, the lesser insulated regions cover a larger percentage of the sleeping pad at the periphery, while the more highly insulated regions cover a larger percentage of the sleeping pad near the center.

The insulative material of sleeping pad 110 includes first and second gas impermeable layers joined together to form a chamber having a cell structure including a plurality of cells that are in fluid communication. One or more interior layers of material are positioned within the chamber between the first and second gas impermeable layers. The one or more interior layers divide the chamber into the plurality of cells. The plurality of cells may form a first layer of cells above a second layer of cells. Any of the cellular structures described above with respect to FIGS. 1-10 or a similar structure can be incorporated into sleeping pad 110.

The increased insulation may be provided by incorporating thicker cells into regions 118, 120, 122, and 124, as compared to regions 126, 128, 130, and 132, respectively. The thicker regions may be thinner by about 1.1 to about 4 times, more specifically about 1.2 to about 3 times, and even more specifically about 1.3 to about 2 times. In one embodiment, these ranges allow thicker regions of insulation without abrupt changes in the contour. The use of thicker and thinner regions is advantageous because the overall volume of the sleeping pad can be reduced and/or the effective insulative potential increased compared to a sleeping pad that maintains the same cell size throughout.

Sleeping pad 110 also includes a valve mechanism 134 that allows a gas to be introduced into sleeping pad 110. Any of the gasses and/or valve mechanisms described herein can be used in conjunction with the insulative material incorporated into sleeping pad 110. The valve mechanism 134 can be actuated by blowing (e.g., by mouth) and/or by using a filling system as described below with reference to FIG. 14. Alternatively, valve mechanism 134 can be actuated using a hand or foot pump and/or using an electric pump to inflate the cells.

The insulative materials with two or more layers of cells as described with respect to FIGS. 7-10 can be incorporated into any outdoor gear or apparel where flexible insulation is desirable. Examples of outdoor gear that can utilize the layered insulative materials described herein include a tent, a sleeping bag, a bivouac bag, or a sleeping pad, or the like. Examples of outdoor apparel that can incorporate the layered insulative material includes, but is not limited to, a vest, jacket, glove, pant, boot, or the like.

FIG. 12 illustrates a wearable item 90 that includes an insulating material having cells 100 formed according to any of the layered materials described above with respect to FIGS. 2-10. The cells 100 may be in fluid communication with an inlet valve 92. The inlet valve 92 may be secured to an outer surface of the wearable item. The inlet valve 92 may be secured to the wearable item 90 by means of adhesive, welding, or the like.

Referring to FIG. 13, in another embodiment, an insulative pad 82 is formed of an upper layer 84 and a lower layer 86 joined at their perimeters to define a cavity. A foam layer 88 may be positioned between the upper layer 84 and lower layer 86. The foam layer 88 is preferably formed of an open-cell foam. The foam layer 88 preferably occupies substantially the entire volume defined by the upper layer 84 and lower layer 86, such as between 80 and 95 percent of the
volume. The pad 82 may be sized to support a sleeping person. For example, the upper layer 84 and lower layer 86 may define a volume have a width of between 60 and 80 centimeters, a length of between 170 and 200 centimeters, and a height of between 3 and 10 centimeters. As with other embodiments described herein, an insulative gas such as argon may be injected into or released from the pad 82 by means of a valve or some other means permitting the inflation and deflation of the pad 82.

IV. System for Inflation of Insulative Material

[0091] The present invention includes a system for inflating and deflating a gas bladder of an insulative material as described above. For example the inflation system can be used to deliver a gas, (e.g., dry gas) to sleeping pad 110 through valve 134 or into jacket 90 using valve 92. Referring to FIG. 14, an inflation device 94, may be selectively coupled to valves 134 or 92. The filling apparatus 94 may include a gas reservoir 96, a house 98, an outlet valve 100, an outlet orifice 102, and a shroud 104. The gas reservoir 96 is secured to the housing 98, such as by means of threads formed on the reservoir 96 engaging corresponding threads on the housing 98. In some embodiments, a spike 99 may be positioned to pierce a membrane of the gas reservoir as the reservoir 96 is threaded into the housing 98. The gas reservoir 96 is in fluid communication with the valve 100 such that the valve 100 controls the release of gas from the reservoir 96 when it is coupled to the housing 98.

[0092] The valve 100 is preferably manually actuated, such as by means of pressing a button or lever. The valve 100 is in fluid communication with the outlet orifice 102 such that gas is released through the orifice 102 when the valve 100 is manually actuated. In some embodiments, a pressure regulator 105 may be positioned in the fluid path between the gas reservoir 96 and the orifice 102 to reduce the output pressure. The shroud 104 surrounds the orifice 102 and performs at least one of two functions: coupling the portable filling apparatus 94 to the valve 92 or 134 of the wearable item 90 or sleeping pad 110 and providing a seal between the valve 92 or 134 and itself. In some embodiments, a post 106 projects outwardly adjacent the orifice in order to depress the valve 92 or 134 when the portable filling apparatus 94 is engaged with the valve 92 or 134.

[0093] The portable filling apparatus 94 may include means for hindering decoupling of the portable filling apparatus 94 from the valve 92. The means for hindering decoupling may also function as means for creating a seal between the portable filling apparatus 94 and the valve 92 or 134.

[0094] For example, the portable filling apparatus 94 may include a friction fit mechanism, a snap-connect mechanism, or a magnet coupler.

[0095] A gas such as air or an inert gas is disposed in portable filling apparatus 94. Where an inert gas is used, the inert gas may be one or more of argon, krypton, or nitrogen. For purposes of this invention, the term nitrogen shall mean diatomic nitrogen, unless otherwise specified. The inert gas is compressed in the canister at a pressure of at least 1000 psi, more preferably at least about 2500, even more preferably at least about 3000 psi, and most preferably at least about 3500 psi or higher. Pressures of at least 2200 psi are important for some embodiment where a relatively large bladder is used. In an alternative embodiment, the pressure volume is at least about 200 MPa-cm³, more specifically 400 200 MPa-cm³, and 600 MPa-cm³. For example to fill an adult size jacket with argon, a pressure of 2200 provides sufficient pressure to ensure that the jacket can be fully inflated. The higher pressures listed above are preferred because they allow additional fills of a jacket or other article without reconnecting a new canister. Using higher pressures is important to some applications in order to obtain a canister that is reasonably portable, light weight, cost effective, and provides sufficient gas for inflating an article of outdoor gear and apparel.

[0096] For the gas canister to be useful in some cold weather applications, the canister may include a gas that undergoes little or no liquefaction at ambient temperatures and pressures in a range from 2000-6000 psi. If the gas in the canister is a liquid (e.g., carbon dioxide), rapid expansion of the gas causes cooling, which can cause a gas filling apparatus to malfunction in cold weather. Examples of suitable insulative gases that can be compressed to high pressures without substantial liquefaction include argon, krypton, and nitrogen. Argon and krypton are particularly preferred for their insulative properties in addition to their suitability for being compressed in a gas canister and rapidly expanded through a gas filling apparatus.

[0097] The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed is:

1. A layered insulative material incorporated into an article of outdoor gear or apparel, comprising:
   - first and second gas impermeable layers joined together to form a chamber having a cell structure comprising a plurality of cells that are in fluid communication; and
   - one or more interior layers of material positioned within the chamber between the first and second gas impermeable layers, the one or more interior layers dividing the chamber into the plurality of cells, wherein the plurality of cells form a first layer of cells above a second layer of cells; and
   - a valve mechanism coupled to the insulative material and configured to allow inflation and deflation of the plurality of cells of the first and second layers of cells.

2. An insulative material as in claim 1, wherein the cell volume is in a range from about 0.25 cm³ to about 2000 cm³.

3. An insulative material as in claim 1, wherein the cell volume is in a range from about 0.25 cm³ to about 1000 cm³.

4. An insulative material as in claim 1, wherein the cell volume is in a range from about 2 cm³ to about 300 cm³.

5. An insulative material as in claim 1, wherein the first and second gas impermeable layers include a woven material.

6. An insulative material as in claim 5, wherein each of the gas impermeable layers includes a gas impermeable laminate material.

7. An insulative material as in claim 6, wherein the gas impermeable laminate material is selected from the group consisting of polyethylene, polypropylene, polyurethane, urethane, silicone rubber, latex rubber, polytetrafluoroethylene (PTFE), expanded PTFE, butyl rubber, and Mylar.

8. An insulative material as in claim 1 further comprising welding a portion of the first and seconds gas impermeable layers together to form the chamber.
9. An insulative material as in claim 8, wherein the welding forms seams that at least partially defines the cells of the plurality of cells.

10. An article of outdoor gear or apparel including an insulative material as in claim 1, the article further comprising a dry gas reservoir configured to allow a dry insulating gas to be introduced into the plurality of cells.

11. An article of outdoor gear or apparel as in claim 10, wherein the dimensions of the plurality of cells are such that the Rayleigh value of the dry insulating gas within the plurality of cells is less than 300,000 for each cell.

12. An article of outdoor gear or apparel as in claim 10, wherein the dry insulating gas is dry atmospheric air having a moisture content less than about 4 percent by weight.

13. An article of outdoor gear or apparel as in claim 10, wherein the dry insulating gas is selected from the group consisting of argon, krypton, xenon, carbon dioxide, sulfur hexafluoride, and combinations thereof.

14. An article of outdoor gear or apparel as in claim 10, wherein the insulative material is incorporated into a coat, a parka, a jacket, a vest, a pant, a glove, a mitten, a hat, a liner, a wader, a boot, a tent, a sleeping bag, a bivouac bag, or a sleeping pad.

15. A method for using an article of outdoor gear or apparel, comprising:
   providing an article of outdoor gear or apparel according to the method of claim 10; and
   filling the plurality of cells with a dry insulating gas selected from the group consisting of atmospheric air, argon, krypton, xenon, carbon dioxide, sulfur hexafluoride, and combinations thereof, wherein the insulating gas has a moisture content less than about 4 percent by weight.

16. A layered insulative material incorporated into an article of outdoor gear or apparel, comprising:
   an insulative material including first and second gas impermeable layers joined together to form a chamber having a cell structure comprising a plurality of cells that are in fluid communication; and
   one or more interior layers of material positioned within the chamber between the first and second gas impermeable layers, the one or more interior layers dividing the chamber into the plurality of cells, wherein the plurality of cells form a first layer of cells above a second layer of cells,
   the first layer of cells including seams between the cells of the first layer,
   the second layer of cells including seams between the cells of the second layer;
   wherein at least a portion of the cells of the first layer of cells overlap with a portion of the seams of the second layer of cells; and
   wherein at least a portion of the cells of the second layer of cells overlap with a portion of the seams of the first layer of cells; and
   a valve mechanism coupled to the insulative material and configured to allow inflation and deflation of the plurality of cells of the first and second layers of cells.

17. An insulative material as in claim 16, wherein the first and second gas impermeable layers are woven.

18. A sleeping pad incorporating a layered insulative material, comprising:
   a sleeping surface sized and configured to support a person lying thereon; and
   a layered insulative material comprising,
   first and second gas impermeable layers joined together to form a chamber having a cell structure comprising a plurality of cells that are in fluid communication; and
   one or more interior layers of material positioned within the chamber between the first and second gas impermeable layers, the one or more interior layers dividing the chamber into the plurality of cells, wherein the plurality of cells form a first layer of cells above a second layer of cells; and
   a valve mechanism coupled to the insulative material and configured to allow inflation and deflation of the plurality of cells of the first and second layers of cells.

19. A sleeping pad as in claim 18, wherein,
   the first layer of cells includes seams between the cells of the first layer;
   the second layer of cells includes seams between the cells of the second layer;
   at least a portion of the cells of the first layer of cells overlap with a portion of the seams of the second layer of cells; and
   at least a portion of the cells of the second layer of cells overlap with a portion of the seams of the first layer of cells.

20. A sleeping pad as in claim 19, wherein the first and second gas impermeable layers are woven.

21. A sleeping pad as in claim 18, wherein certain regions of the camping pad have different sized cells compared to other regions of the camping pad.

22. A sleeping pad as in claim 21, wherein the average thickness of the cells in a region of the sleeping pad configured to support the torso portion of a person is thicker than a region of the sleeping pad configured to support the legs of a person.