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(54) **QUILTED COLD-WEATHER GARMENT WITH A SUBSTANTIALLY UNCOMPRESSED INTERIOR FOAM LAYER**

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(57) **ABSTRACT**

Disclosed is an improved cold weather garment construction. The construction uses two fabric layers positioned about an intermediate foam layer. To improve range of motion and reduces bulkiness, the three layers are quilted together and the foam is provided in varying thicknesses to match anticipated weather conditions. Additionally, the intermediate foam layer can have a skinned layer adjacent to the exterior layer and a convoluted surface opposite the interior layer.

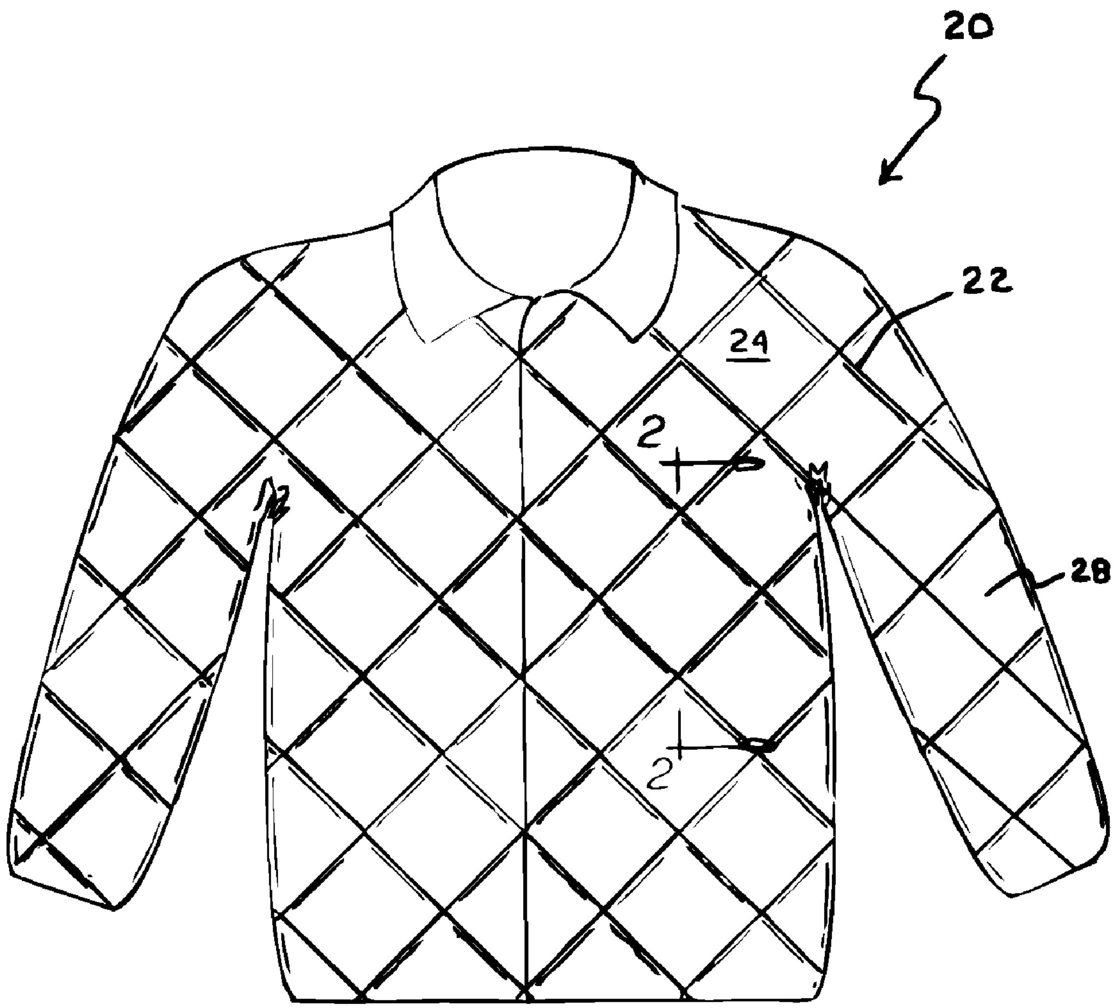


FIG 1

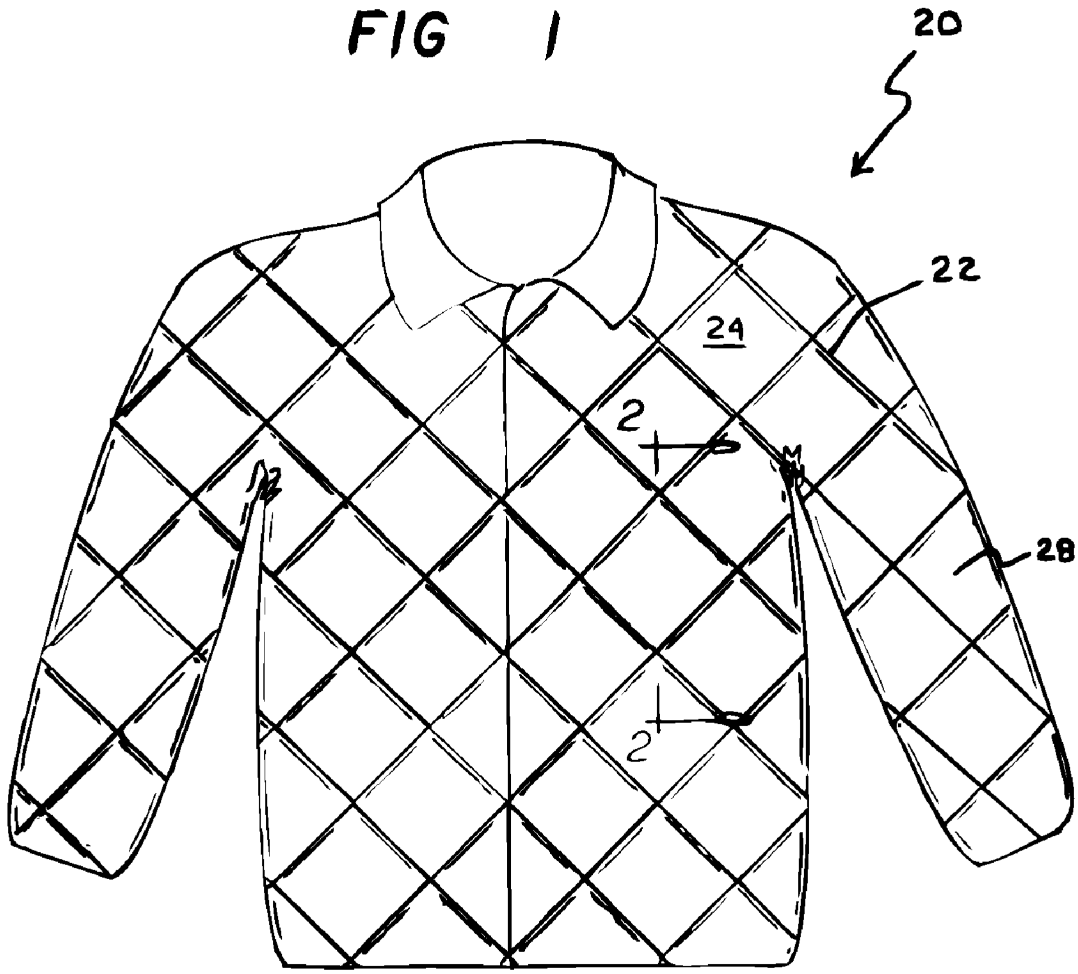


FIG 2

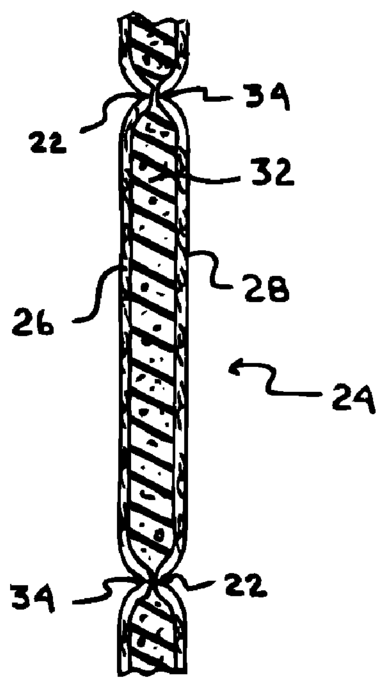


FIG 3

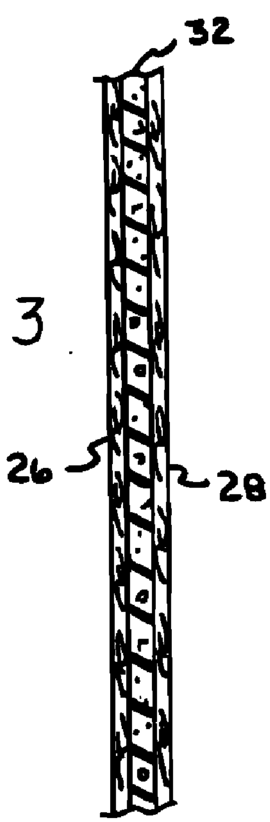


FIG 4

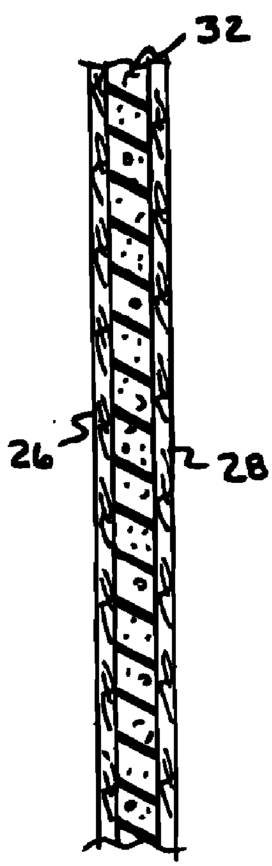


FIG 5

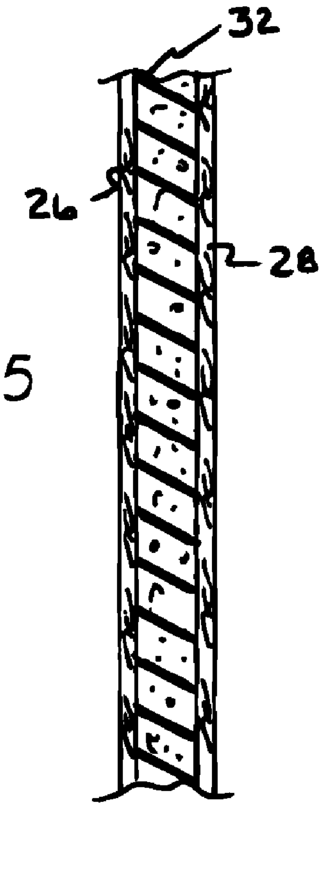
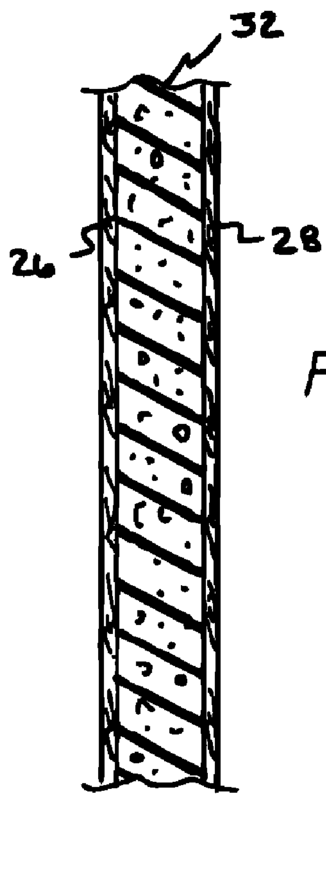


FIG 6



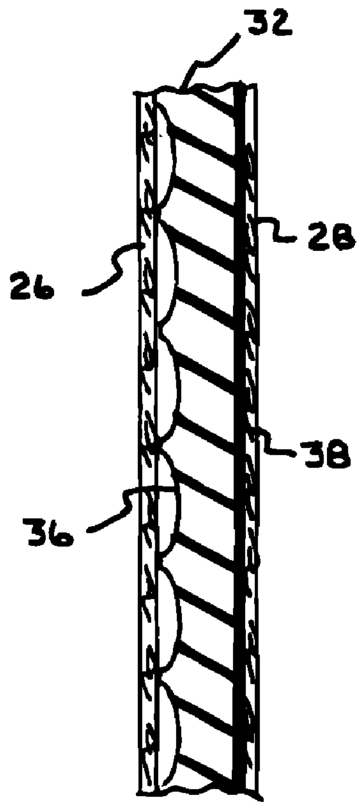


FIG 7

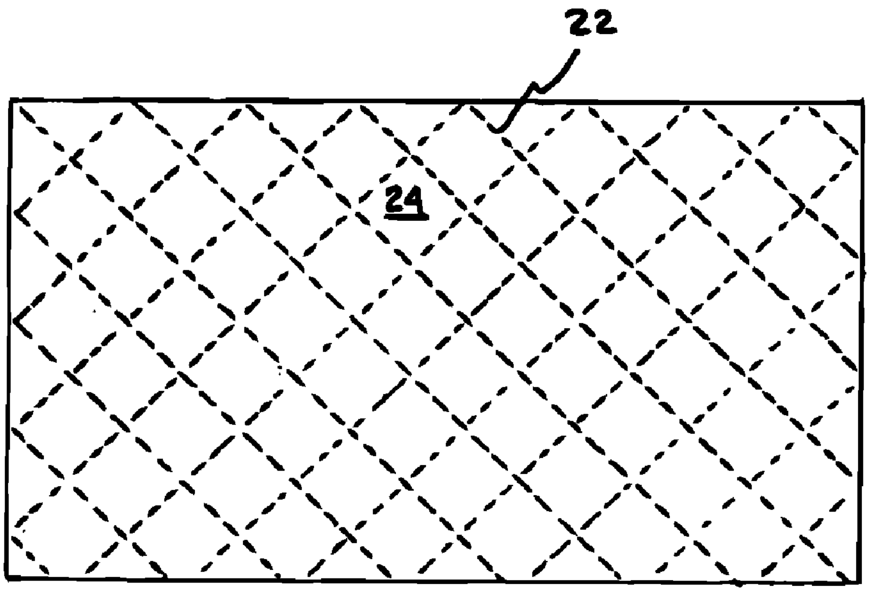


FIG 8

FIGURE 9

Fabric	Thickness(mm)	Density(kg/m^3)
1	24 ± 1.0	19.2 ± 0.84
2	24 ± 1.4	27 ± 2.0
3	12.8 ± 0.60	46 ± 3.1
4	8.0 ± 0.23	39 ± 1.4
5	18 ± 1.3	18 ± 1.3
6	21.8 ± 0.84	29 ± 1.4
7	13.3 ± 0.40	33 ± 1.6
8	24 ± 1.2	23 ± 1.0
9	24.5 ± 0.78	28 ±1.6
10	23 ± 2.4	14 ± 2.6
11	26.6 ± 0.33	25.0 ± 0.41
12	21.0 ± 0.26	25.7 ± 0.31

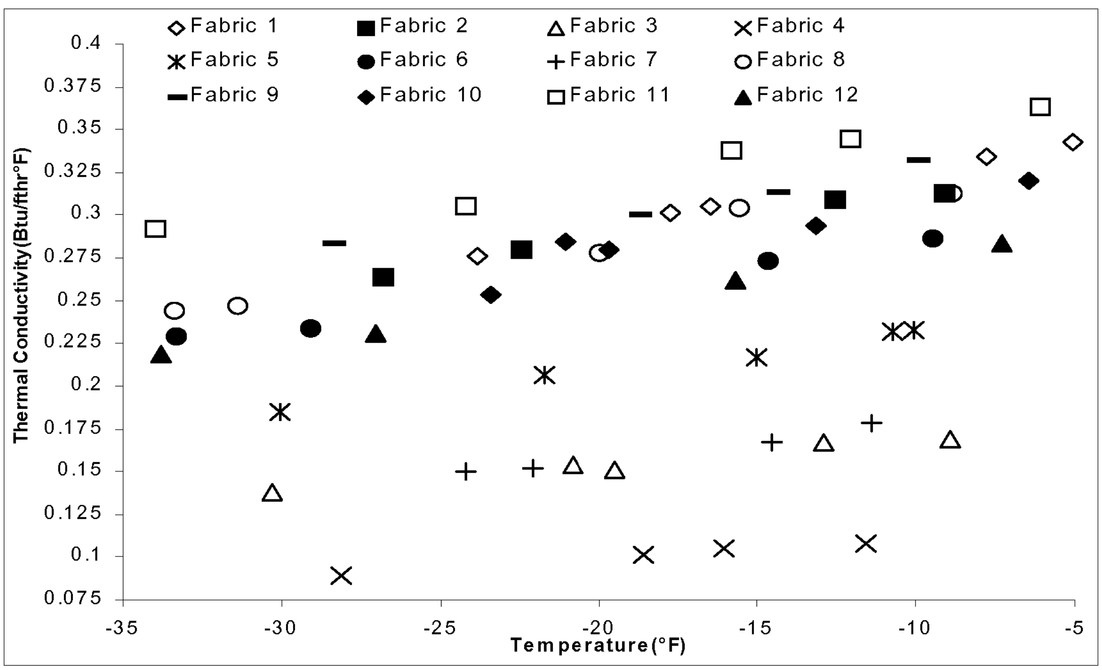


FIGURE 10

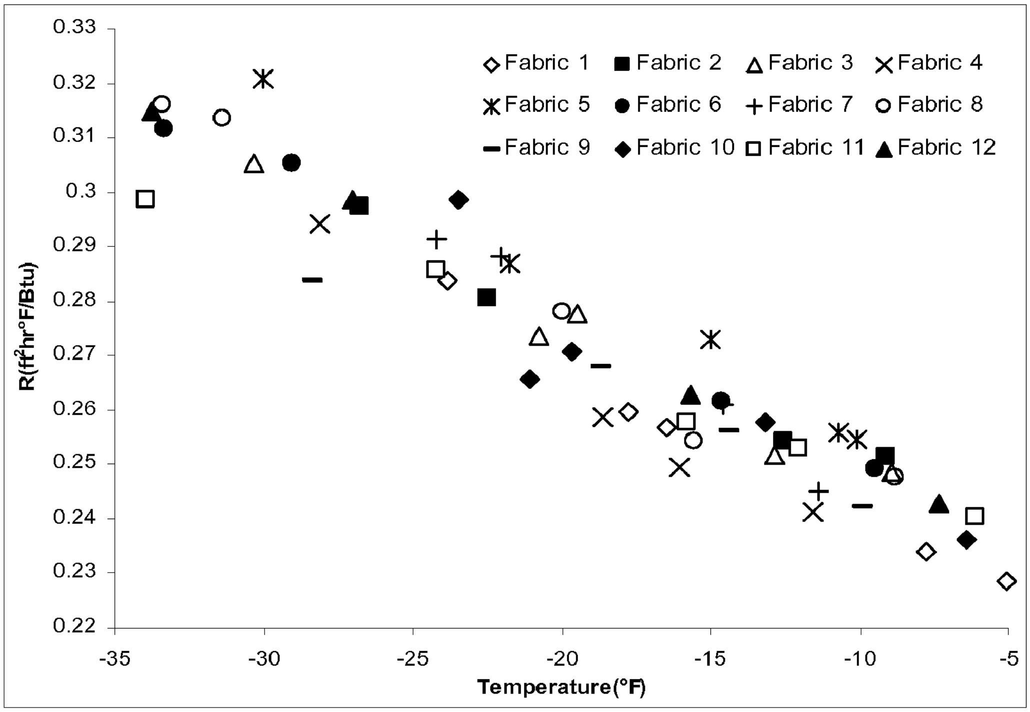


FIGURE 11

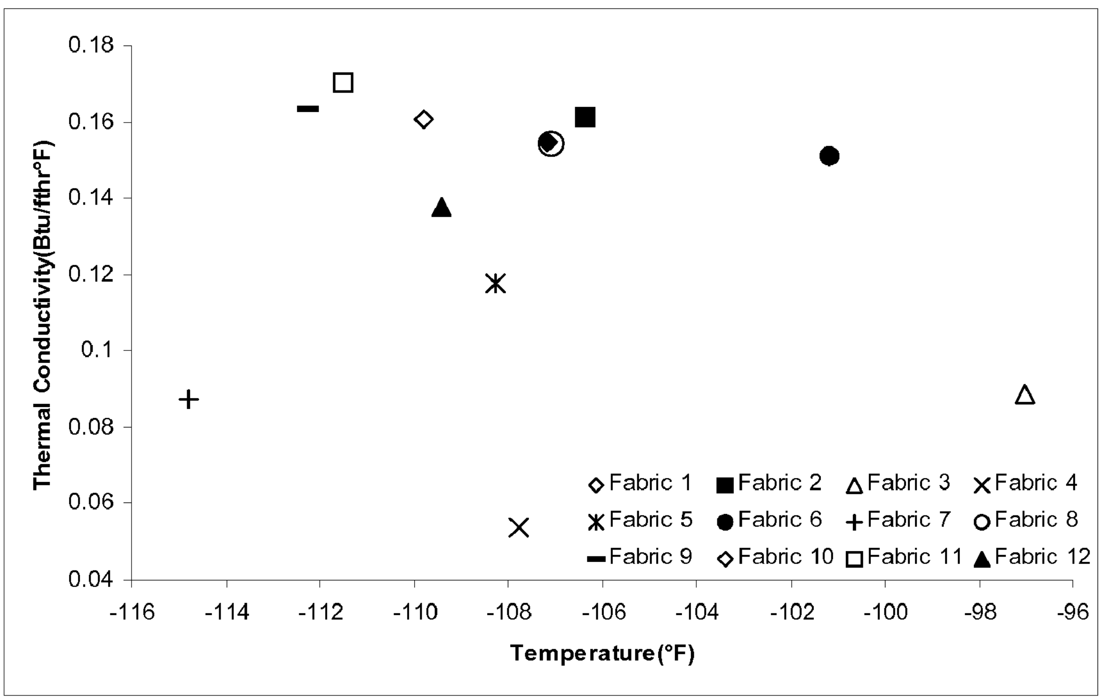


FIGURE 12

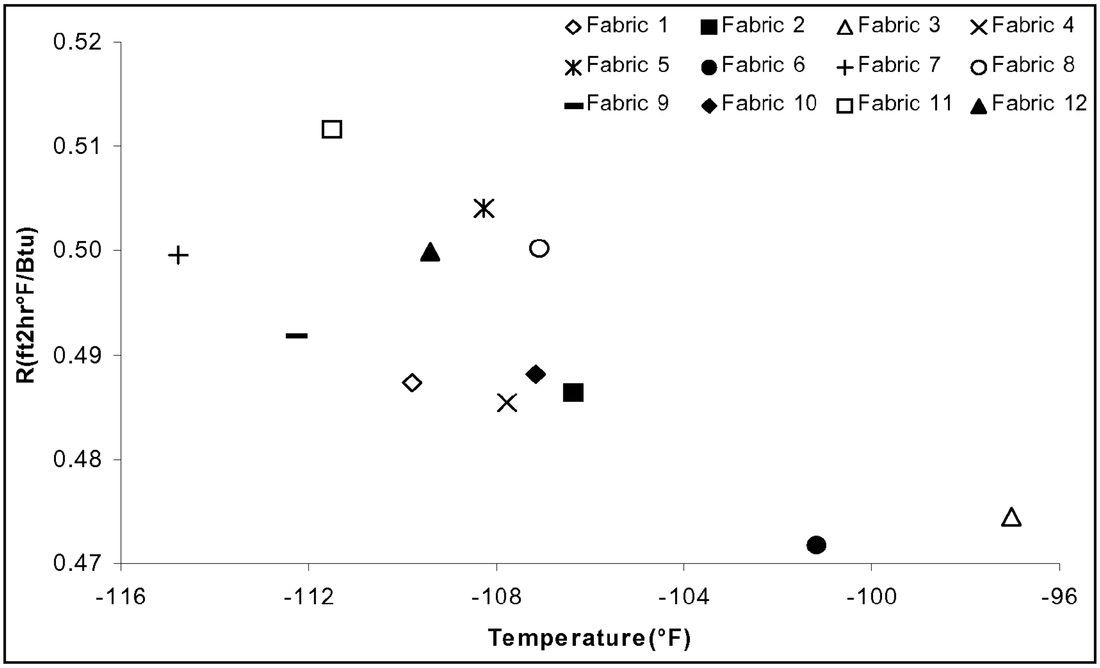


FIGURE 13

	Thermal Conductivities in Btu/(ft * hr * °F)					
Fabric #	**0°F**	**-20°F**	**-40°F**	**-60°F**	**-80°F**	**-100°F**
1	0.36	0.29	0.23	0.19	0.17	0.16
2	0.34	0.28	0.24	0.20	0.18	0.16
3	0.19	0.15	0.13	0.11	0.09	0.09
4	**0.13**	**0.10**	**0.08**	**0.06**	**0.05**	**0.05**
5	0.26	0.21	0.17	0.14	0.12	0.12
6	0.32	0.26	0.21	0.18	0.16	0.15
7	0.21	0.16	0.12	0.10	0.08	0.08
8	0.35	0.28	0.23	0.19	0.16	0.15
9	0.36	0.30	0.25	0.22	0.19	0.17
10	0.34	0.28	0.22	0.18	0.16	0.15
11	0.38	0.32	0.27	0.23	0.20	0.17
12	0.31	0.25	0.21	0.17	0.15	0.14

FIGURE 14

	R Values in $(ft^2 * hr * °F)/Btu$					
Fabric #	**0°F**	**-20°F**	**-40°F**	**-60°F**	**-80°F**	**-100°F**
1	0.21	0.27	0.32	0.37	0.42	0.47
2	0.22	0.28	0.33	0.38	0.43	0.47
3	0.22	0.28	0.33	0.38	0.43	0.48
4	0.20	0.27	0.33	0.38	0.43	0.47
5	0.22	0.29	0.35	0.40	0.45	0.49
6	0.22	0.27	0.33	0.38	0.42	0.47
7	0.20	0.28	0.35	0.40	0.45	0.48
8	0.21	0.28	0.34	0.39	0.44	0.49
9	0.22	0.27	0.31	0.36	0.41	0.46
10	0.22	0.28	0.33	0.38	0.43	0.47
11	0.23	0.27	0.31	0.35	0.39	0.43
12	0.22	0.28	0.33	0.38	0.43	0.48

FIGURE 15

Best Insulator			
Rank	**Static Test**	**Sweat Test**	**Wind Chill Test**
1	Fabric 4	Fabric 4	Fabric 4
2	Fabric 7	Fabric 3	Fabric 7
3	Fabric 3	Fabric 5	Fabric 3
4	Fabric 5	Fabric 6	Fabric 5
5	Fabric 12	Fabric 9	Fabric 12
6	Fabric 6	Fabric 1	Fabric 8
7	Fabric 10	Fabric 7	Fabric 6
8	Fabric 8	Fabric 2	Fabric 10
9	Fabric 2	Fabric 8	Fabric 2
10	Fabric 1	Fabric 11	Fabric 1
11	Fabric 9	Fabric 10	Fabric 9
12	Fabric 11	Fabric 12	Fabric 11

FIGURE 16

QUILTED COLD-WEATHER GARMENT WITH A SUBSTANTIALLY UNCOMPRESSED INTERIOR FOAM LAYER

RELATED APPLICATION

[0001] This application is continuation in part and claims the benefit of priority of U.S. nonprovisional application Ser. No. 11/074,303, filed Mar. 4, 2005, the entire contents of which are incorporated herein by this reference.

FIELD OF THE INVENTION

[0002] This invention relates to a cold weather garment. More particularly, the present invention relates to a multi-layer, quilted garment with a substantially uncompressed interior foam layer.

BACKGROUND

[0003] Through the years, various improvements have been made in the area of cold weather garments. All cold weather garments to date have sought to provide adequate insulation against cold temperatures, wind and water, while at the same time allowing for sufficient moisture vapor transmission from the wearer's body. Garments achieving these goals, however, tend to be unattractive and bulky.

[0004] One well-known cold weather garment system was developed by the outdoorsmen J. G. Phillips, Jr. and Sr. and is known as the Phillips System. The Phillips System, which has been in use for over two decades, provides an opened cell foam layer in between interior and exterior fabric layers. The exterior fabric, or shell, is typically a nylon fabric, and the interior layer is typically a woven or knit lining. The edges of the garment are stitched together. The resulting construction is a unitary garment that is effective in cold weather. The drawbacks of the Phillips System, however, are that it has poor wind resistance and is bulky. Over the years there have been a number of improvements to the Phillips System.

[0005] U.S. Pat. No. 4,690,847 to Lassiter discloses one such improvement. Lassiter '847 improves upon the Phillips System by convoluting the face of the intermediate foam layer. The convoluted face is positioned adjacent the inner fabric layer. The convoluted foam increases flexibility, reduces material and weight and enhances moisture transfer by increasing surface area. This System, however, still suffers from the aforementioned problem of bulkiness and, as a result, it often lacks sufficient dexterity to perform routine movements.

[0006] Another improvement to the Phillips System is disclosed in U.S. Pat. No. 4,734,306 to Lassiter. Specifically, Lassiter '306 employs a skinned foam layer between the interior and exterior fabric layers. The "skinning" is achieved by forming a thin layer upon a flat surface of the foam. The opposite face of the foam can either be convoluted as taught in Lassiter '847 or flat. The use of a skinned foam improves handling during manufacturing, enhances wind resistance, while at the same time maintaining sufficient moisture vapor transmission rates. However, although skinned foam facilitates handling during manufacturing, it does not remedy the bulkiness inherent to the Phillips System.

[0007] Yet another improvement to the Phillips System is demonstrated by U.S. Pat. No. 4,739,522 to Lassiter. Lassiter '522 provides a Phillips-type garment with increased buoyancy by interspersing a series of polystyrene pellets within an opened polyurethane foam to thereby form an intermediate foam layer with both opened and closed cells. The resulting garment allows its wearer to keep warm and remain afloat while immersed in cold water. The interior foam can also have a convoluted face as taught by Lassiter '847. Again, this improvement does not address the aforementioned problem of bulkiness.

[0008] U.S. Pat. No. 4,807,303 to Mann improves upon the Phillips System by providing an exterior layer with low air permeability and high moisture vapor transmission. This increases wind resistance without sacrificing breathability. Mann teaches a garment comprised of three components, an outer layer of nylon fabric; an approximately one inch thick layer of soft and flexible polyurethane open cell foam; and an interior woven or knit lining fabric. The exterior layer can be a woven fabric that is constructed from a fine denier, multi-filament, synthetic yarn woven into a high density construction with controlled air porosity and moisture vapor transport properties. The interior foam layer can be convoluted as described in Lassiter '847. Again, although Mann '303 addresses weather resistance, it is not concerned with the mobility of the resulting garment. Mann does not teach or suggest a plurality of lines of stitching securing together the exterior, interior and intermediate layers in a quilt, wherein the plurality of lines intersect one another to form a box stitch pattern upon the garment.

[0009] U.S. Pat. No. 5,408,700 to Reuben teaches an inner lining having a down-fill or down-fill composition disposed within a pouch forming the inner lining, wherein the composition is substantially evenly distributed throughout the pouch and retained therein in a compressed form. Significantly, the loft of the down-fill composition is reduced by at least twice the normal loft thereof to produce an insulating lining of reduced thickness. By substantially compressing the down-fill material, a thin lining is formed at the expense of the thermal insulating value, which is substantially compromised. Reuben does not teach or suggest a substantially uncompressed intermediate layer of opened-celled polyurethane foam.

[0010] Thus, although each of the above referenced inventions achieves its individual objective, they all suffer from a common problem. Namely, neither the original Phillips System, nor any of its subsequent variations or other known prior art, address a wearer's dexterity and range of movement while wearing the garment and, concomitantly, preserve superior insulating properties of an interior foam layer. In all previous constructions, a thick intermediate foam layer is provided throughout the garment that needlessly encumbers its wearer and/or the intermediate layer is substantially compressed in quilting. Therefore, there exists a need in the art to provide a more streamlined garment that nonetheless affords sufficient weather resistance and moisture vapor transmission. The invention is directed to overcoming one or more of the problems and solving one or more of the needs as set forth above.

SUMMARY OF THE INVENTION

[0011] It is therefore one of the objectives of this invention to create a cold weather garment affords its wearer increased dexterity and a wider range of movement, while not sacrificing cold weather resistance.

[0012] It is also an object of this invention to provide a multilayered garment wherein the multiple layers are quilted together to reduce bulkiness.

[0013] Still another object of this invention is to provide a multilayered garment in a number of different thicknesses such that users can select a specific garment based upon anticipated weather conditions.

[0014] These and other objectives are achieved by providing a cold weather garment with an interior layer, an exterior layer, and an intermediate layer of a polyurethane foam there between. The garment additionally includes a plurality of lines of stitching that secure together the interior, exterior, and intermediate layers into a quilt pattern.

[0015] The objectives of the present invention are also achieved by providing a cold weather garment formed of an exterior layer of a waterproof and/or windproof breathable fabric and an interior layer of a mesh fabric. A layer of an open-celled polyurethane foam is positioned in between the interior and exterior layers. The intermediate layer has a first flat face disposed adjacent to the exterior layer and a skin formed upon the flat face to enhance ease of construction and improve wind resistance. The intermediate layer also includes a convoluted surface with peaks and valleys that is disposed adjacent to the interior layer. The convoluted surface reduces material and weight and improves moisture vapor transfer. A plurality of lines of stitching are provided to secure together the exterior, interior and intermediate layers as a quilt. The plurality of lines also intersect one another to form a box stitch.

[0016] The foregoing has outlined rather broadly the more pertinent and important features of the present invention in order that the detailed description of the invention that follows may be better understood so that the present contribution to the art can be more fully appreciated. Additional features of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and the specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The foregoing and other aspects, objects, features and advantages of the invention will become better understood with reference to the following description, appended claims, and accompanying drawings, where:

[0018] FIG. **1** is a front view of a quilted cold-weather garment constructed in accordance with the principles of the present invention;

[0019] FIG. **2** is a cross-sectional view of the quilted garment taken along line **2-2** of FIG. **1**;

[0020] FIGS. **3-5** are cross-sectional views of quilted garments employing intermediate layers of varying thicknesses;

[0021] FIG. **7** is a cross-sectional view of a garment constructed in accordance with an alternative embodiment of the present invention wherein the interior layer has opposing convoluted and skinned surfaces;

[0022] FIG. **8** is a detailed view of the quilting employed upon the garment of the present invention; and

[0023] FIG. **9** provides a table that shows properties of 12 tested fabrics, wherein fabric **4** is the only multi-layer, quilted garment with a substantially uncompressed interior open-celled foam layer; and

[0024] FIG. **10** provides a plot of thermal conductivities of tested cold weather fabrics under static conditions; and

[0025] FIG. **11** provides a plot of thermal resistances of unknown cold weather coat fabrics under static conditions; and

[0026] FIG. **12** provides a plot of thermal conductivities of the unknown test fabrics under static conditions using liquid nitrogen to reach extremely cold temperatures;

[0027] FIG. **13** provides a plot of thermal resistances of unknown test fabrics under static conditions using liquid nitrogen to achieve extremely cold temperatures;

[0028] FIG. **14** provides a table of calculated thermal conductivities for tested cold weather fabrics;

[0029] FIG. **15** provides a table of calculated thermal resistances for unknown cold weather fabrics; and

[0030] FIG. **16** provides a table of rankings of fabrics in order of insulating properties for both static and sweat tests, based on thermal conductivities.

[0031] Those skilled in the art will appreciate that the figures are not intended to be drawn to any particular scale; nor are the figures intended to illustrate every embodiment of the invention. The invention is not limited to the exemplary embodiments depicted in the figures or the types of footwear, shapes, relative sizes, ornamental aspects or proportions shown in the figures. Similar reference characters refer to similar parts throughout the several views of the drawings.

DETAILED DESCRIPTION

[0032] Referring to the Figures, in which like parts are indicated with the same reference numerals, various views of an exemplary quilted cold-weather garment constructed in accordance with the principles of the present invention are shown. The present invention relates to an improved cold weather garment construction. The construction uses two fabric layers positioned about an intermediate foam layer. To improve range of motion and reduce bulkiness, the three layers are quilted together and the foam is provided in varying thicknesses to match anticipated weather conditions. Additionally, the intermediate foam layer can have a skinned layer adjacent to the exterior layer and a convoluted surface opposite the interior layer. The various components of the present invention, and the manner in which they interrelate, will be described in greater detail hereinafter.

[0033] With reference now to FIG. **1**, a cold weather garment constructed in accordance with the principles of the present invention is depicted. The particular garment illustrated is a jacket **20**. However, it will be understood by those skilled in the art that the present invention can be used in constructing a variety of garments. By way of non-limiting example, the garment construction described herein can be used in the manufacture of pants, gloves, hats, and bodysuits. The invention can be applied to any garment that would benefit from both increased flexibility and enhanced weather resistance. FIG. **1** further illustrates the intersecting lines of stitching **22** that give jacket **20** its quilted construction. In the preferred embodiment, a box stitch is employed that results in a number of rectangular cells **24** being formed over the entire surface of jacket **20**. FIG. **2** is a cross sectional view of an individual cell **24** that shows the various layers in the construction.

[0034] More specifically, FIG. **2** illustrates the interior **26**, exterior **28** and intermediate foam **32** layers of jacket **20**. The stitching **22** at the periphery of cell **24** is also depicted in this Figure. The specific materials making up the interior and exterior layers (**26** and **28** respectively) is next described. In the preferred embodiment, exterior layer **28** is constructed from a waterproof and/or windproof breathable fabric. Any of a number of different types of waterproof and/or windproof breathable fabrics can be employed and those skilled in the art will be familiar with suitable examples. Waterproof breathable fabrics are desirable because they repel water while at the same time allowing for moisture vapor transmission from the wearer's body to the atmosphere. Thus, while the garment can repel rain it is nonetheless breathable. Similarly, windproof breathable fabrics provide suitable moisture vapor transmission while at the same time shielding the wearer from high wind conditions. A preferred exterior fabric would have an air permeability of less than 10 cubic feet per minute per square foot at 0.5 inches head of water. The moisture vapor transmission is also preferably at least around 1,000 grams per square meter per 24 hrs. One example of a suitable waterproof and windproof material is the polytetrafluoroethylene (PTFE) fabric constructed by W. L. Gore & Associations of Newark, Del., under the trade name Gore-Tex®. Another suitable fabric is made by Burlington Industries, Inc. under the trade name Versatech®.

[0035] Unlike exterior layer **28**, interior layer **26** need not be windproof and/or waterproof. The primary purpose of interior layer **26** is to prevent the user's skin from contacting foam layer **32**. Nonetheless, interior layer **26** should have a sufficient degree of moisture vapor transmission, so that moisture from the user's skin can pass through the fabric. Any of a number of mesh fabrics will suffice and those of ordinary skill will be familiar with a number of suitable examples. In the preferred embodiment, interior layer **26** is formed from a tricot fabric. Tricot is a plain warp-knitted fabric with a close, inelastic knit. A loosely knit nylon fabric will also suffice.

[0036] With continuing reference to FIG. **2**, intermediate layer **32** is next described. Intermediate layer **32** is primarily used to provide insulation against cold temperatures. In this regard, intermediate layer **32** is preferably constructed as a foam layer that is substantially thicker than either the interior or exterior fabric layers (**26** and **28** respectively). As described in greater detail hereinafter, the exact thickness of the foam is selected on the basis of anticipated weather conditions. In the preferred embodiment, intermediate layer **32** is constructed from a soft, flexible, polyurethane or polyester foam. As noted in FIG. **2**, the thickness of intermediate layer **32** is reduced at the point **34** where the stitching **22** joins the three layers (**26**, **28** and **32**) together.

[0037] FIGS. **3** through **6** illustrate intermediate foam layers of varying thickness. In the preferred embodiment there are four thicknesses: ⅛ of an inch (FIG. **3**), ¼ of an inch (FIG. **4**), ½ of an inch (FIG. **5**) and ¾ of an inch (FIG. **6**). The thinner layers would be used in more temperate climates, while the thickest layers would be used in only the most severe temperatures. In this way the user need not wear a garment that is too thick for the prevailing weather conditions. This allows for the greatest range of movement and dexterity.

[0038] FIG. **7** illustrates an alternative embodiment for intermediate foam layer **32**. In the alternative embodiment, intermediate foam layer **32** is provided with a convoluted face **36** adjacent to interior fabric layer **26**. Convoluted face **36** is described in greater detail in U.S. Pat. No. 4,690,847 to Lassiter, the contents of which are incorporated herein by reference. As described in Lassiter '847, the peaks and valleys of convoluted surface **36** increase the surface area facing interior fabric layer **26** to thereby increase the transfer of moisture vapor from the user's body. The convolutions also serve to reduce the amount of foam material used and the overall weight of the garment. The embodiment of FIG. **7** also includes a skinned layer **38** that is formed on the foam opposite convoluted face **36**. Skinned layer **38** is described in greater detail in U.S. Pat. No. 4,734,306 Lassiter, the contents of which are incorporated herein by reference. As discussed in Lassiter '306 the skin improves the garment's wind resistance and facilitates handling while the garment is being manufactured.

[0039] The preferred stitching arrangement for the garment is next described with reference to FIG. **8**. FIG. **8** illustrates the plurality of lines of stitching **22** that are used to secure together the interior, exterior and intermediate layers (**26**, **28**, and **32**) of the garment to form a number of individual cells **24** over the surface of the garment. This gives the garment its quilted construction. Cells **24** serve to improve the overall flexibility of the resulting garment. Users thus have a far greater range of motion than they would otherwise have if the garment was unquilted. In the preferred embodiment, a box stitch is used to quilt the garment. That is, each of the cells **24** is a rectangle. However, it is within the scope of the present invention to use any other type of stitching arrangements. For example, the individual cells could be circular, oval or any of a number of geometric patterns.

[0040] Importantly, an exemplary quilted cold-weather garment constructed in accordance with the principles of the present invention includes an intermediate layer of substantially uncompressed opened-celled polyurethane foam. The thickness of the foam is selected on the basis of weather conditions. While the foam is necessarily compressed at the stitching, it remains generally uncompressed within the center of the cells (i.e., "substantially uncompressed") to provide superior thermal insulation, moisture vapor transfer and flexibility. Illustrating the uncompressed condition, in one embodiment the intermediate layer includes a convoluted surface with peaks and valleys disposed adjacent to the interior layer. Substantial compression is disfavored as it would collapse the peaks and valleys, which are key features of Applicant's convoluted embodiment, and undesirably compromise the thermal insulating value of Applicant's intermediate layer. Concomitantly, substantial compression of the intermediate layer would collapse the opened cells in the foam, which would defeat the purpose of using opened cell foam and disadvantageously impede moisture vapor transfer while decreasing overall flexibility. In sum, substantial compression would render Applicant's garment inoperable or inferior for its intended purpose.

[0041] A series of experiments were performed to determine the thermal conductivity and thermal resistance of a series of 12 clothing fabrics, as described in FIG. 9, under a range of cold weather conditions using a cold weather test chamber that replicates ASTM standard D 1518-85 (2003). Thermal conductivity is a proportionality factor that quantifies the efficiency of unidirectional heat transfer per unit area through a substance. Following the method outlined in ASTM standard D 1518-85 (2003), an estimated value for thermal conductivity was calculated. In this method, the thermal transmittance of a material is first calculated using Equation 1. This equation assumes that thermal conductivity is linear with respect to temperature. From Equation 1 the thermal conductivity is then found using Equation 2.

$$U = \frac{P}{A\Delta T} \quad \text{Equation 1}$$

Where:

[0042] U=thermal transmittance ($W/(m^2 \cdot ^\circ C.)$)

[0043] P=heat flux from test plate (W)

[0044] A=area of the copper test plate (m^2)

[0045] ΔT=change in temperature across the material (° C.)

$$k=(t_i)(U) \quad \text{Equation 2}$$

Where:

[0046] U=thermal transmittance ($W/(m^2 \cdot ^\circ C.)$)

[0047] k=thermal conductivity ($W/(m \cdot ^\circ C.)$)

[0048] t_i=thickness of the specimen (m)

[0049] Thermal resistance (R-value) is a measure of a material's resistance to heat flow. Mathematically thermal resistance is the thickness of the material divided by the thermal conductivity of the material. The thermal conductivity and thermal resistance of a fabric are of great importance when determining the applicability of a fabric in cold weather conditions. A low thermal conductivity means the fabric material has a high resistance to heat flow. Therefore, to obtain a given level of heat flow, materials with lower thermal conductivities can be made thinner. R-value measures the overall effectiveness based on the combination of the thermal conductivity of the material and its thickness. Two materials with different thermal conductivities may have the same R-value if their thicknesses are correspondingly different. Thus, both values are important in designing or evaluating clothing fabrics.

[0050] The testing procedure used was based on the procedure described in the ASTM Standard D 1518-85 (2003), Standard Test Method for Thermal Transmittance of Textile Materials, with certain changes to better test performance at extremely cold temperatures. Triple replicate samples of 12 code marked fabrics, cut and sewn into the exact same surface area, but with the thickness of the original clothing item were fabricated by the client. None of the personnel involved in the tests had access to or were aware of the identification of the 12 fabric samples. This blind test approach guarantees impartiality in the results.

[0051] 1. One of the 12 code marked test fabrics, chosen at random, was placed in the test chamber on top of the copper test plate and held down by a wooden frame. The wooden frame does not cover any of the area over the copper test plate.

[0052] 2. A rheostat controlling the heat blanket was set to around 20% of its total 720 W, in order to allow the copper plate to slowly heat to the steady state desired value. The rheostat was adjusted, depending on the air temperature, to keep the heat blanket at the desired temperature.

[0053] 3. A block of dry ice (frozen carbon dioxide, CO2) or a beaker of liquid nitrogen (ultra cold tests) was inserted into a basket hanging inside the test chamber. The use of dry ice facilitates bringing the temperature of the test chamber down to the desired level. This basket hangs near the air inlet so that when the vacuum pump returns air into the chamber from the air chiller unit, it blows onto the dry ice block, helping to keep the chamber at a consistent temperature. From this point on, the air chiller unit was continually used to regulate the test chamber temperature.

[0054] 4. The final step before data collection was to install the top of the test chamber; sealing the box.

[0055] 5. Lab View® Visual Instrumentation software was started for automatic data collection. Every four seconds, the program measures the temperatures of 7 thermocouples in the system and logs the data in a file. Any previous data trial is automatically backed up to ensure no data are lost or erased. Every five or ten minutes, an average of 15 points (one minute of data) is sent to a spreadsheet to record the average current temperatures of the copper test plate and the air immediately above the test fabric. Collecting averages ensures precision in the temperature readings. When these two temperatures begin to approach the ones necessary for a trial to begin, data is collected more frequently, every three minutes. The temperature of the test plate must be 30° C.±0.5° C. which is approximately 86° F. (simulating human external skin temperature), and the temperature of the air above the fabric is at the predetermined level for that test plus or minus one half a degree. The data ranged from −20° C. to −82° C. which is approximately −4° F. to −115° F. When the system was at steady state for 15 minutes the trial was started.

[0056] 6. To begin the trial, the Lab View® data collection routine was stopped and restarted in a new file so the pretrial data could be kept separate from the trial data. Temperature readings were recorded every four seconds and placed into this new file.

[0057] 7. At time "zero", the heat blanket was turned off. During the hour long trial, the average temperatures were checked every 20 minutes to make sure the data look reasonable and that the air temperature was being maintained at the desired value. After an hour of testing, Lab View® was stopped, the heat blanket was reenergized, and Lab View® was restarted to collect pretrial data for the next test.

[0058] 8. When the fabric needed to be changed or more dry ice needed to be added, the cover was unscrewed and the process continued. Also desiccant used to remove water from the air before it entered the heat exchanger was replaced when it neared saturation.

[0059] During the static tests with dry ice, the temperature of most fabrics decreased between 8 and 13° C. over the one hour test period. When using liquid nitrogen for the extreme cold temperatures, the fabrics decreased as much as 23° C. over the test period. Shorter, bare plate trials were performed as calibration tests over the same temperature decrease range.

[0060] A set of experiments were performed to ascertain differences in fabric performance under conditions that might occur during exertion (i.e. if the wearer of the garment was sweating). Using a small grid-shaped rack on the under side of the fabric, water was trickled uniformly onto the test area of the fabric at a rate of 15 ml per hour. This was a flow rate that best simulates the typical sweat generation rate of a human onto an eight by eight inch square portion of the average person's torso. The "sweat rack" consisted of a series of perforated copper tubes, laid out in a grid arrangement. This arrangement distributed the water evenly over the entire skin side surface of the test region of the fabric.

[0061] The experimental procedure for these tests was identical to that used for the static tests, as outlined above with the following exception. When the heat blanket was deenergized, water flow was initiated at the predetermined flow rate to simulate sweat. The water flow rate was stopped when the trial was stopped (after one hour) and restarted only when the next trial was begun.

[0062] A set of experiments was then run to test the fabrics for their ability to withstand wind chill. Compressed air was used to experimentally model wind speeds of 5 and 20 miles per hour in the test chamber. The air inlet for this wind was placed right above the fabric and the air blown straight across the face of the fabric. These tests used nearly the same procedure as described for the static tests with one small difference, when the actual trial data was started, the compressed air was turned to a predetermined setting to give the desired wind speed. This wind speed was held constant for the hour long trial and if necessary the compressed air supply bottle was changed out before the next trial began. To account for the difference in temperature between the wind coming in and the air in the test chamber, the chiller unit was modified so that the air from the supply bottle was routed through the chiller unit before entering the test chamber.

[0063] Static experiments were run for each of the three replicates of the 12 unknown fabrics at 4-5 different temperatures ranging from 0 to −35° F. using dry ice as the cooling medium. Additional experiments were run for each of the three replicates of the 12 unknown fabrics at a single temperature ranging from −97 to −115° F. using nitrogen as the cooling medium. This ultra-cold test was run so that we could correctly quantify the relationship between fabric insulating properties and cold temperatures over the range of −100 to 0° F.

[0064] In addition, the density and thickness of each fabric sample was also measured. These are shown in FIG. **9**. Equation (1) was then used to calculate the thermal transmittance "U" for each of the 12 fabrics based on the experimental test data and the heat flux, "P" found in the bare plate test trials. Equation (2) was then used to find the thermal conductivity "k" and equation (3) to find the thermal resistance "R" of each individual fabric. FIGS. **10** and **11** show the thermal conductivity and thermal resistance of each of the twelve fabrics at their actual test temperatures. As noted above, thermal resistance depends upon both thermal conductivity and thickness.

[0065] The best fabric in terms of insulating properties is fabric **4**, i.e., a fabric according to principles of the invention. From all static test results, dry and wet, windy or calm, tests clearly showed that the thermal conductivity of fabric **4**, i.e., a fabric according to principles of the invention, is lower than any of the other fabrics tested. Based upon these data, clothing made from fabric **4** has the potential to have the best insulating properties. For any given thickness of material, a garment made from fabric **4**, i.e., a multi-layer, quilted garment with a substantially uncompressed interior open-celled foam layer, will resist heat loss the best. Test results are summarized in FIGS. **10** through **16**. FIG. **10** provides a plot of thermal conductivities of tested cold weather fabrics under static conditions. FIG. **11** provides a plot of thermal resistances of unknown cold weather coat fabrics under static conditions. FIG. **12** provides a plot of thermal conductivities of the unknown test fabrics under static conditions using liquid nitrogen to reach extremely cold temperatures. FIG. **13** provides a plot of thermal resistances of unknown test fabrics under static conditions using liquid nitrogen to achieve extremely cold temperatures. FIG. **14** provides a table of calculated thermal conductivities for tested cold weather fabrics. FIG. **15** provides a table of calculated thermal resistances for unknown cold weather fabrics. FIG. **16** provides a table of rankings of fabrics in order of insulating properties for both static and sweat tests, based on thermal conductivities.

[0066] The present disclosure includes that contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention.

[0067] While an exemplary embodiment of the invention has been described, it should be apparent that modifications and variations thereto are possible, all of which fall within the true spirit and scope of the invention. With respect to the above description then, it is to be realized that the optimum relationships for the components and steps of the invention, including variations in order, form, content, function and manner of operation, are deemed readily apparent and obvious to one skilled in the art, and all equivalent relationships to those illustrated in the drawings and described in the specification are intended to be encompassed by the present invention. The above description and drawings are illustrative of modifications that can be made without departing from the present invention, the scope of which is to be limited only by the following claims. Therefore, the foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents are intended to fall within the scope of the invention as claimed.

What is claimed is:

1. A cold-weather garment comprising: an exterior layer of a waterproof and windproof breathable fabric; an interior layer of a mesh fabric; a substantially uncompressed intermediate layer of an opened-celled polyurethane foam positioned between the exterior and interior layers, the intermediate layer having a first flat face disposed adjacent the exterior layer, the flat face having a skin so as to enhance ease of construction and improve wind resistance, the intermediate layer also having a second convoluted face including peaks and valleys disposed adjacent the interior layer, the convoluted face reducing weight and providing added surface area for moisture transfer; a plurality of lines of stitching securing together the exterior, interior and intermediate layers in a quilt, wherein the plurality of lines intersect one another to form a box stitch pattern upon the garment, the quilting improving the dexterity of the garment's wearer, and improving insulation and water vapor transmission of the garment.

2. A cold-weather garment comprising: an exterior layer, an interior layer, and a substantially uncompressed intermediate layer of a polyurethane foam; a plurality of lines of stitching securing together the interior, exterior and intermediate layers into a quilt pattern formed from a series of individual cells throughout the garment, the quilt pattern improving the dexterity of the garment's wearer, and improving insulation and water vapor transmission of the garment.

3. The garment as described in claim 2 wherein the exterior layer is formed from polytetrafluoroethylene fabric.

4. The garment as described in claim 2 wherein the interior layer is formed from a mesh fabric.

5. The garment as described in claim 2 wherein one face of the foam layer is convoluted.

6. The garment as described in claim 2 wherein the face of the foam layer is skinned.

7. The garment as described in claim 2 wherein the foam is an opened cell polyurethane foam.

8. The cold weather garment as described in claim 2 wherein the foam is either ⅛, ¼, ½ or ¾ inches thick and wherein the thickness is selected on the basis of anticipated weather conditions.

9. A cold-weather garment comprising a substantially uncompressed intermediate foam layer formed between interior and exterior fabric layers, the foam being an opened cell synthetic foam; a number of lines of stitching securing together the interior, exterior and intermediate layers, the lines of stitching intersecting one another at multiple locations upon the garment, the intersecting lines of stitching forming a box stitch, the uncompressed foam layer improving insulation and water vapor transmission of the garment.

10. The cold weather garment as described in claim 9 wherein the foam is ⅛, ¼, ½ or ¾ inches thick and wherein the thickness is selected on the basis of anticipated weather conditions.

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