Jan. 6, 1948. H. C. BAZETT ET AL 2,433,834

PROTECTIVE CLOTHING

Filed June 7, 1945

Fig. 2

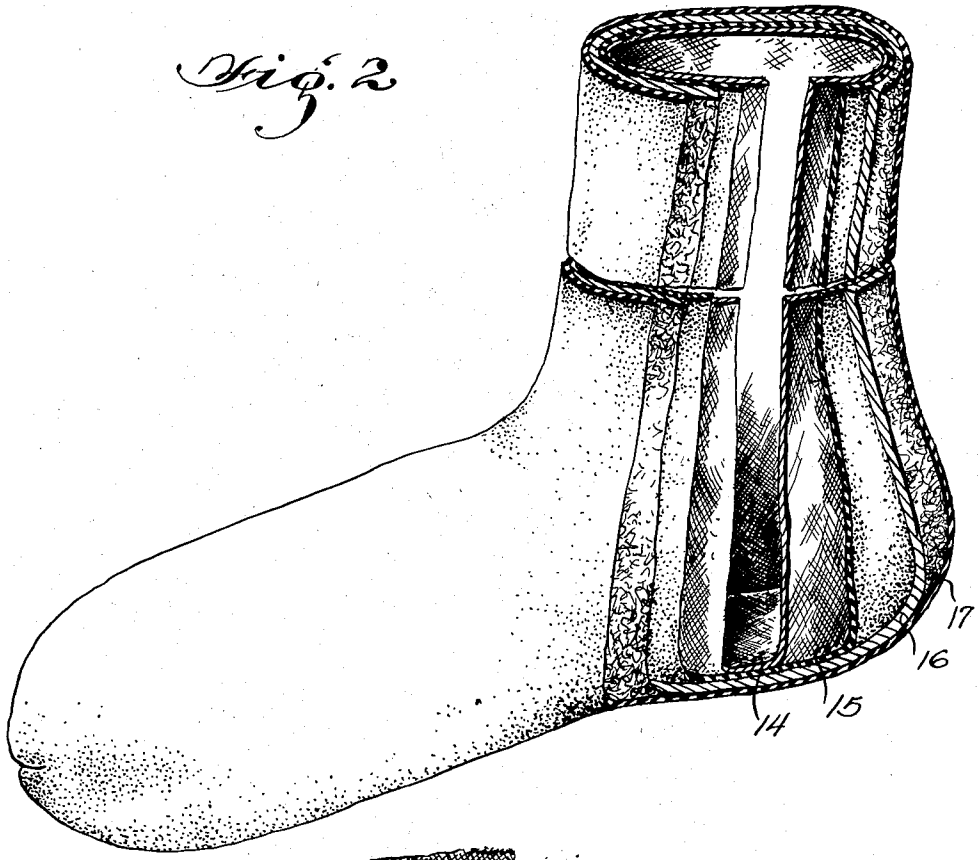
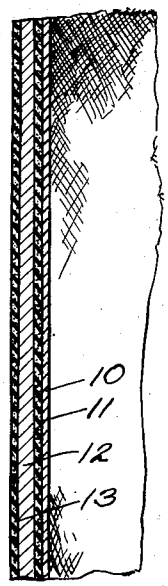


Fig. 1



INVENTORS
Henry C. Bazett
Paul A. Siple
BY
William F. Desmond
ATTORNEY

Patented Jan. 6, 1948

2,433,834

UNITED STATES PATENT OFFICE

2,433,834

PROTECTIVE CLOTHING

Henry C. Bazett, Haverford, Pa., and Paul A. Siple, United States Army, Arlington, Va.

Application June 7, 1945, Serial No. 598,201

5 Claims. (Cl. 2—243)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

1

The invention described herein, if patented may be manufactured and used by or for the Government for governmental purposes, without the payment to us of any royalty thereon.

Our invention relates to a method for clothing the human body and a material therefor which will afford an optimum of protection against both dry and damp or wet cold, and may be used to protect the body as a whole or only the individual members of the body, such as the feet and hands.

An object of the invention is the provision of a new and improved method of clothing, and clothing material, for protection against the cold which will prevent passage of water vapor from the body to the thermal insulating portions of the clothing.

Another object of the invention is the provision of a new and improved method of clothing, and clothing material, which is effective to prevent evaporation of water vapor directly from the body to the atmosphere thereby preventing dissipation of the body heat absorbed in such evaporation.

Another object of the invention is the provision of a new and improved clothing which is effective to prevent passage of the body vapors from the body to the outer layer of clothing where, in the ordinary course of events, it would condense and its latent heat would be given up to the colder outer layer of clothing from which the heat would be lost to the atmosphere by direct conduction through the outer layer of clothing.

Another object of the invention is the provision of a new and improved method of clothing, and clothing material for the body, which effectively protects against both dry and damp or wet cold.

Another object of the invention is the provision in a clothing for the human body, or its members, of means for confining the body vapors in definite portions of the garment to maintain at least one thickness of thermal insulating material in a dry condition.

Another object of the invention is the provision of a new and improved laminated clothing or similar protective cover which will afford a maximum of protection against the cold.

Another object of the invention is the provision of a new and improved method for protecting the body against heat loss due to "insensible perspiration" and vaporization of body fluids which occurs continuously and independently of normal perspiration.

Another object of the invention is the provision of a new and improved method of clothing, and clothing material, which is effective to retard and control the loss of water vapor from the human body in cold weather.

2

Another object of the invention is the provision of a new and improved waterproof clothing for the human body which will remain warm when worn for extended periods of time, and which is so constructed that condensation of body vapors on the interior surface of the outer layer of the clothing is prevented.

Another object of the invention is the provision of a new and improved material for the construction of cold weather garments which is inexpensive to manufacture and light in weight and flexible, so that garments constructed therefrom do not restrict the movements of the wearer.

Another object of the invention is the provision of a new and improved clothing for protecting the human body or the separate members thereof against inclement weather which may be fabricated from the proper materials into separate garments conforming to the shape of the body or body member to be covered, the separate garments being adapted to be received one over the other to form a complete protective cover.

In the past various methods, and types of clothes, have been used in clothing the body for protection against cold, but all have failed to provide suitable protection against both dry and damp or wet cold conditions, or even sufficient protection against dry cold where the wearer remains inactive for relatively long periods of time. Special problems have arisen in the construction of suitable clothes for combat troops because of the unusual and widely varying climatic conditions in which such troops may be forced to operate. Clothing for flying personnel is an example of the extreme conditions that must be provided against. Although the temperature may be at a comfortable level on the ground, as the elevation increases the temperature decreases, and at the elevations commonly flown in combat the temperature is many degrees below zero. This has necessitated the development of interiorly heated suits which may be turned on to provide additional warmth at high elevations. Proper clothing of the men in the ground forces also presents difficult problems, because these men may be forced to live and operate in water, mud, slush, snow or rain at near freezing temperatures, or below, and may be forced to remain immobile in fox holes, or other cover or concealment, under these conditions for long periods of time without outside sources of heat. When protected by the clothes now in use many casualties result due to immersion foot, trench foot, chilblains, respiratory diseases and other ailments directly attributable to improper protection from the elements,

and in addition to the actual casualties, there is also a large impairment of the morale, stamina and general fighting ability of all the men and a lowering of their resistance and general physical condition.

In an effort to conserve man power and preserve the morale and fighting ability of the men, we have studied the problem of properly clothing men for combat and have devised a new method of clothing and clothing material for protection against adverse weather conditions, the principle of which may be used in the construction of many different types of protective coverings such as socks, gloves, suits, blankets, sleeping bags and many other articles suitable for either civilian or military use.

Normally, heat is lost from the body in several ways, namely, by conduction, as a result of evaporation of fluids from the skin, and through the lungs. Loss of heat from the skin may occur by direct conduction or it may be due to evaporation of fluids from the surface of the skin with the attendant absorption of heat of vaporization. An additional and indirect loss results from the evaporation of body fluids in cold weather, because the vapors condense in the clothes and moisten them, thereby lowering the thermal insulating value of the clothes and resulting in a greater conduction of heat directly through the clothes from the body to the environment.

Loss of heat by evaporation occurs not only during and after normal perspiration, but also independently of normal perspiration, as a result of the operation of certain natural laws. This latter heat loss is due to the ordinarily imperceptable, but nevertheless, constant loss of water vapor which occurs even though the body is not overheated, and which is occasioned by the difference between the vapor pressure at the warm skin and the lower vapor pressure in the surrounding atmosphere. Tests have shown that the vapor pressure at the skin surface varies between 43 mm. when the skin is warm and 32 mm. when the skin is cold, and that the vapor pressure of the atmosphere rarely exceeds 25 mm. even under the most humid conditions. For this reason, vaporization of body fluids is bound to occur, even in cold weather, and while a person is inactive. This has been called "insensible perspiration" and accounts for an average of about fifteen per cent of the heat lost by the body. When it occurs in cold weather the vapor penetrates the clothing of the individual where it condenses causing the clothes of the individual to become damp, and thereby destroying much of their thermal insulating value. In such a case the temperature of the body is reduced, not only directly due to the vaporization, but also indirectly, due to the fact that heat is more readily conducted directly from the body to the atmosphere. This, and the fact that a certain amount of revaporization and recondensation of the moisture occurs in the clothes, due to the body heat, is the reason why damp clothes are cold and uncomfortable if the air is even slightly chilly.

Recognition of the several ways in which the body heat is dissipated and of the existence of "insensible perspiration" lead to a new concept in the clothing of the body for protection against cold and to a new construction for cold weather garments and a fabric suitable for use in making such garments.

In the drawing accompanying this application Figure 1 is a fragmentary view in perspective

showing the manner in which my clothing material is fabricated in layers.

Figure 2 is a view of a covering for the foot showing the manner in which separate socks may be received one over the other to form a complete protective covering.

Referring to the drawings, we will now describe the manner in which materials may be fabricated to provide a suitable fabric for carrying out our invention. According to the invention, we provide a clothing material or clothes of laminated construction, the laminations consisting of layers of textile fabric and layers of water and water vapor impermeable materials. These layers are arranged in a definite order to form two portions or sections in the clothing, one of the impermeable layers being positioned to form with a lining layer of textile fabric an inner portion or section for confining body vapors within the area covered by the particular garment and preventing the vapors from traveling outwardly into the other portion of the garment. The other portion or section which overlays the inner portion consists of an outer impermeable layer and a layer of textile fabric having a high thermal insulating value. The impermeable layer extends over the outer surface of the insulating layer and prevents exterior moisture from traveling inwardly. Thus the insulating material forms an intermediate layer between the two impermeable layers, and it is protected against penetration of moisture and vapor on both of its sides by these impermeable layers.

In fabricating a material from which protective coverings of all sorts may be made an inner lining layer **10** is provided of cotton, wool or any other suitable material which has high absorbent properties and does not chafe or irritate the skin. Completely overlying the outer surface of this layer is a second layer **11** consisting of any material impermeable to both water and water vapor. Various types of materials may be used for this purpose, and such materials as rubber vinylite, or any of the synthetic rubbers or plastics which are flexible enough to be made into clothing, are suitable for this purpose, provided they are impermeable to both water and water vapor, impermeability to water vapor being particularly important. This second layer is covered by a third layer of textile fabric **12** consisting of any material having a high thermal insulating value, such as wool. This layer prevents the dissipation of heat from the body by direct conduction and its thickness may be varied to provide insulation against the degree of cold expected to be encountered. A fourth layer of material **13** is also provided, completely overlying the outside of the third layer, and consisting of a material similar to that used in the second layer, and impermeable to both water and water vapor, for preventing exterior moisture from penetrating into the thermal insulating layer. These layers of material may be stitched or cemented together, or may be secured in any other suitable manner to form a fabric for use in making garments or other types of coverings.

In some instances, when a particular member or members of the body is to be protected, such as the feet, individual socks of the different materials may be made up and the individual socks placed on the foot one over the other with the insulating sock overlaid and underlaid by an impermeable sock to prevent moisture from reaching the thermal insulating sock, either from with-

in or without the socks. As shown in Figure 2 an ordinary G. I. cotton or light weight wool sock 14 is first placed on the foot. Over this is placed a second sock 15 constructed from one of the impermeable materials mentioned above. The third sock 16 is an ordinary G. I. issue wool sock which may be of heavy or light weight depending on the temperature and the degree of activity or inactivity expected to be encountered. In some cases it may even be advisable to wear two pairs of wool socks. Overlaying all of these socks is a second impermeable sock 17 which should be long enough to extend up the leg to a point well above the highest point that it is expected that the leg may be immersed in water, mud or slush. The shoe packs, boots or other footgear are placed on over these socks.

When the feet are protected by laminations of material as above set forth, or a garment for the body is constructed from a fabric laminated as above described, "insensible perspiration" will occur but the cooling effect thereof is controlled as will now be explained. When such perspiration occurs the vapor penetrates the inner sock 14 but that is as far as it goes because it is confined therein by the vapor impermeable layer or barrier 15, so that only this inner sock is dampened, and the insulating sock 16 remains dry and fully effective to prevent direct conduction of heat from the body to the exterior surface of the socks. For this reason, and because the moisture cannot be vaporized directly into the atmosphere, dampness of the inner lining sock does not result in any noticeable cooling of the foot. Even though it is damp, it is maintained at substantially the temperature of the skin, and no discomfort is felt by the wearer. The outer impermeable sock 17 prevents moisture from getting into the thermal insulating sock from the outside and thereby destroying its thermal insulating property. As the dampness of the lining sock 14 increases, a point of equilibrium or saturation is reached after which no further vaporization of the body fluids will occur from the foot. In this manner "insensible perspiration" of particular members of the body is controlled and the cooling effects thereof diminished.

Our invention is valuable not only in protecting against dry or damp cold, but also is particularly effective in protecting against wet cold. Using a foot cover of the type disclosed herein as an example, if the wearer is forced to stand or wade in mud or water not over the tops of the outer impermeable layer 17, and his boots or other footgear soak through, then the outer impermeable layer 17 will prevent this outside moisture from reaching the insulating layer 16 so that it will remain dry and fully effective as a thermal insulator, and the feet will remain warm. The insulating layer 16 prevents heat from passing to the footgear to vaporize the water therein, so that the heat absorbed in the vaporization of liquids in the footgear must come from sources other than the foot itself, and the feet remain warm even though the footgear is cold and wet.

Even if the water reaches above the outer impermeable layer and the insulating layer 16 becomes wet, actual tests have shown that a foot protected as we have described will become warm again much sooner than one not so protected. This is explained by the fact that after ordinary foot-coverings become wet, the moisture in the footgear and socks slowly vaporizes, and a large amount of heat is lost from the foot because of this evaporation. Water in vaporizing absorbs

a great deal of heat, on the order of 539 calories per gram, and most, if not all of the heat required to vaporize the water in the footgear is absorbed from the foot. In addition to this, if the socks are also wet, as they would be in the absence of an outer impermeable layer, and the moisture in them is free to pass into the footgear, it will gradually do so as the water in the footgear vaporizes, and it will be vaporized from the footgear, thus causing a further loss of heat from the foot. When our impermeable foot covering is used the outer impermeable sock 17 forms a barrier between the insulating sock 16 and the shoe through which water and water vapor in the layers underneath cannot pass, therefore, this water is not vaporized, and only the footgear dries by evaporation. For this reason the total loss of heat from the feet is so much less that the feet warm up sooner than when no impermeable layer is used, even though such a layer causes the insulating material to remain wet.

The use of our new method of clothing individuals for protection against cold is not limited to the sock as above described, but the same method may be adopted for the construction of handgear, complete suits, sleeping bags and special purpose suits, such as suits for the flying personnel of the air corps or the personnel of the armored forces.

Another special application of our method of constructing clothing which would be particularly advantageous is in the manufacture of waterproof garments for use on board ships, or wherever protection is required against rain, water or spray. It is, of course, well known that the ordinary raincoat or water repellent garment tends to sweat or become damp on its inner surface, and if it is worn for any length of time, the clothes under the garment absorb moisture from this inner surface and themselves become damp. Wetting of the inner surface of a raincoat is caused by body vapors penetrating the clothes worn under the raincoat and condensing on the cool inner surface of the raincoat, and not from seepage or leakage from the outside. Whenever this condensation of moisture occurs in such a garment, it means that body heat has been carried to the surface of the garment by body vapors and dissipated to the surrounding atmosphere upon condensation of the vapor. Some of this moisture is again vaporized by the warm body and recondenses on the inner surface of the garment with a further loss of body heat, and if the clothes under the garment become damp, heat is more readily lost by direct conduction to the outer surface of the garment. The combined effect of these several losses of heat is a large loss of heat to the body. This accounts for the uncomfortable coolness of such garments after they have been worn for more than a relatively short interval of time in cold or chilly weather.

A garment constructed in accordance with the method herein disclosed remedies the defects common to this type of garment because the body vapors are stopped at the inner impermeable layer, and are absorbed in the inner absorbent lining layer. The outer impermeable layer prevents moisture from getting into the insulating layer so that its thermal insulating properties are not impaired, and it is fully effective to perform its function of retaining body heat.

No attempt has been made in this description to enumerate all of the instances in which the principles of the invention may be advantageously applied. The specific instances described

were used as examples, and this description is not intended to limit the uses of the invention to the particular examples set forth. Having thus described our invention, what we claim as new and desire to secure by Letters Patent is as follows:

1. A laminated garment for a body or body member, comprising in combination an inner absorbent layer to contact said body or body member, a second, water-impermeable and water-vapor-impermeable layer secured to said inner layer and spaced from said body or body member by said inner absorbent layer, said second layer being a vapor barrier to prevent evaporative chilling of said body or body member, and a third layer of thermally insulating material secured to said second layer and spaced from said inner absorbent layer by said second layer.

2. A laminated garment for a body or body member, comprising in combination an inner absorbent layer to contact said body or body member, a second, water-impermeable and water-vapor-impermeable layer secured to said inner layer and spaced from said body or body member by said inner absorbent layer, said second layer being a vapor barrier to prevent evaporative chilling of said body or body member, a third layer of thermally insulating material secured to said second layer, and a fourth layer of moisture impermeable material secured to said third layer and spaced from said second layer by said third layer, said fourth layer to prevent impairment of the thermal insulation material afforded by said second layer.

3. A laminated garment for a body or body member, comprising in combination a layer of water-impervious and water-vapor-impervious material, the shape of said layer substantially corresponding to the shape of said body or body member, an inner lining of absorbent material inwardly of and secured to said layer, an outer lining of thermally insulating material outwardly of and secured to said layer, and a protective shell of moisture-impervious material outwardly of and secured to said outer lining.

4. The method of reducing the loss of body warmth of a body member such as a hand or a foot due to exposure to inclement weather, comprising placing next to the skin of said body member an absorbent fabric layer of a shape substantially corresponding to the shape of said body member, to absorb moisture evaporated from the skin; completely surrounding said absorbent fabric layer with a water-impermeable and water-vapor-impermeable material of a shape substantially conformable to the shape of said body member, to prevent moisture absorbed in said absorbent fabric layer from escaping into the atmosphere and from evaporatively cooling said body member; and completely surrounding said water-impermeable and water-vapor-impermeable material with a layer of thermally-insulating material of a shape substantially corresponding to the shape of said body member, to provide a zone of low heat conductivity about said body member and retard conductive cooling thereof.

5. The method of reducing the loss of body warmth of a body member such as a hand or a foot due to exposure to wet-cold weather, comprising placing next to the skin of said body member an absorbent fabric layer of a shape substantially corresponding to the shape of said body member, to absorb moisture evaporated from said skin; completely surrounding said absorbent fabric layer with a water-impermeable and water-vapor-impermeable material of a shape substantially conformable to the shape of said body member, to prevent moisture absorbed in said absorbent fabric layer from escaping into the atmosphere and from evaporatively cooling said body member; completely surrounding said water-impermeable and water-vapor-impermeable material with a layer of thermally-insulating material of a shape substantially corresponding to the shape of said body member, to provide a zone of low heat conductivity about said body member and retard conductive cooling thereof; and overlaying said last-named layer with a water-impermeable outer barrier, to prevent penetration of exterior moisture and impairment of the thermal insulation afforded by said zone of low heat conductivity.

HENRY C. BAZETT.
PAUL A. SIPLE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,250,693	Stanger	Dec. 18, 1917
2,290,166	Craig et al.	July 21, 1942