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Sept. 4, 1956 T. A. FEILD, JR., ET AL 2,761,515

PROCESS AND APPARATUS FOR FIRE PROTECTION

Filed May 2, 1955

Fig. 1.

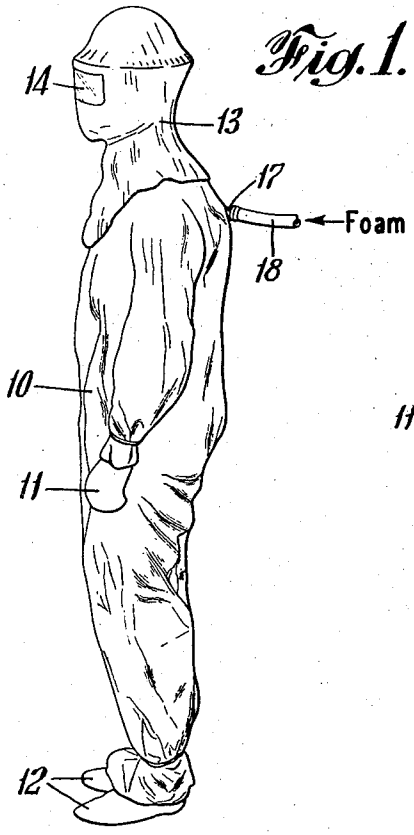


Fig. 2.

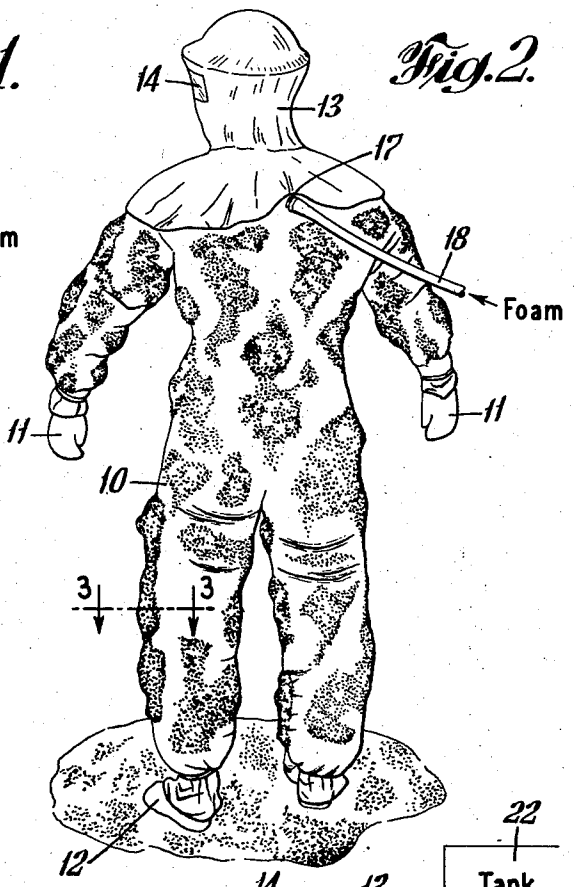


Fig. 5.

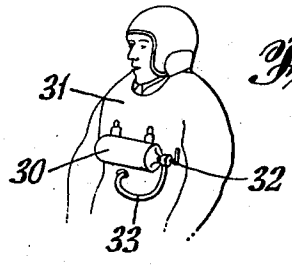


Fig. 4.

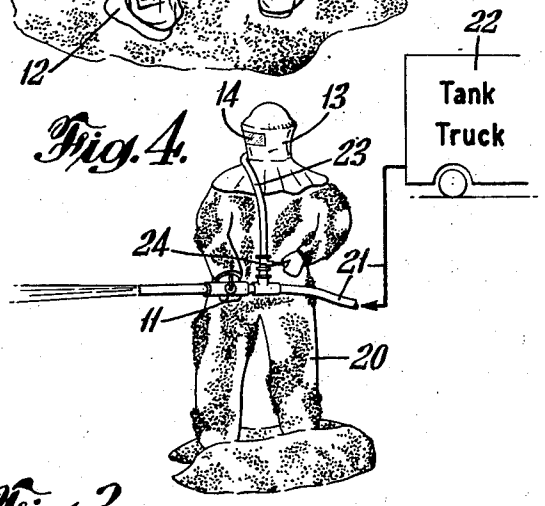
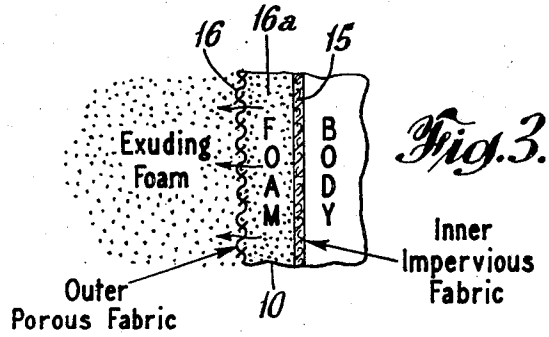


Fig. 3.



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PROCESS AND APPARATUS FOR FIRE PROTECTION

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16 Claims. (Cl. 169—1)

This invention relates to a new and improved method of protecting persons and objects exposed to flames and intense heat and also to new heat-resistant wearing apparel and new combinations thereof with certain types of fire-fighting equipment.

The general object of this invention is to provide an improved method of and apparatus for insulating areas of persons and objects exposed to flames and/or intense heat, which permits such persons and objects to be so exposed without harm for an unlimited period of time. A more specific object is to provide over exposed areas of persons or objects a confined protective layer of consumable insulating material across which a substantially constant temperature gradient providing a safe margin of protection can be maintained continuously regardless of the duration of the exposure to intense heat.

A specific object of the invention is to provide a method of rendering ordinary wearing apparel fire-resistant almost instantaneously for a sufficient time to enable a person suddenly exposed to the hazard of flames and/or intense heat to extricate himself from the danger zone.

Another object of the present invention is to provide a fire-resistant suit which is exceedingly light and inexpensive, which permits a high degree of mobility to the wearer, which will absorb considerable shock so as to provide protection against impact, and which affords protection against radiant heat.

Still another object of this invention is to provide a fire-fiighting suit in the form of a pervious, foam-filled garment, which is especially adapted for use with fire-fighting equipment employing a foam fire-fighting medium, the suit having a connection with the foam delivery line of such equipment for supplying and replenishing garment foam.

Other objects, features and advantages of the invention will become apparent from the following detailed description of the accompanying exemplary drawings in which:

Figure 1 is a side view of a person wearing a suit suitable for the practice of this invention, the suit being shown without its protective filling;

Figure 2 is a back view of a person wearing the suit of Figure 1, the suit shown here being filled with a foam material exuding through the pores of the fabric;

Figure 3 is a diagrammatic sketch showing a section through a suit of the present invention filled with insulating foam medium;

Figure 4 is a diagrammatic sketch of a fire-fighter utilizing foam fire-fiighting medium in his protective suit; and

Figure 5 is a fragmentary perspective view of an airplane pilot wearing a suit adapted for the practice of this invention.

According to one feature of this invention, a garment made of suitable porous material is fitted loosely over a subject to receive a continuous or batchwise inflow of reasonably stable foam, and this garment is distended by such foam, which spreads over the surface covered by the garment and is held in a layer of predetermined thickness by the garment. It has been found that this confined foam layer affords exceptional protection to a subject against fire and heat and also against impact.

With reference now to drawings, there is shown in Figure 1 a man clothed in a garment **10**, which encloses all of his body except his hands, feet, and head, which are respectively covered by gloves **11**, shoes **12**, and a hood **13**. The hood may be of conventional design, being provided with a window **14** for visual purposes. Garment **10** is loose fitting except at its extremities (the neck, wrists and ankles), where it is fitted tightly to the wearer by any suitable binding means. As shown in Figure 3, garment **10** may have an inner layer **15** of an impervious fabric and an outer layer **16** of foam-pervious fabric, the outer layer having sufficient freedom relative to the inner layer so that an intermediate layer **16***a* of insulating material may be interposed therebetween. The composition of the outer fabric may be selected to suit the nature of the service to be performed by the suit. Flame resistant fabrics, such as those made of synthetic fibers, are preferred but not necessary. It is desirable, however, that the fabric be light weight, for the wearer's comfort, and have a reasonably close weave to prevent excessive or overly rapid loss of foam insulating medium from the garment. It is to be understood that a double layer garment is not essential to the practice of this invention, for a single layer foam-pervious fabric will serve equally as well.

In accordance with this invention, foam, generated from water containing agents capable of producing reasonably stable foams, is introduced between the two layers of the garment to distend the garment and form a foam layer of relatively uniform thickness between the wearer's body and the ambient atmosphere. For this purpose, the garment **10** may have a suitable fitting **17** for connection with a foam supply line **18**, which will commonly be a flexible hose. The flexible hose preferably should be of a construction which will exude foam and thereby provide its own protection against fire and heat. The foam in the protective layer eventually escapes through the porous outer fabric, or it breaks down and drains from the suit. In order to maintain a desired level of protection, fresh foam may be supplied continuously or batchwise to replace lost foam or even to effect a continuous or intermittent displacement of foam in the protective layer. The seepage condition is shown clearly in Figure 2, which also indicates that escaping foam falls to the ground and settles there without presenting any impediments to the process or the wearer. The porous outer fabric **16** thus serves to confine foam supplied to the garment and temporarily hold it in a protective layer over parts of the body enclosed within the garment. Thickness of the foam layer is controlled by the size of the garment and may be selected to meet specific requirements. It has been found that a foam layer two inches thick between the body member and the garment affords a practical degree of protection under ordinary conditions.

It is not necessary for the suit to have any insulating value, for it serves primarily to retain the foam in the protective layer. The foam is an excellent insulator and maintains a wide temperature gradient between the outer fabric layer **16** and the wearer's body. At the same time it absorbs heat applied to the surface of the suit. Many foams subsequently break down, wetting the fabric and preventing its destruction. As it breaks down, it drains from the suit and carries away absorbed heat. By continuously replacing the escaping foam, a relatively uniform layer is constantly maintained which affords a high degree of protection to the wearer. In this way, the suit never becomes unbearably hot and the wearer can remain exposed to flames or intense heat for an unlimited period of time.

Moreover, it is not necessary that a foam readily wet the

fabric. For example, a cotton sleeve made from an eight ounce cotton duck fabric was filled with shaving cream foam. One thermocouple was fastened ½ inch from the outside fabric surface. Another thermocouple was placed in the foam layer 2 inches from the inside fabric surface. The flame from a butane blow torch was directed against the fabric. At first the flame was held six inches from the fabric. Over a period of 1 to 2 minutes the flame was moved nearer the fabric until the hottest part of the flame impinged on the thermocouple just above the fabric surface. The temperature on the outside of the sleeve as measured by the outside thermocouple was 1658° F. After seven minutes the temperature measured with the inside thermocouple was less than 80° F. The foam used in this example did not wet the fabric, but at the point where the flame impinged on the fabric surface the foam oozed through the fabric and formed an estimated ½ inch protective layer on the outside surface.

There are several distinctive advantages of the present invention over known fire-protective suits, the most successful of which have been made of asbestos and glass fibers with various insulating materials such as aluminum foil. These known suits are generally heavy, unwieldy, and expensive, they retain the heat absorbed, and they eventually become too hot for the wearer to remain in the danger zone. In contrast, a garment confining a protective foam layer is very light and affords comfort and excellent personal mobility to the wearer. The protective foam layer presents little resistance to any body movement so that there is freedom of action on the part of the wearer.

These advantages are illustrated by the following example. A cotton garment worn by a worker was filled with foam. The foam was generated by pumping a water solution containing 2 percent sodium alkyl sulfates and 0.5% sodium carboxymethyl cellulose through a jet into a stream of air. The air and liquid then passed through a packed mixing chamber to form the foam which was directed to the garment attachment by means of a ¾ inch by 10 foot rubber hose. The rate of flow of foam was controlled by regulating both the liquid flow and the air flow. The foam was composed of 25 volumes of air for each volume of the liquid.

The garment was a cotton coverall type with sleeve and leg cuffs closed by means of rubber bands and weighing 2½ pounds including the foam hose attachment. The hose attachment was made from a 2 x ¾ inch iron pipe nipple, which protruded through the fabric at a point between the shoulders and was held to the fabric by means of a conduit connector. The rubber hose from the foam supply generator was attached to the nipple.

The rate of foam generation was adjusted to fill the garment in 1½ minutes and, when the garment was filled, the volume of foam was estimated at 15 gallons and weighed 6 pounds. One-half minute after the garment was filled with foam the fabric surface was wet. The foam supply was continued intermittently to replace the small amount of foam lost in wetting the fabric and lost mechanically through small openings in the garment. The foam formed an insulating layer inside the garment. This layer was uniformly distributed to a thickness of 2 to 4 inches over the body, arms, and legs of the wearer. The wearer was not hampered in his movements and experienced no discomfort. For example, the wearer was able to kneel, stoop, sit, lie prone, and stand with arms upraised without more than normal effort.

It has been found that the process of this invention not only affords protection against an open flame but also protects against radiant heat. These important advantages are respectively demonstrated by the following examples.

A garment sleeve made from a fabric, the fiber of which was made from a polymer composed of 60% vinyl chloride and 40% acrylonitrile, was closed at both openings and filled with foam by the method described above.

The rate of foam flow was so adjusted to permit a slight flow through the fabric surface. A butane blow torch flame was directed against the fabric and the temperature was measured by thermocouples placed respectively at a point ¼ inch above the fabric surface and at another point 3 inches beneath the fabric-foam interface. The thermocouple above the fabric surface reached a red heat at a temperature above 1700° F. The thermocouple beneath the layer of foam remained at room temperature, 80° F. and the fabric was not damaged.

A garment sleeve was made from an eight ounce cotton duck fabric and placed on a live subject. The openings in the extremities of the sleeve were fastened with rubber bands, and the sleeve was filled with foam by the method described above. The sleeve was then subjected to a source of radiant heat at a point where the foam layer was 2 inches thick. Three 250-watt Westinghouse infrared lamps were used as the heat source. The lamps were located four inches from the fabric surface.

With no foam flowing, the temperature at the skin surface after 5 minutes was 107° F. and at the wet fabric surface was 157° F. The flow of foam was then adjusted to a rate to permit a movement of the foam layer such that the sleeve was distended at all times and some foam oozed through the fabric surface. With the same heat source and after 10 additional minutes, the temperature at the skin surface was no greater than normal body temperature, whereas the temperature at the wet fabric surface was 184° F.

Moreover, the protection afforded by a suit filled with foam is not limited to insulation against heat; it also serves to resist impact stresses. This is especially advantageous, for it lessens the danger of personal injury to fire fighters from obstacles and falling debris. This feature is shown by the results of a test wherein a garment sleeve made from an eight ounce cotton duck fabric was filled with foam of the type described above. A pane of window glass was placed in the sleeve in such a way as to be covered with a foam layer 4 to 4½ inches thick. A steel ball weighing 1.84 pounds was dropped directly on the foam layer covering the glass. At a height of 36 inches the steel ball did not break the glass. In a duplicate test but without the foam layer and with only the wet fabric covering the glass, the glass pane was broken when struck by the steel ball dropped from a height of 12 inches.

The suit is especially adapted for fire fighting when employing a foam fire fighting medium. As shown in Figure 4, a fireman, dressed in a suit **20** of the present invention and controlling and directing a foam delivering line **21**, may selectively deliver foam material from supply line **21** into suit **20** through a branch connection **23** between such supply line and the suit by manipulation of a hand valve **24** disposed in the branch line **23**. This enables the fireman to render his clothing fire-resistant at any time and for any period necessary during the fire fighting operation. The foam supply line **21** can be connected to a tank truck **22** within which foam is generated.

A further embodiment of this invention, shown in Figure 5, is especially adapted for allowing a person who has suddenly become exposed to the hazards of fire to provide himself with a protective covering for a limited time during which he can remove himself from the danger zone. In this embodiment the personal garment of a person, an airplane pilot is shown, who, in his occupation runs the risks of becoming exposed to fire hazards, may be provided with a small container **30** of foaming medium, which is connected to the interior of the garment **31** by a hose connection **33** and which has a control valve **32** that may be operated either manually or automatically (by temperature responsive means, for example) to generate foam and deliver it rapidly into the garment. In this way, although only a single batch of foam can be delivered to the garment,

it is sufficient to provide a protective layer about the person's body for a limited time during which they may extricate themselves from their danger. In this case, foam generating solutions with dissolved gases for activation are preferred. Known foaming devices, such as canned shaving cream type of devices, are suitable for the practice of this embodiment. For example, a cotton garment worn by a live subject and closed at the elbows and at the knees was filled with a contained, portable source of foam. The foam was obtained from cans of a well-known brand shaving cream. The foam was introduced beneath the fabric surface by inserting the nozzle through small openings in the fabric. The garment was filled in 2 minutes of actual flow of foam. The foam distributed itself evenly throughout the garment up to the points of confinement, i. e. to the knees and elbows.

The methods used to generate foam depend on the circumstances under which the invention is to be employed. Thus, it has been seen that where the invention is to be used for the continuous protection of personnel fighting fires and exposed to high heat for long lengths of time, a large supply of foam generating solution with a suitable mobile pump and air compressor are required. In this case delivery may be effected as shown by a flexible hose connection as shown in Figures 1–3. The rate of delivery of the foam can be controlled to provide any desired level of protection. In the case where a single batch of foam is necessary, a small container attached to the garment may be provided as described with reference to Figure 5.

The foam making agents which may be employed in the present invention are almost unlimited and the type of foam generating solution will depend on the type of protection to be provided. Services requiring large continuous supplies of foam, as in fire fighting, employ simple water solutions of wetting agents with suitable corrosion inhibitors.

Foam of this type was prepared when a 2% aqueous solution of an alkylphenoxy polyoxyethylene ethanol surface-active agent, was used instead of the solution of sodium alkyl sufates and sodium carboxymethyl cellulose. Foam of the type described above was also prepared when a 4% aqueous solution of mixed isopropanolamine oleate, an amine soap type surface active agent, was used. Foam of the type described above was also prepared when a 2% aqueous solution of sodium oleate was used as the foam generating agent. Services requiring a limited supply of foam needed for an extended period may use in addition to the wetting agent foam stabilizers such as hydroxyethyl cellulose and carboxymethyl cellulose. Obviously those services where only a single filling is provided require foams with the greatest stability. Foam of the latter type was prepared when 0.5% sodium alginate was used instead of sodium carboxymethyl cellulose as the foam stabilizing agent. Foam of the latter type described was also prepared when 0.5% hydroxyethyl cellulose was used as the foam stabilizing agent.

It will be understood that the principles of the present invention may be embodied in various other forms and have various other uses within the scope of the appended claims. For example, objects may be protected from severe heat or flames in the same manner herein described and illustrated with reference to protection for persons.

What is claimed is:

1. Fire protection apparatus comprising a foam-pervious covering adapted to cover loosely the parts of an object to be protected, foam generating means associated with said covering, a fluid connection between said means and the interior of the covering for delivering foam into the covering for building up a protective layer of foam between the covering and the object, and means operable for controlling the flow of foam through said fluid connection to said covering.

2. Fire protection apparatus comprising a porous garment adapted to cover loosely the parts of a wearer's body to be protected, foam generating means associated with said garment, a fluid connection between said means and the interior of the garment for delivering foam into the garment for distending the garment and building up a protective layer of foam between the garment and the wearer, and means operable for controlling the flow of foam through said fluid connection to said garment.

3. Apparatus as described in claim 2 wherein said garment is made of a fire-resistant fabric.

4. Fire protection apparatus comprising a distensible garment made of an inner fluid-impervious layer and an outer fluid-pervious layer movable relative to each other to provide an interspace, foam generating means associated with said garment, said outer garment layer having a fitting to receive a fluid into the interspace, said foam generating means having a conduit connected to said fitting for delivering foam into the interspace for building up a protective layer of foam between the garment and the wearer, and means operable for controlling the flow of foam through said conduit to said garment.

5. A fire-protective suit comprising a porous garment adapted to cover loosely the parts of a wearer's body to be protected, said suit having means associated therewith for generating a limited amount of foam medium and a connection between such means and the interior of the garment for delivering foam medium generated by such means into the garment for building up a protective layer of foam between the garment and the wearer.

6. A fire-protective suit comprising a porous garment adapted to cover loosely the parts of a wearer's body to be protected, said suit having means associated therewith for generating a limited amount of a foam medium, a connection between such means and the interior of the garment for delivering foam medium generated by such means into the garment for building up a protective layer of foam between the garment and the wearer, and manually operated means accessible to at least one of the wearer's hands for activating the foam generating means.

7. A fire-protective suit comprising a porous garment adapted to cover loosely the parts of a wearer's body to be protected, said suit having means associated therewith for generating a limited amount of a foam medium, a connection between such means and the interior of the garment for delivering foam medium generated by such means into the garment for building up a protective layer of foam between the garment and the wearer, and ambient temperature responsive means operative at temperature exceeding a predetermined temperature to activate the foam generating means.

8. Fire-protective apparatus comprising a porous garment adapted to cover loosely the parts of a wearer's body to be protected, a foam generating unit carried by said garment, a fluid connection between said unit and the interior of the garment for delivering generated foam into the garment for building up a protective layer of foam between the garment and the wearer, and means associated with the unit and operable by the wearer for activating the foam generating unit.

9. Fire-protective apparatus comprising a porous garment adapted to cover loosely the parts of a wearer's body to be protected, a foam dispensing container fitted into said garment charged with a foam generating solution with dissolved dispensing gas, said container having a fluid connection with the interior of the garment for delivering generated foam into the garment for building up a protective layer, and means associated with the unit and operable by the wearer for activating the foam generating unit.

10. Fire fighting apparatus comprising, in combination, with a foam-supply hose adapted to be manipulated by a fireman for directing foam fire-fighting medium over

a fire, a porous garment adapted to be worn by the fireman and having a fluid connection with said supply hose for delivering foam into the interior of the garment for building up a layer of foam between the garment and the fireman, and valve means connected with said fluid connection and operable selectively by the fireman for controlling the delivery of foam to the garment.

11. Fire fighting apparatus comprising, in combination, a foam-supply hose adapted to be manipulated by a fireman for directing foam fire-fighting medium over a fire, said hose being made of a foam-pervious material, a porous garment adapted to be worn by the fireman and having a fluid connection with said supply hose for delivering foam into the interior of the garment for building up a layer of foam between the garment and the fireman, and valve means connected with said fluid connection and operable selectively by the fireman for controlling the delivery of foam to the garment.

12. A method of protecting a surface to be exposed to intense heat, comprising passing foam of at least moderate stability to such surface, distributing the foam over such surface to form a protective covering layer, and confining the foam outwardly by a foam-pervious medium to maintain the foam layer in reasonably stable position over the surface while permitting restricted emission of foam from said layer.

13. A method as described in claim 12, wherein said foam is a wet foam.

14. A method as described in claim 12, wherein said foam is a dry foam.

15. A method of protecting a surface to be exposed to intense heat, comprising delivering foam of at least moderate stability to such surface, distributing the foam over such surface to form a protective covering layer, confining the foam outwardly by a foam-pervious medium to maintain the foam layer in reasonably stable position over the surface while permitting restricted emission of foam from said layer, and replenishing foam drained from said layer so as to maintain a predetermined temperature gradient across said layer.

16. A method of protecting a surface to be exposed to intense heat, comprising delivering continuously foam of at least moderate stability to such surface, distributing the foam over such surface to form a protective covering layer of predetermined thickness, confining the foam outwardly by a foam-pervious medium to maintain the foam layer in reasonably stable position over the surface while permitting restricted emission of foam from the layer, and regulating the rate of foam delivery to maintain the layer at said predetermined thickness and at a predetermined temperature gradient across the layer.

References Cited in the file of this patent

UNITED STATES PATENTS

1,853,460	Rzeminiecke	Apr. 12, 1932
1,991,601	DeLasaux	Feb. 19, 1935
2,632,163	Spandau	Mar. 24, 1953