

[54] AIR CONDITIONED SUIT

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[51] Int. Cl. **F28f 7/00**

[58] Field of Search ... **128/142.3, 400, 401, 402, 1 R, 128/1 B; 165/46, 47, 96; 312/1**

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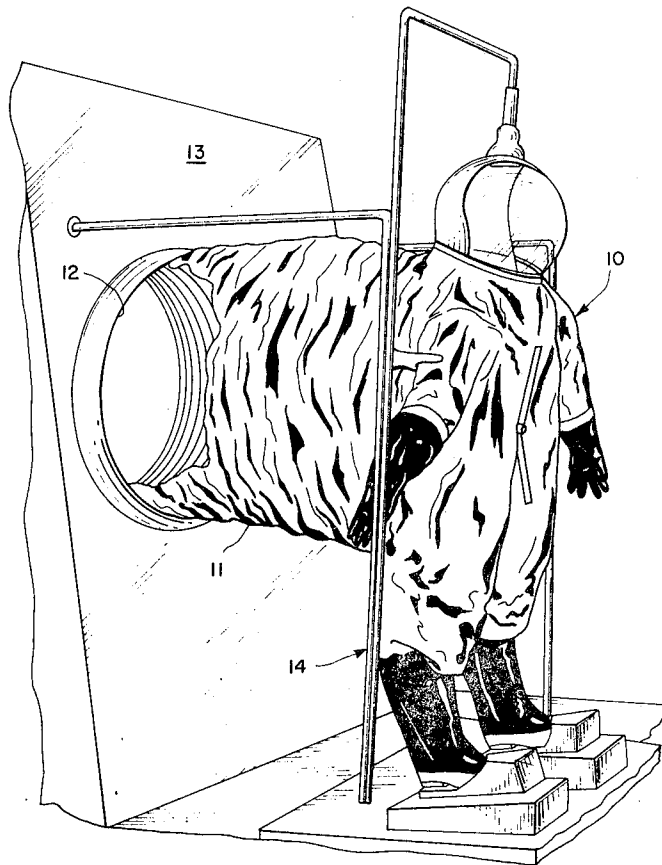
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[57] **ABSTRACT**

An environmentally controlled suit consisting of an airtight outer garment attached by an airtight bellows to the wall of a sterile chamber, an undergarment providing for circulation of air near the skin of the wearer, and a circulation system comprised of air supply and distribution to the extremities of the undergarment and central collection and exhaust of air from the midsection of the undergarment. A workman wearing the undergarment and attached circulation system enters the outer garment through a tunnel in the chamber wall and the attached bellows to work in the chamber without any danger of spreading bacteria.

10 Claims, 3 Drawing Figures



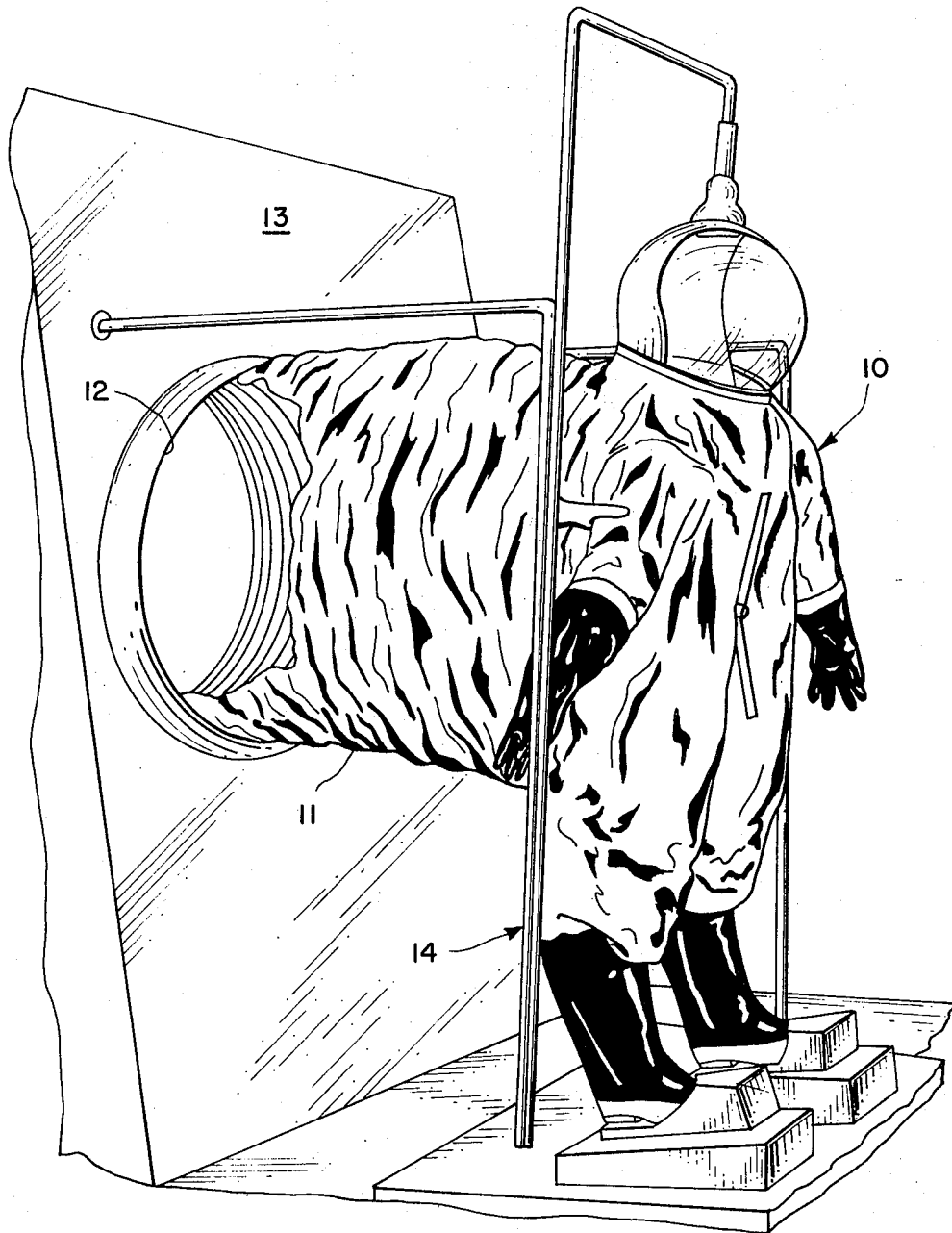


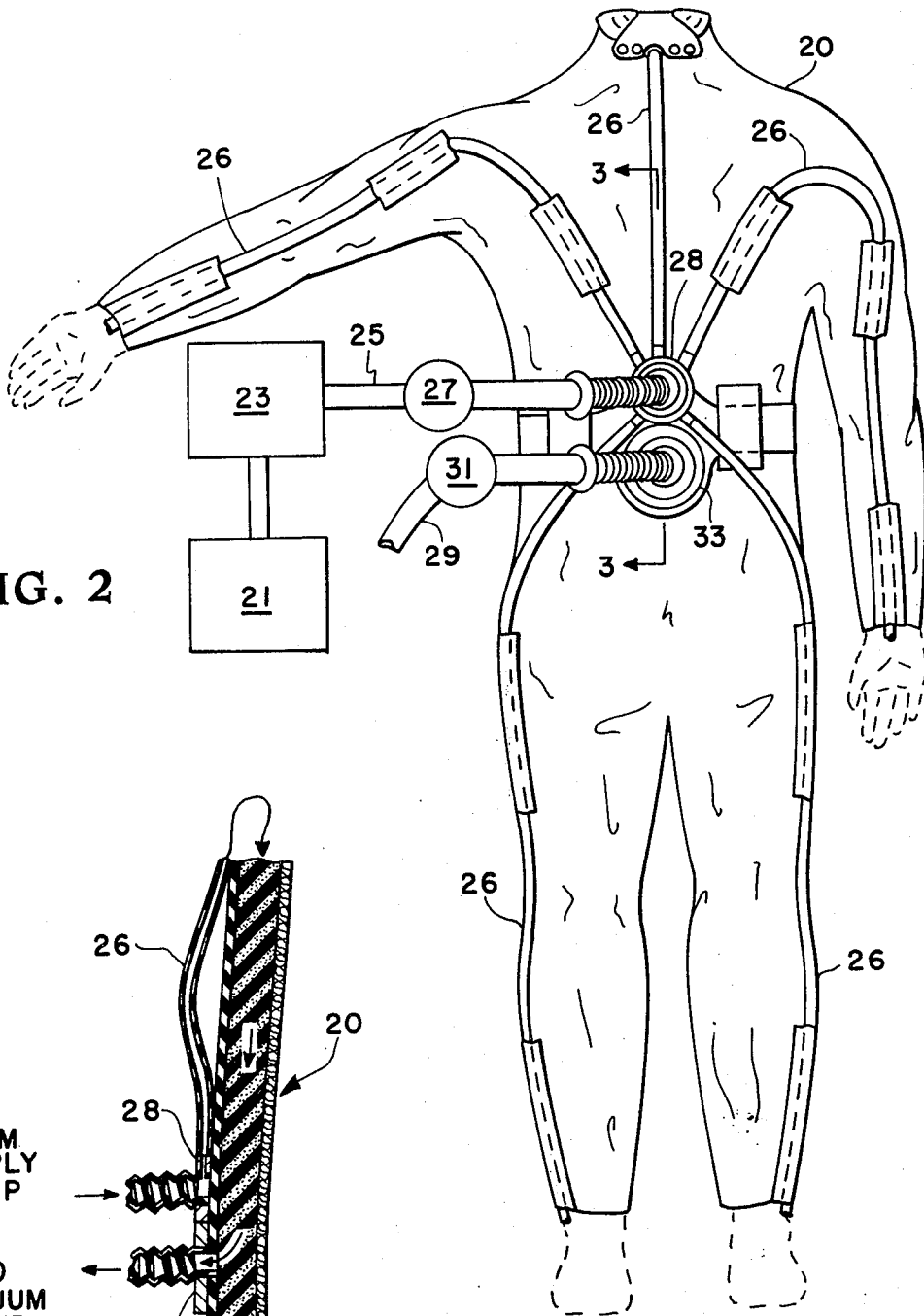
FIG. 1

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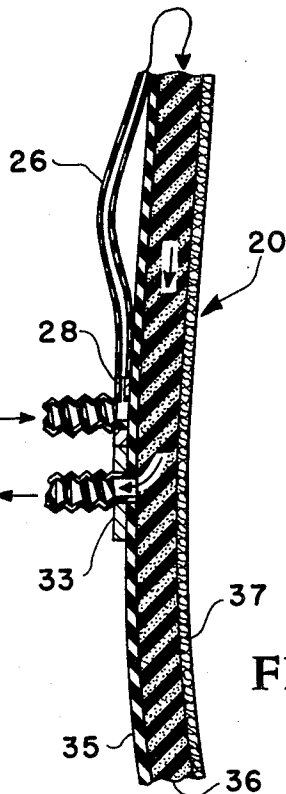
FIG. 2



FROM
SUPPLY
PUMP

TO
VACUUM
PUMP

FIG. 3



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AIR CONDITIONED SUIT

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

This invention relates generally to an environmentally controlled suit, and more particularly to a garment worn to insulate the wearer from his environment while air of desired temperature, moisture and chemical composition is circulated about the wearer's body by supply and exhaust systems. Under an international planetary quarantine agreement, all spacecraft which are to land on another planet must be sterilized before launch to avoid the introduction of potentially dangerous foreign life forms into the environment of the destination planet. Once sterilized, the spacecraft must be isolated from all contact with earth bacteria, making subsequent access for maintenance and handling of the spacecraft a difficult problem. The solution to this sterile handling problem has been the invention of an environmentally controlled germproof suit. The loose-fitting, airtight, watertight, germproof outer garment, which completely encases the human form, remains in the sterilization chamber during heat soak so that the outer surfaces of the garment are sterilized along with the spacecraft. A technician wearing an air-circulating undergarment with an attached air circulation system dons the suit through an access tunnel in the wall of the sterilization chamber. Wearing this novel suit, the technician may perform necessary operations on the spacecraft in comfort and without introducing contaminants into the sterilization chamber.

Air-conditioned suits comprising the prior art, while generally providing protection for the wearer in hot or cold conditions, do not completely insulate the wearer from his environment. Presently, air-conditioned suits of convective design provide an inflow of heated or cooled air around the wearer. The air that is supplied is allowed to escape by leaking around wrist, ankle, or neck openings or leaking out of the suit itself which has a semiporous outer layer. Such devices do not maintain proper carbon dioxide and oxygen balance for breathing and do not provide for germproofing to allow the wearer to work in a sterile environment.

Accordingly, it is an object of the present invention to provide a novel environmentally controlled undergarment to control the temperature, moisture, and chemical composition of air circulating next to the skin of the wearer.

Another object of the present invention provides suitable breathing air for the wearer.

Another object of the present invention is to provide an exhaust system for positive circulation of air throughout the suit.

Another object of the invention is the removal of moisture and waste products given off by the skin of the wearer.

A further object of the present invention is to germproof the wearer, that is, to contain bacteria within the suit (in particular the outer garment) to allow human operation in a sterile environment without contamination.

According to the present invention the foregoing and other objects are obtained by providing an airtight outer garment effectively sealing off the wearer from the environment outside the suit, an undergarment constructed to circulate air to over or near the wearer's body, and an air control circulation system. The outer garment may be attached by a bellows to the edges of an opening in the wall of a sterile chamber so that the suit remains in the sterile chamber. The bellows and points of attachment of the bellows at the wall and at the suit are likewise airtight, watertight and germproof. A technician wearing the undergarment and the attached air circulation system dons the outer garment by climbing through the wall opening and the bellows and into the outer garment.

Air of a desired temperature, moisture level, and chemical composition is fed by a supply pump through distribution lines to the extremities of the undergarment. The undergarment consists of a foam sandwich formed by an airtight outer layer, a highly porous open cell foam layer, and a nylon mesh inner layer. Supply air pumped to the extremities is drawn by an exhaust pump from the wrist, ankle and neck openings of the undergarment through the porous liner of the undergarment and thence to an exhaust plenum where the air leaves the suit via an exhaust line.

A more complete appreciation of the invention and the many inherent advantages thereof will be more clearly understood by reference to the following detailed description when considered with the accompanying drawings wherein:

FIG. 1 is a perspective view of the airtight outer garment including the attached bellows in the sterile chamber.

FIG. 2 is a rear view of the undergarment and air circulation system partly in schematic; and

FIG. 3 is a cross sectional view of the foam sandwich construction of the undergarment and the air circulation path through the undergarment.

Referring now to the drawings wherein like numerals designate identical or corresponding parts throughout the several views, and more particularly to FIG. 1, there is shown in a sterile chamber, a loose fitting outer garment 10 capable of completely encasing the human body. The back of outer garment 10 opens into a flexible bellows 11 which is attached to an access tunnel 12 in the wall 13 of a sterile chamber. A donning support mechanism 14 holds the outer garment 10 in position for wearer exit and entry and while the outer garment 10 is not being worn. Outer garment 10, bellows 11 and all attachments between the bellows and the outer garment and wall 13 are airtight, watertight and germproof effectively segregating the wearer from the sterile area within the chamber.

Referring now to FIG. 2, undergarment 20 is shown together with an air circulation system. This system consists of a source 21, a regulator 23, a supply line 25, a supply plenum 28, a supply pump 27, air distribution lines 26, an exhaust plenum 33, a vacuum pump 31, and an exhaust line 29. This structure is of a conventional design and need not be explained in detail.

Referring now to FIG. 3, more complete appreciation and better understanding of air circulation through undergarment 20 as shown in FIG. 2 will be readily apparent. Undergarment 20 as shown in FIG. 2 is con-

structed of a foam sandwich having a nylon-reinforced, rubber layer 35 which is nonporous, an open cell foam layer 36 which is highly porous and a nylon mesh inner layer 37 which is also highly porous. The body of the wearer and the nylon reinforced rubber layer 35 define the boundaries of the path of the circulating air. Air is free to circulate through the open cell foam layer 36 and the nylon mesh inner layer 37 thus passing over or near the skin of the wearer. Adequate circulation is obtained at ordinary (90° F.) temperatures with only one quarter inch thickness of the open cell foam.

OPERATION

From the above description, operation of the suit should be readily apparent. A technician or other workman or scientist wishing to work within the sterile chamber climbs through access tunnel 12 and bellows 11 into the outer garment 10 while wearing an undergarment 20 equipped with an air circulation system. Once in the outer garment 10 which is airtight, watertight, and germproof, the workman is insulated from the sterile area and he may move about the chamber to the extent of the expanded length of bellows 11.

The environment of the workman within the suit is controlled by the air circulation system. Air of a desired temperature, moisture, and chemical composition is fed from source 21 through regulator 23 and supply line 25 to a supply plenum 28 by supply pump 27. From supply plenum 28, air is fed to the wrist, ankle and neck areas of undergarment 20 by air distribution lines 26. Air collecting at these extremities of the outer garment is drawn through the undergarment 20 to exhaust plenum 33 by vacuum pump 31 and is exhausted through exhaust line 29.

The undergarment 20 is constructed of a foam sandwich 40 having a nonporous, nylon-reinforced rubber outer layer 35, a highly porous open-cell foam layer 36, and a highly porous nylon mesh inner layer 37. This construction insures that the air drawn from the extremities will be circulated near or over the skin of the wearer (between layer 35 and the skin of the wearer). The circulated air supplied oxygen for breathing and cools or heats the wearer as required while removing bodily waste products such as exhaled air and perspiration vapor. Suit temperature control and general wearer comfort can be more readily affected by increasing the suction of the exhaust system than by increasing the supply pressure which illustrates the importance of suction in air circulation.

Although the invention has been described and illustrated in detail in its specific embodiment thereof, it is to be understood that this description is by way of illustration only and is not to be taken as limiting on the applicant's invention. Obviously, there are many modifications and variations of the present invention possible in the light of the above teachings. The outer garment could be made as an independent unit rather than a continuation of a tunnel in the wall of the sterile chamber. The wearer could be sealed into the outer garment during operation in the chamber with air circulation lines extending through sealed openings in the outer garment. Various arrangements of circulation paths through the undergarment can be used without deviation from the basic concept. For example, the air could be fed to the wearer's midsection and removed by non-

collapsible suction lines at the wrist, ankle and neck openings reversing the flowpath previously described. Materials other than those disclosed in construction of the undergarment could be used provided the outer covering is nonporous and the inner layer or layers is highly porous. Construction materials used in the outer garment, in addition to being watertight, airtight, and germproof, should be selected with regard to the temperatures and pressures to be experienced in the work area which could be a sterile chamber, vacuum chamber or other hostile (to human life) environment. Of course vacuum chamber operation or high or low temperature uses would require some redesign of the outersuit.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. An air-conditioned suit adapted to be used for activities in a sterilized environment such as a clean room wherein the wearer can work in the sterile environment without the suit or the wearer contaminating the sterile area the improvement comprising:

means including access to a chamber in the sterile environment

suit means providing a loose-fitting, airtight, watertight, germproof garment enclosing substantially the entire body and adaptable in conformity to said access means;

air-conditioning means;

air-circulation means including regulator means connected to said air-conditioning means and suit means for maintaining constant temperature; moisture and chemical composition of the air within said garment and adjacent the skin of the wearer of said suit.

2. The suit of claim 1 wherein said air circulation means includes:

a close-fitting, air-circulating undergarment;

an air supply system for supplying conditioned air of variable temperature, moisture, and chemical composition to be circulated within said undergarment;

an air exhaust system for positively drawing air supplied by said air supply system from within said undergarment.

3. The suit of claim 2 wherein the close-fitting, air-circulating undergarment is constructed of three layers-an outer covering constructed of an essentially airtight material, an open-cell foam layer, and a fabric mesh inner covering whereby air may be circulated through the mesh and throughout the open-cell foam layer to cool or heat convectively.

4. The suit of claim 3 wherein the outer covering is constructed of reinforced rubber.

5. The suit of claim 2 wherein the air supply system consists of a source of air; a regulator to control air temperature, moisture, and chemical composition, a supply pump; a supply line, a supply plenum and distribution lines for distributing conditioned air to various parts of the undergarment; and the exhaust system consists of an exhaust plenum, an exhaust line, and a vacuum pump.

6. The suit of claim 4 wherein the distribution lines extend from the supply plenum to the extremities of the undergarment and the exhaust plenum is centrally located near the mid-section of the undergarment.

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7. The suit of claim 1 wherein the air circulation means includes:

a close fitting, air-circulating undergarment comprised of three layers-a nylon-reinforced rubber outer covering, an open-cell foam layer, and a nylon mesh inner covering;

an air supply system consisting of a source of air, a regulator to control air temperature, moisture, and chemical composition, a supply pump, a supply line, a supply plenum and distribution lines for distributing conditioned air to the extremities of the undergarment; and

an exhaust system consisting of an exhaust plenum centrally located near the mid-section of the undergarment, an exhaust line and a vacuum pump for positively drawing air supplied by said air supply system from within said undergarment.

8. An environmental control device comprising: a sterile chamber;

an air-conditioned suit means within said chamber including a loose-fitting, airtight, watertight, germproof garment covering substantially the entire body;

air-conditioning means;

air circulation means including regulator means connected to said air-conditioning means and suit

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means for maintaining constant temperature, moisture, and chemical composition of the air within said garment and adjacent the skin of the wearer of said suit means;

access means for entering the suit through a wall of said sterile chamber;

airtight, watertight, germproof means for connecting said access means interior said sterile chamber to the open back of said suit means; said connections being watertight, airtight, and germproof; whereby a human being can don the suit means by climbing through the access means and the airtight, watertight, germproof means and move about in said sterile chamber without introducing contaminants into said sterile chamber.

9. The environmental control device of claim 7 wherein the airtight, watertight, germproof means is an extendible and retractable bellows.

10. The environmental control device of claim 8 wherein the access means is an aperture in a wall of the sterile chamber and said airtight, watertight, germproof means is an extendible and retractable bellows whereby the exterior surface of said bellows and said suit and the interior wall surfaces of said sterile chamber define the boundaries of a sealed sterile area.

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