

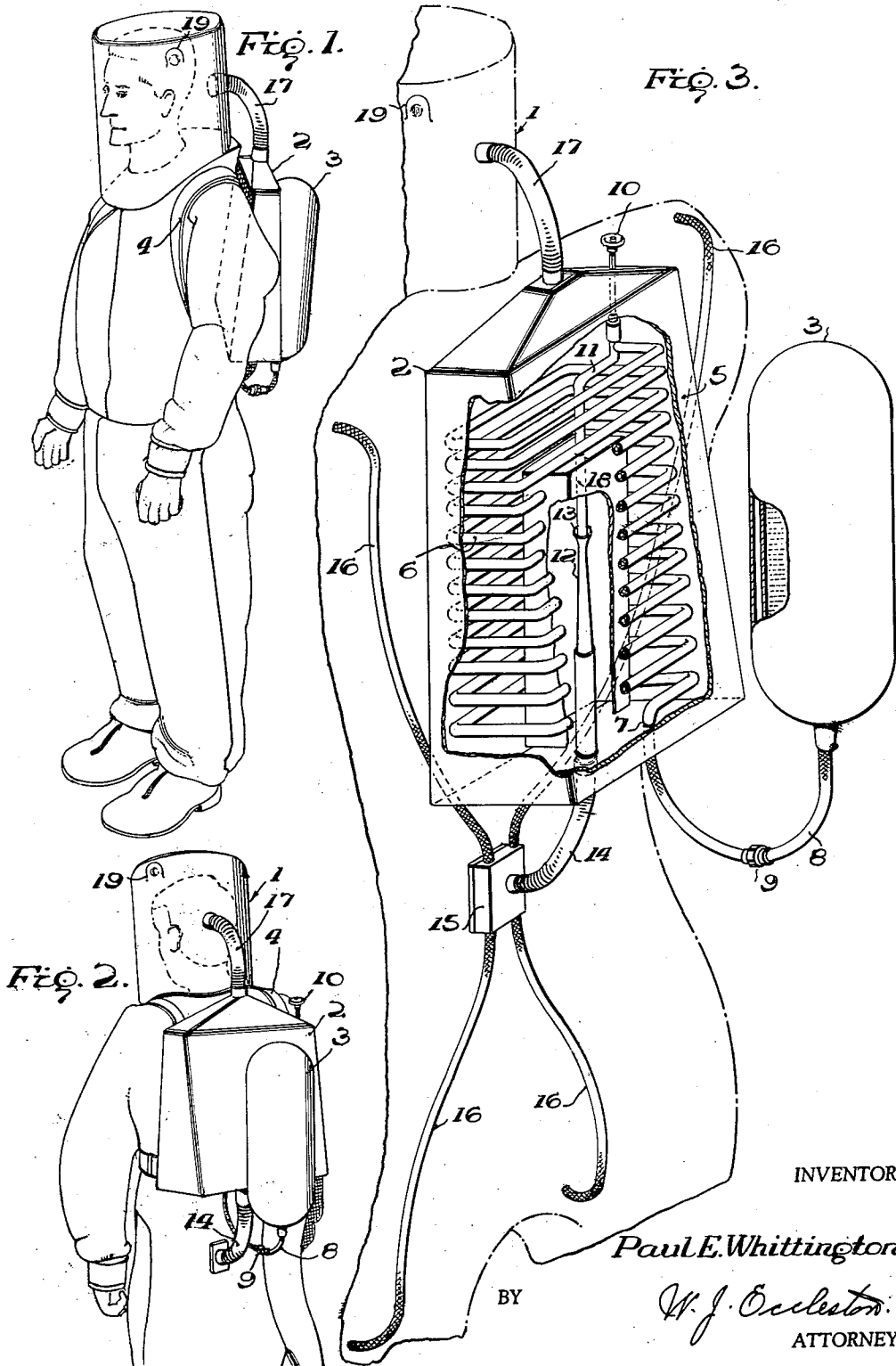
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AIR CONDITIONED FUEL HANDLING SUIT

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AIR CONDITIONED FUEL HANDLING SUIT

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10 Claims. (Cl. 62-259)

(Granted under Title 35, U.S. Code (1952), sec. 266)

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

This invention relates generally to air-conditioning systems and especially to self-contained units wherein enclosed spaces may be automatically air conditioned for human occupancy.

Inasmuch as humans generate heat, moisture, and carbon dioxide, all of which may have deleterious effects on the human body, it is a primary object of the present invention to provide novel and effective means for removing suitable proportions of these injurious items.

A further object of the invention consists in supplying respiratory gas to the interior of the enclosure so as to maintain a sufficient quantity of oxygen therein, while at the same time ejecting from the enclosure a sufficient proportion of the heat, moisture, and carbon dioxide generated therein, to provide a healthful atmosphere.

In accordance with the present embodiment of the invention, a heat exchanger is disposed adjacent the enclosure and produces cool respiratory gas, which serves to remove excessive heat and moisture from the atmosphere while causing the atmosphere to circulate and a portion of the carbon dioxide to be ejected.

More specifically, it is an object of the invention to combine with a suit and head covering, providing a complete impermeable enclosure for the human body, a heat exchanger and a supply of liquid oxygen, the heat exchanger being so constructed that the vapor from the expanding liquid oxygen passes through a venturi tube thereby causing a continuous circulation of the ambient air over the heat exchanger to cool the air and to separate therefrom a portion of the moisture given off by the occupant of the enclosure.

Other objects and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawings, in which

FIGURE 1 is a perspective view of the novel air-conditioned suit in use,

FIGURE 2 is a similar view taken at a different angle to more clearly show the apparatus, with parts omitted for the sake of clearness, and

FIGURE 3 is an enlarged schematic view of the apparatus, parts being broken away to more clearly disclose the arrangement of the heat exchanger and related parts.

Referring to the drawings in greater detail and by reference numerals, the numeral 1 indicates the encapsulating suit or other enclosure which is formed of air-imperious material and is completely sealed against acid fumes or other dangerous fluids with which the suit may be surrounded. An the primary purpose of the invention consists in providing suitable air for the occupant of the suit while removing at least a substantial proportion of the carbon dioxide, moisture, and heat generated by him.

The air-conditioning apparatus consists primarily of a heat exchanger indicated generally by the numeral 2, a double-walled tank 3 containing liquid air or oxygen, and straps 4 for supporting the apparatus from the shoulders of the wearer. It will be understood, of course,

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that the space between the walls of the tank will be evacuated to reduce the leakage of heat from the outside to the liquid within the tank.

The heat exchanger 2 is composed of a casing 5 in which is mounted a pipe coil 6 which enters the bottom of the casing as indicated by the numeral 7 and is connected with the lower end of the oxygen tank 3 by hose 8. This hose is provided with a quick-detachable coupling 9 which will permit a quick replacement of a tank 3 after it has discharged its contents.

A manually operable valve 10 within reach of the wearer of the suit serves to regulate or control the flow of liquid oxygen to the expansion coil 6. From this valve 10 a pipe 11 extends to the center of the coil and thence downwardly into a somewhat larger pipe 12 provided with a flared open end 13 to form a venturi tube for circulating ambient air through the suit 1 as will presently appear.

The lower end of the venturi tube passes through the bottom of the casing 5 of the heat exchanger and connects with a flexible hose 14 leading to a plenum chamber 15. From this chamber 15 flexible hose connections 16 lead the expanded and warmed gas to the interior of various parts of the suit, there being four such connections in the present disclosure extending to the arms and legs of the suit.

The upper portion of the suit 1 is provided with an opening to which a flexible hose 17 is connected for directing the spent gases to the interior of the casing 5 for heating the expanding fluid flowing passing upwardly through the coil 6. To facilitate this action of the spent gases on the fluid flowing from tank 3 into and through the coiled expansion pipe 6, a baffle 18 is provided. This baffle is in the form of a box closed at its upper end but provided with an opening to receive the pipe 11, and open at its lower end to permit the entrance of ambient air as it is drawn into the venturi tube 13; the ambient air being the air in the casing 5. It will thus be seen that the baffle 18 causes relatively warm and moisture-laden air passing into the casing 5 from the tube 17 to pass over and around the expansion coil 6 prior to its entrance into the venturi tube for recirculation.

The suit 1 is provided with a gas-tight zipper closure to permit donning or doffing of the suit, and the upper or hood portion of the suit is provided with a check or dumping valve 19 to permit the automatic escape of a portion of the spent air.

In the operation of the air-conditioned suit, controlled amounts of liquid air are withdrawn at approximately -312° F. to the expansion coil 6 at about 70 p.s.i.g. The liquid oxygen or air is converted into a gas by absorbing heat from the warm moist air that passes downwardly over the coil by reason of aspiration caused by the venturi 13. The volume of air passing through the heat exchanger or converter may be controlled by the manually-operable valve 10 which is a non-stop valve conveniently located for flow control by the user. Subsequent to its conversion to a gas, the gaseous air passes downwardly through pipe 11 into the venturi tube which causes by aspiration six (6) to eight (8) volumes of spent air from the suit to combine with one (1) volume of gas from the expansion coil. This mixture of gases enters hose 14 at a relatively low pressure and at a temperature between 55° and 70° F. The tempered air enters the plenum chamber 15 and is distributed through the four hose connections 16 to the arms and legs of the wearer of the suit. The air after moving over the arms, legs and torso passes to the hood portion of the suit, where a portion of it equal to the pure air being converted from the liquid state and entering the venturi tube will pass through a check valve 19 to the atmosphere. The other portion of the air entering the hood portion of the

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suit is returned through hose 17 to the heat exchanger where it will pass over the coiled expansion pipe 6 and be cooled so that excess moisture previously taken up from the body of the wearer will condensed and freeze on the exterior of the coiled pipe. During the periods of non-use, the frost will melt from the coiled pipe, as it becomes warmer, and flow downwardly to the bottom of the casing 5 from which it may be drained by pet cock (not shown).

From the above description taken in connection with the accompanying drawings, it will be apparent that I have devised a relatively simple and inexpensive combination of an air-impermeable suit, heat exchanger and oxygen tank which will operate in a reliable manner for circulating respiratory air through the suit, that the air is automatically relieved of a portion of the carbon dioxide, moisture, and heat generated by the wearer and that the entire series of operations involved is caused by the action of the venturi tube located within the expansion coil and the manually operable valve 10.

As heretofore stated, liquid air or liquid oxygen may be used in the apparatus of the present invention, and, hence, it is to be understood that the claims are not intended to be limited to an apparatus using liquid oxygen only.

In accordance with the patent statutes I have described what I now consider to be the preferred form of the invention but inasmuch as various minor changes may be made in structural details without departing from the spirit of the invention it is intended that all such changes be included within the scope of the appended claims.

I claim:

1. In combination, an air-impervious suit for humans, a heat exchanger including a casing and a coiled expansion pipe therein, a tank of liquid oxygen communicating with the pipe at the lower end of the coil, means for conveying oxygen expanded in said coiled expansion pipe from the upper end of the pipe to the interior of the suit, said means including a venturi tube having an inlet into which oxygen expanded in said coiled expansion pipe is discharged, an outlet and a suction throat, and means for conveying air from the suit to the interior of said casing, the suction throat of said venturi communicating with the interior of said casing so that air from said casing will be drawn into said venturi by the suction generated at the throat of said venturi when expanded oxygen is discharged into the said inlet of the venturi from said coiled expansion pipe whereby said venturi tube will cause a circulation of air through the suit and casing.

2. In combination, an air-impervious suit for humans, a heat exchanger including a casing and a vertically disposed coiled expansion pipe therein, a tank of liquid oxygen communicating with the pipe at the lower end of the coil, means for conveying fluid expanded in said coiled expansion pipe from the upper end of the pipe to the interior to the suit, said means including a venturi tube disposed centrally of said pipe coil, means for conveying air from the suit to the interior of said casing, and a baffle enveloping the top and sides of the venturi tube, whereby air entering the casing is caused to pass downwardly over the coils of the tube prior to entering the venturi tube.

3. In combination, an air-impervious suit for humans, a heat exchanger including a casing and a coiled expansion pipe therein, a tank of liquid oxygen communicating with the pipe at the lower end of the coil, means for conveying fluid expanded in said coiled expansion pipe from the upper end of the pipe to the interior of the suit, said means including a venturi tube, means for conveying air from the suit to the interior of said casing, whereby said venturi tube will cause a circulation of air through the suit and casing, and a valve in the suit for permitting the escape of a portion of the circulating air.

4. In combination, an air-impervious suit for humans, a heat exchanger including a casing and a coiled expansion

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pipe therein, a tank of liquid oxygen communicating with the pipe at the lower end of the coil, means for conveying fluid expanded in said coiled expansion pipe from the the upper end of the pipe to the interior of the suit, said means including a venturi tube, means for conveying air from the suit to the interior of said casing, whereby said venturi tube will cause a circulation of air through the suit and casing, and a check valve in the suit for permitting the escape of a portion of the circulating air, and a hand-operated valve for controlling the flow of the expanded fluid to the venturi tube.

5. Protective apparatus comprising an air impervious garment for completely inclosing a wearer, means for supplying conditioned air to the interior of said garment including an expansion coil having an input end and an output end, a casing to house said coil, a source of liquid oxygen connected to the input end of said expansion coil so that expansion of the oxygen includes a circulation of the same through said coil, a venturi having an inlet connected to the output end of said expansion coil, a suction throat communicating with the interior of said casing and an outlet, means for establishing communication between the interior of said garment and said casing so that the aspiration of air from said casing by said venturi will induce a circulation of air from the garment to the casing, passage forming means to direct the air flowing into said casing from said garment into the area surrounding said coil and means for connecting the outlet of said venturi to the interior of said garment so that there is delivered to the interior of said garment when said device is operating a mixture comprising the oxygen vaporized in said expansion coil and the air aspirated from said casing through the suction throat of said venturi.

6. Protective apparatus comprising an air impervious garment for completely enclosing a wearer, a source of liquid oxygen, an expansion coil having an input end connected to said source of oxygen and an output end, a casing to house said expansion coil, a baffle in said casing having walls spaced from the walls of said casing, one end of said baffle being open to establish communication between the interior of the baffle and the interior of said casing, said expansion coil being disposed in the space between the walls of said casing and the walls of said baffle, a venturi housed in the space defined by the walls of said baffle and having an inlet connected to the output end of said expansion coil, a suction throat communicating with the space in said baffle so as to aspirate air therefrom and an outlet connected to said garment to discharge thereto a mixture of oxygen expanded in said coil and the air aspirated by said venturi, means for returning air from said garment to the space in said casing so that the aspiration of air from said casing by said venturi will induce a circulation of air from the garment to the casing, a manually operable valve to control discharge of expanded air to said venturi and a pressure relief valve for discharging air from said garment to the exterior.

7. A system for supplying conditioned air to an enclosed space such as an air impervious body-encapsulating garment comprising a source of liquid oxygen, an expansion coil having an input end connected to said source of oxygen and an output end, a casing to house said expansion coil, a baffle in said casing having walls spaced from the walls of said casing, one end of said baffle being opened to establish communication between the interior of the baffle and the interior of said casing, said expansion coil being disposed in the space between the walls of said casing and the walls of said baffle, a venturi housed in the space defined by the walls of said baffle and having an inlet connected to the output end of said expansion coil, a suction throat communicating with the space in said baffle so as to aspirate air therefrom and an outlet connected to said garment to discharge thereto a mixture of oxygen expanded in said coil and the air aspirated by said venturi, means for returning air from said

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garment to the space in said casing so that the aspiration of air from said casing by said venturi will induce a circulation of air from the garment to the casing, a manually operable valve to control discharge of expanded air to said venturi and a pressure relief valve for discharging air from said garment to the exterior.

8. In combination, an air-impervious suit for humans, a heat exchanger including a casing and a coiled expansion pipe in said casing having an inlet and an outlet, a tank of liquid oxygen communicating with the inlet end of said coiled expansion pipe, means for conveying air from the suit to the interior of said casing and means for conveying gaseous fluid from the outlet end of said coiled expansion pipe to the interior of said suit including means for drawing said air from said casing and mixing the same with the expanded oxygen discharged from the outlet end of said coiled expansion pipe, said air drawing means being actuated to draw air from said casing by the passage of expanded oxygen from the outlet end of said coiled expansion pipe into the means for conveying gaseous fluid to said suit.

9. In combination, an air-impervious suit for humans, a heat exchanger including a casing and a coiled expansion pipe in said casing having an inlet and an outlet, a tank of liquid oxygen communicating with the inlet end of said coiled expansion pipe, means for conveying air from the suit to the interior of said casing, means for conveying gaseous fluid from the outlet end of said coiled expansion pipe to the interior of said suit including means for drawing said air from said casing and mixing the same with the expanded oxygen discharged from the outlet end of said coiled expansion pipe, said air drawing means being actuated to draw air from said casing by the passage of expanded oxygen from the outlet end of said

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coiled expansion pipe into the means for conveying gaseous fluid to said suit, and a manually operated valve for controlling the flow of oxygen through said coiled expansion pipe.

10. An air conditioner for conditioning the air in an enclosed space such as an encapsulating suit for humans comprising a heat exchanger including a coiled expansion pipe having an inlet and an outlet and a casing for enclosing the same, a baffle in said casing having walls spaced from the walls of said casing, the said coiled expansion pipe being disposed in the space between the walls of said casing and the walls of said baffle, a tank of liquid oxygen communicating with the inlet end of said coiled expansion pipe, means for conveying air from the interior of said suit to the upper regions of the space between the walls of said casing and the walls of said baffle and means for conveying gaseous fluid from the outlet end of said coiled expansion pipe to the interior of said suit including means for drawing said air from said casing and mixing the same with the expanded oxygen discharged from the outlet end of said coiled expansion pipe, the expansion of liquid oxygen from said tank producing a flow of expanded oxygen through said coiled expansion pipe and the said air withdrawing means being actuated to draw air from said casing by the flow of expanded oxygen from the outlet end of said coiled expansion pipe into the means for conveying gaseous fluid to said suit.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,064,448

November 20, 1962

Paul E. Whittington

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 62, for "An" read -- And --; column 2, line 8, for "those" read -- hose --; line 29, strike out "flowing"; line 53, for "thr" read -- the --; column 3, line 4, for "condensed" read -- condense --; line 56, for "interior to" read -- interior of --; column 4, line 1, for "oxygen" read -- oxygen --; line 18, for "includes" read -- induces --; line 21, for "communicatiing" read -- communicating --.

Signed and sealed this 14th day of May 1963.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents