

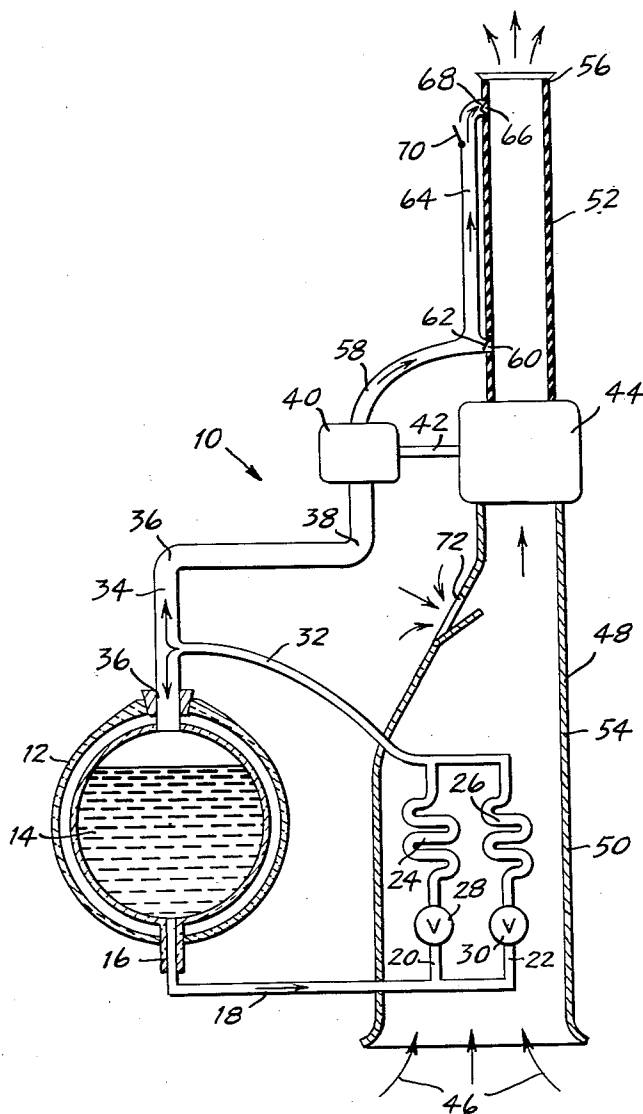
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AIR CONDITIONING UNIT

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AIR CONDITIONING UNIT

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This invention relates to relatively small compact air conditioning units and more particularly to a light weight air conditioning system particularly suited for use in cooling aviators' suits.

Modern aviator suits are very often tight fitting and impervious to air, necessitating some means for supplying cooling air to a flyer's suit. The suits can become extremely uncomfortable during periods when the pilot is unable to hook into the general air conditioning system of the aircraft.

It is not uncommon for the flight suit to be donned up to an hour before flight time during which period the pilot very often has his briefing. The novel light weight unit of the present invention makes it possible for the pilot to use the present system before he enters the airplane and during the time he is undergoing briefing and pre-flight instructions. The unit may be made completely portable and may be carried around in a brief case or the like during the pre-flight period. In addition, the suit may be ventilated by the system of the present invention even when the pilot is in the aircraft such as when he takes his position in the cockpit before the engines are started.

The present invention provides a novel light weight unit which through the utilization of ambient air requires only a minimum amount of cold bottled air. Furthermore, the system of the present invention provides cooling air of a temperature as low as minus 200° F. without the necessity of building up excessive pressures in the Dewar containing the cold air and without imposing stringent efficiency requirements on either the compressor or the expander incorporated in the unit. It is therefore possible to provide an improved unit of light weight and high efficiency suitable for use in aircraft wherein the weight of such auxiliary unit is an all important factor.

It is therefore a primary object to provide a novel air conditioning unit.

Another object of the present invention is to provide a novel air conditioning unit for aviators' suits.

Another object of the present invention is to provide a novel light weight portable air conditioning unit having improved reliability and efficiency.

These and other objects and advantages of the invention will be more apparent upon reference to the following specification, claims and appended drawing wherein the single figure of the drawing is a partially schematic diagram of the novel air conditioning unit of the present invention.

Referring to the drawing, the air conditioning unit generally indicated at 10 comprises a double walled insulating container 12 more commonly referred to as a Dewar filled with liquified air or pure liquified oxygen at a pressure of approximately 120 to 150 p.s.i. as indicated at 14.

Coupled to a lower outlet 16 of the Dewar is a conduit 18 connected to a pair of parallel branch lines 20 and 22 provided with coils 24 and 26 and flow control

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valves 28 and 30. One of the coils such as coil 26 illustrated in the drawing may include a greater number of turns than the other coil. A return line 32 connects the upper ends of the coils 24 and 26 to a vertical conduit 34 connected at its lower end to the inlet 36 formed in the upper end of Dewar 12.

Vertical conduit 34 includes a pair of right angle elbows 36 and 38 leading to the input side of an expander 40. Expander 40 is mechanically coupled as indicated by the shaft 42 to a compressor 44.

Ambient air is directed upwardly as indicated by the arrows at 46 through an elongated tube 48 which may be made of metal or other suitable material. Tube 48 preferably includes an enlarged lower section or casing 50 and a small upper section 52. While indicated as having a circular cross section throughout the configuration of tube 48 may be varied as desired and in many instances is formed with a flat side 54 adapted to be mounted against a flat surface. The upper section 52 is preferably formed as a flexible hose. The casing 50 communicates with the inlet side of compressor 44 whereas the outlet of compressor 44 enters the flexible upper section. Air flows outwardly from the extreme upper end of hose 52 indicated at 56 which end is adapted to be connected to a suitable inlet coupling on an aviator's suit.

A conduit 58 connects the output side of expander 40 to the upper section 52 as indicated at 60 through a suitable valve 62. Also connected to conduit 58 is a further conduit 64 extending parallel to the upper section or hose 52 and connected thereto at 66 through a suitable check valve indicated at 68. An exhaust valve 70 may be provided in the conduit 64 if desired. Also shown in the drawing is a by-pass valve 72 formed in the lower enlarged section 50 of the air flow tube 48.

Tests have shown that in one particular application it is desirable to provide a cooling flow of air to an aviator's suit in the quantity of approximately 1 pound per minute for a period of 1 hour. This requires that a total amount of air of approximately 60 pounds be supplied to the suit. Furthermore, it has been found that the total weight of the auxiliary air conditioning equipment should be limited so as not to exceed approximately 25 pounds. As can be seen, the 60 pounds required air cannot be stored in any self-contained equipment having a total weight of only 25 pounds.

As a solution to this problem the present invention provides a novel unit wherein the ambient warm air is mixed with a smaller amount of cold stored air. By way of example only, if it is assumed that 12½ pounds of air is stored in a liquid air bottle or Dewar, this leaves 12½ pounds of dead weight available for the other air conditioning components such as the coils, compressor, expander and the like. However, the energy extracted from this 12½ pounds of liquid air must act to pump the remaining 47½ pounds required to provide a total of 60 pounds of air to the aviator's suit. The stored liquid air must be maintained at a cold enough temperature to cool ambient air by mixing or heat transfer so as to deliver the air to the aviator's suit at a temperature in the range of 55 to 80° F. The flow ratio of cold air to outside air required therefore is about 4 to 1. The Dewar 12 while described as containing liquid air may contain as an alternative liquid oxygen or if desired liquid nitrogen for mixing with the ambient air.

In order to start operation either valve 28 or valve 30 must be open. Liquid from Dewar 12 then flows either through coil 24 or coil 26, evaporates, and pressurizes the Dewar through return line 32 and inlet 36. In addition, a portion of the evaporated liquid flows through vertical conduit 34 to the expander 40. Since expander 40 is mechanically coupled to compressor 44 this flow of

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evaporated liquid starts the compressor 44 into operation. The expander may be of any conventional type such as a free piston arrangement or vane motors. As soon as the expander and compressor start to operate warm air is pulled across the coils 24 and 26 increasing the evaporation rate within the coil through which the stored air is flowing and in a short time normal operation is arrived at.

If pressure in Dewar 12 is built up to too high a value, valve 72 is opened and by-passes a portion of the flow of warm ambient air around the coils 24 and 26. The opening of valve 72 may be in automatic response to the pressure within the Dewar through any well known pressure responsive connection. Since less heat is then supplied to the coil the pressure within the Dewar is reduced.

Since the warm air entering the lower end of air flow tube 48 may be moderately humid, it is possible that water will freeze out and be deposited on the cold coils so as to adversely influence the operation of the air conditioner. In order to avoid this difficulty, cold liquid air is supplied to only one coil, for example to coil 24 while valve 28 is open. At the same time, valve 30 is maintained closed so that coil 26 is not operating. When enough ice builds up on coil 24 suitable means may be provided to sense a pre-set temperature difference between the coil and the air flowing across it, so that valve 28 is automatically closed and valve 30 opens. Alternatively, the valves may be periodically opened and closed manually. Thus, coil 24 will be permitted to gradually defrost while coil 26 starts to gradually pick up ice during the time that liquified gas is evaporating inside the coil. By this arrangement, the heat is only temporarily lost by freezing out humidity and is then recovered because air always flows across both coils.

It is also possible to provide temperature control to an aviator's suit through the apparatus of this invention. Valve 62 either mixes cold air in conduit 58 with warm air supplied by compressor 44 right at the compressor exit or by-passes this connection and sends the cold air through the parallel line 64 to the very end of the flexible hose leading to the suit. In this way, cold air is warmed up by ambient air while the two are running parallel to each other through lines 52 and 64 and then mixed together. If desired, the construction can be modified such that one of the lines 64 and 52 is coaxially positioned inside the other so as to constitute a single structural flexible hose unit.

If the air is still too cold then it may be blown off to atmosphere through valve 70 and only compressor air supplied to the suit. For this reason valve 70 is preferably a temperature sensitive valve. Check valve 68 is provided to prevent backflow of warm gas through conduit 64.

The construction of the present invention substantially improves over a high pressure bottle arrangement in that the expander 40 is not required to have high adiabatic efficiency because it does not have to provide high cooling by expansion. In other words, the air entering the expander 40 is already cold and the expander may be operated without internal expansion. Using high pressure air on the other hand the expander would have to be extremely efficient to match the exit temperature which may be as low as minus 200° F. with the present arrangement. The components shown all may be very small and can be packaged in a small light weight unit. While described in conjunction with warm ambient air the device will operate with equal facility in conjunction with

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cold ambient air where actual warming up of the air is required.

It is apparent from the above that the present invention provides a novel light weight unit of compact construction with increased efficiency and reliability. Important features of the present invention include the fact that the expander need not operate at high efficiency and that only relatively low liquid gas pressures in the pressure bottle or Dewar are required.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. An air conditioning unit comprising a container for liquified gas, an evaporating coil coupled to opposite sides of said container, means for diverting a portion of the gas evaporated in said coil through an expander, and a compressor mechanically coupled to said expander for drawing ambient air through said compressor over said evaporating coil.

2. An air conditioning unit comprising a container for liquified gas, an output line connecting one side of said container to an evaporating coil, a return line connecting said coil to the opposite side of said container, a conduit connecting said return line to an expander, a compressor mechanically coupled to said expander for drawing ambient air over said evaporating coil, and means for mixing the output from said expander with the output from said compressor.

3. An air conditioning unit according to claim 2 wherein said liquified gas is air.

4. An air conditioning unit according to claim 2 including a second evaporating coil connected between said output line and said return line, and valve means for alternately directing said gas through first one coil and then the other.

5. An air conditioning unit comprising a container for liquified air, an output line connecting one side of said container to an evaporating coil, a return line connecting said coil to the opposite side of said container, a conduit connecting said return line to an expander, a compressor mechanically coupled to said expander for drawing ambient air over said evaporating coil, and means for combining the output from said expander with the output from said compressor, said combining means including a flexible hose for connecting to an aviator's suit.

6. An air conditioning unit according to claim 5 wherein the heat exchange between said combined outputs may be varied.

7. An air conditioning unit according to claim 5 including a second evaporating coil connected between said output line and said return line, and valve means for alternately directing said gas through first one coil and then the other.

8. An air conditioning unit according to claim 7 including a tubular casing for directing ambient air over said coils.

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