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Gronroos

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[54] **LIFE SUPPORT SYSTEM WITH A HULL HEAT EXCHANGER**

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy,** Washington, D.C.

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[21] Appl. No.: **300,000**

[52] **U.S. Cl.** .... **114/16 R,** 62/435, 114/0.5 R, 244/1 SC

[51] **Int. Cl.** **B63g 8/00**

[58] **Field of Search** .... 114/16 R, 0.5 R; 62/435, 434, 436, 438, 6; 244/1 SC

[56] **References Cited**

UNITED STATES PATENTS

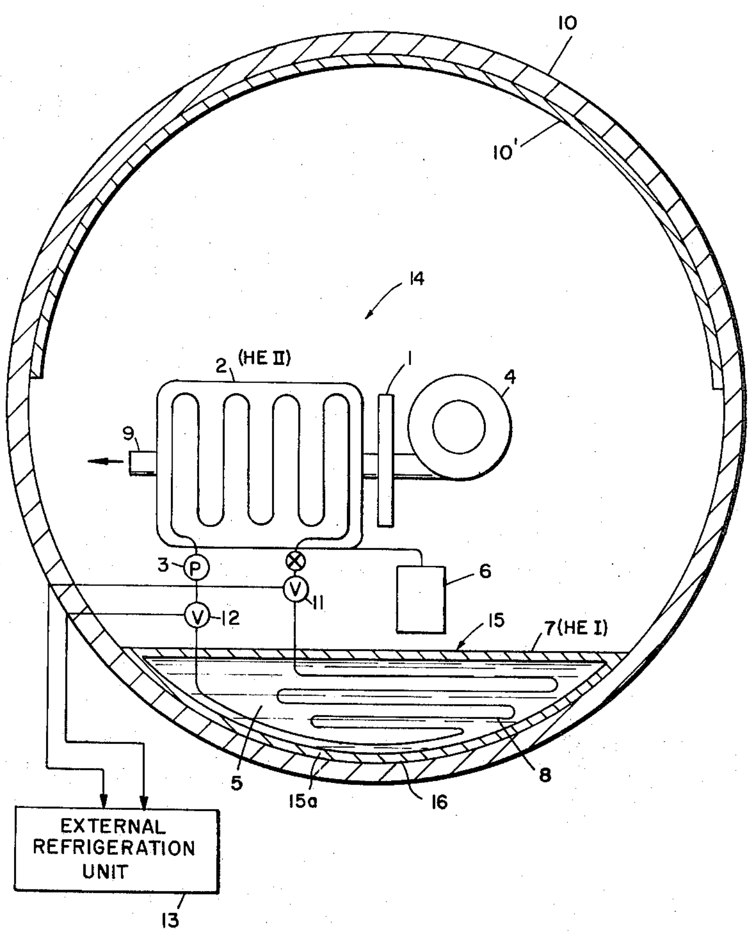
2,720,084	10/1955	Hailey	62/435 X
3,375,671	4/1968	Lloyd	61/69 R
3,379,021	4/1968	Link	61/69 R
3,661,107	5/1972	Jacobs et al.	114/16 R

Primary Examiner—Trygve M. Blix
Attorney—R. S. Sciascia et al.

[57] **ABSTRACT**

A life support system with a heat exchanger cooling system comprising a heat exchanger located below a false floor in the cabin of the life support system and a heat exchanger located in the crew compartment. The heat exchanger cooling system further comprises a cabin heat exchanger with a bypass hull heat exchanger. A circulation system is provided for the three heat exchangers. Heat for the vehicle is provided by the electrical components and a supplementary heater if required.

7 Claims, 2 Drawing Figures



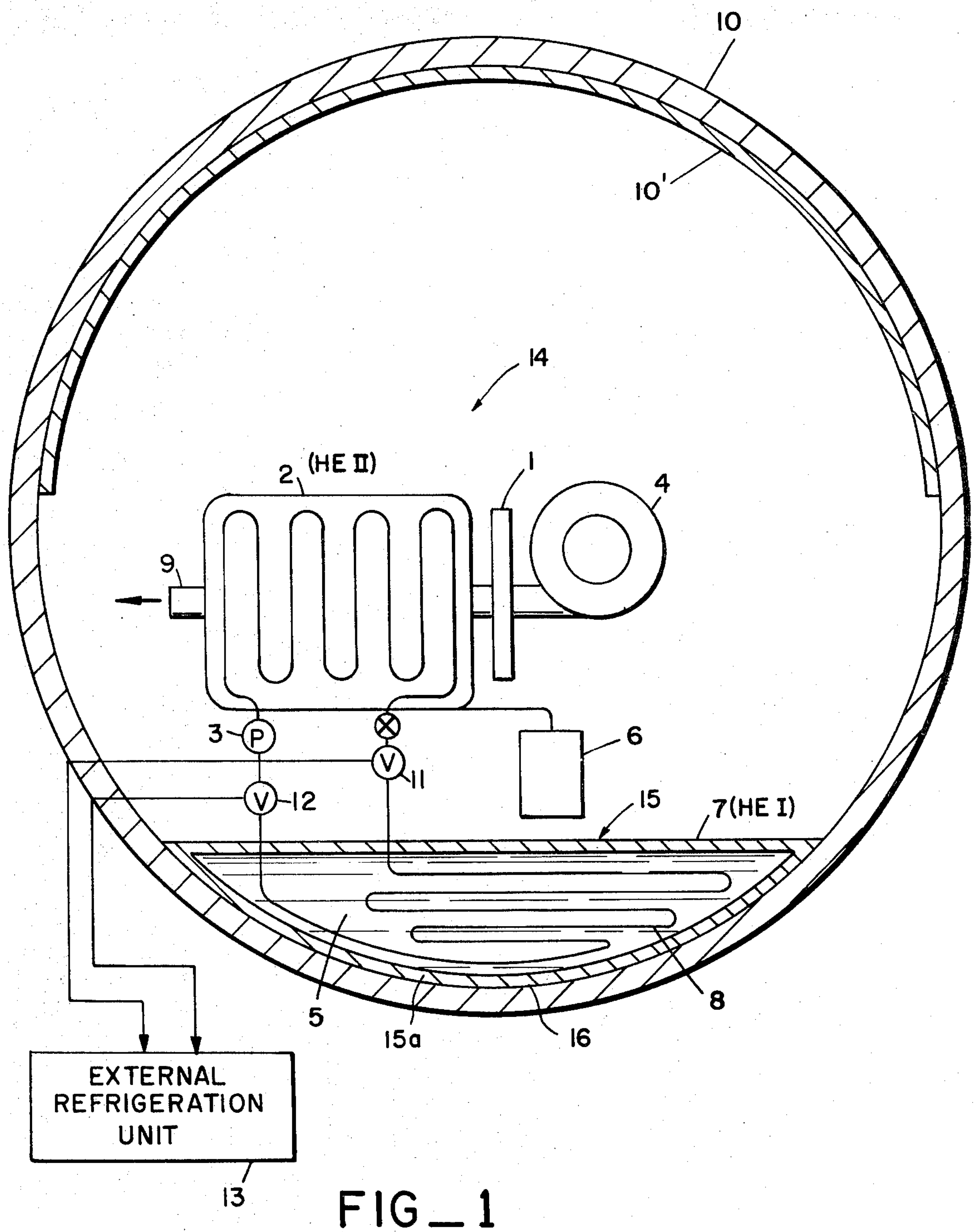

10
10'
14
2
(HE II)
1
4
9
3
P
V
11
6
V
12
15
7(HE I)
8
5
15a
16
EXTERNAL
REFRIGERATION
UNIT
13

FIG_1

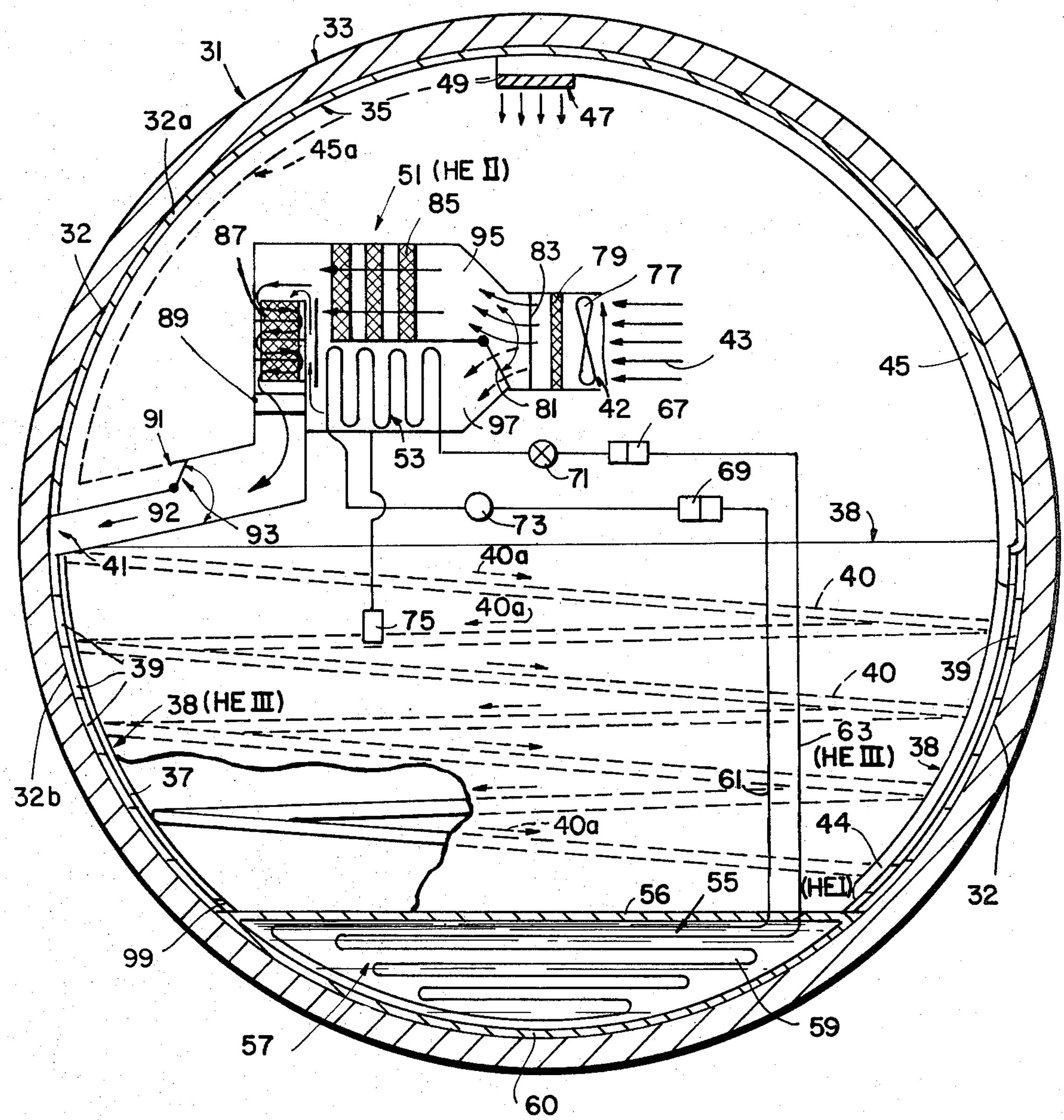

31
33
32a
35
49
47
45a
51 (HE II)
85
32
87
95
83
79
77
89
43
45
91
53
97
81
42
67
71
69
73
92
93
38
41
40a
40
75
39
38 (HE III)
63
(HE III)
37
32b
61
40a
44
(HE I)
56
55
32
99
57
59
60

FIG_2

LIFE SUPPORT SYSTEM WITH A HULL HEAT EXCHANGER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a life support system for a deep submersible vehicle with a heat exchanger system and more particularly to a heat exchange system which uses the hull of the vehicle as a heat exchanger in combination with a cabin heat exchanger.

2. Description of the Prior Art

Prior systems, such as described in U.S. Pat. No. 3,661,107, issued to Richard M. Jacobs et al., have heat absorption capacities equivalent to the size of the heat sink in heat exchanger and the rate flow. These systems are limited by their capacity as well as their useful working time.

SUMMARY OF THE INVENTION

Briefly, the present invention is a life support system with a heat exchanger cooling system comprising a heat exchanger located below a false floor, in the cabin, of the life support system and a heat exchanger located in the crew compartment. The heat exchanger cooling system further comprises a modified cabin heat exchanger with a bypass hull heat exchanger. A circulating system is located between the three heat exchangers. Heat for the vehicle is provided by the electrical components and a supplementary heater if required. The unique integrated cabin heat exchanger system increases the heat absorption capacity of prior system by using the hull as a heat exchanger in addition to a cabin heat exchanger. The unique integrated hull design allows the versatility of circulating the cabin air through either, both or neither heat exchanger systems depending upon the total amount of working required. By adding the external environment of the sphere and using the hull heat exchanger as an additional heat sink, the total heat absorption capacity of the system can be extended considerably. The capacity would be increased as the temperature of the external environment is decreased.

STATEMENTS OF THE OBJECTS OF THE INVENTION

A primary object of the present invention is to provide an improved heat exchange system with an integrated hull heat exchanger.

A particular feature of the present invention is an integrated hull heat exchanger which increases the system's capacity when water temperature are cold enough to allow efficient use of the hull scrubbing heat exchanger, thereby allowing longer hours of operation on one charge of the super-cooled ice or gel.

Other objects and features will be apparent from the following description of the invention and from the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration showing the deep submersible system including the old integrated heat exchanger and temperature control system combination; and

FIG. 2 is an illustration of the improved heat exchanger system including the hull heat exchanger, parts being broken away from the lower hull to illustrate the hull heat exchanger.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, specifically, the heat exchanger (HEI) unit **7** is cooled by a contained volume of gel **5** which freezes at about −10° F and has a specific heat equal to that of water. The gel **5** is located under the floor **15** in the bilge area **16** which forms an insulated container **15***a* for containing gel **5** and refrigeration coils **8.** The heat exchanger system **14** is internally connected to external refrigeration unit **13** through valves **11** and **12.** When valve **11** and valve **12** are closed, the heat exchanger **7** (HEI) is connected to external refrigeration unit **13** through valves **11** and **12.** When valve **11** and valve **12** are in the proper positions, the heat exchanger **7** (HEI) is connected to heat exchanger **2** (HEII) and condensate collector **6.** It should be noted that valve **11** and valve **12** could be disconnecting couplings which could be used to connect unit **7** and unit **2,** or unit **7** and unit **13,** thus isolating the preselected unit. The coolant pump **3** is used to circulate a waterglycol solution between the two heat exchangers. A condensate collector **6** is connected to the heat exchanger **2** (HEII). A blower **4,** air filter **1** and a ventilation air outlet **9** form the overall heat exchanger system **14.** The hemisphere **10** is insulated in the upper cabin area with a wall insulation material **10'**. Before a dive, a shipboard dockside, or external refrigeration unit **13,** is connected to the refrigerator coils **8** and gel **5** and cooled to about −30° F. The coils **8** are purged of freon and then connected to the cabin heat exchanger **2** (HEII) and the whole system is filled with a waterglycol solution. A variable speed pump **3** will circulate the coolant through the "ice block" coils **8** and the cabin heat exchanger **2** (HEII) during the dive. This system is very simple and can cool the cabin even in warm water. The system eliminates the need for using toxic material directly in the cooling system.

The heat exchanger for the integrated life support system (ILSS) for any submersible vehicle, such as hemisphere **10,** functions in the following manner: A thermally insulated container, heat exchanger **7** (HEI) containing a material of high specific heat such as water, light salt brine, blue-ice gel or any material which has specific heat equal to that of water, is super-cooled to a temperature below the freezing point of the materials. For example, the blue-ice gel freezes at about −10° F. Immersed within the container, heat exchanger **7** (HEI) and the gel **5** is a continuous copper or aluminum refrigeration tube or coil **8.** This tube contains a fluid capable of removing heat energy from heat exchanger **2** (HEII) located in the cabin. The fluid can be either a water glycol solution or any other non-toxic fluid with a low freezing point. Since the atmosphere within the submersible vehicle must be kept free from any toxic substance, great care must be exercised if freon is used as a substance to initially cool the "ice block." The alternative is to use a non-toxic media such as a brine or water-glycol solution for this heat removal process.

A complete understanding of the system described above may be had by reference to the disclosure of FIGS. **1** and **2** in the U.S. Pat. No. 3,661,107 filed on Dec. 28, 1970 by R. M. Jacobs et al.

Referring to FIG. **2,** wherein heat exchanger **2** (HEII), described in FIG. **1,** has been modified and coupled to the hull heat exchanger **38** (HEIII) located in the lower interior hull portion 32*b*: The heat exchangers 7 (HEI) and 2 (HEII) of FIG. 1 correspond to cabin heat exchanger 51 (HEII) and bilge heat exchanger 55 (HEI), respectively. The deep diving sphere 31 is comprised of an exterior hull 33, an upper interior hull portion 32*a* and a lower interior hull portion 32*b*. An upper hull insulation material 35 is attached to the upper interior hull portion 32*a* by any well known standard attaching means. An enclosed half-dome-shaped enclosure is located in the lower section 60 of the hemisphere 31 to form a false floor 56 as well as the bilge heat exchanger 55 (HEI). The bilge heat exchanger 55 (HEI) is comprised of heat exchanger coils 59 and super-cooled ice or gel 57. Coils 59 are connected in series with flow lines 61 and 63, respectively. The cabin air 43 is drawn into the inlet aperature 42 by fan 77. The air is then filtered by filter 79 and de-ionized by deionizer 83. The de-ionized air flow is then directed into the major components of the cabin heat exchanger 51 (HEII). The cabin heat exchanger 51 (HEII) is comprised of the variable intake gate 81, heat exchanger bypass channel 95, heat exchanger channel 97, desicant pads 85, CO_2 scrubber 87 and activated carbon 89 and cabin heat exchanger coils 53. A condensate collector 75 is located in the lower sump area of cabin heat exchanger 51 (HEII). The filtered air may be directed into either the heat exchanger channel 97 or bypass channel 95 or both by properly positioning variable gate 81. When gate 81 is positioned over the heat exchange channel 97, the air flow is directed through desicant pads 85 down through the CO_2 scrubber 87 to remove the CO_2 and then through the activated carbon filter 89 through air channel 92 to hull heat exchanger 38 (HEIII) and air flow inlet 41. This allows recirculation without cooling and allows for moisture removal. The air flow to the air flow inlet 41 may be shut off by closing variable gate 93 so that the cabin air duct 91 is open. This allows the air to flow directly into the cabin rather than through the hull heat exchanger 38 (HEIII) or directed into the standard cabin's ducted ventilation system by attaching air duct 91 thereto. This will allow cooling air to flow over the electrical components, or even the view ports, to prevent fogging. By closing off bypass channel 95 with variable gate 81, the air flow is directed over coils 53 and directly through the CO_2 scrubber 87 while bypassing the desicant pads 85. The air flow is directed through carbon filter 89 and to hull heat exchanger 38 (HEIII) via air channel 92. The cabin heat exchanger coils 53 are connected to heat exchanger coils 59 by quick disconnect fittings 67 and 69. A pump 73 controls the flow of cooling fluid through the coils 53 and 59 and through flow lines 61 and 63. The use of cabin heat exchanger 51 (HEII) can be isolated from the rest of the system by closing throttling valve 71. The external refrigeration unit 13, illustrated in FIG. 1, may be connected to valves 67 and 69 in a standard manner as described with respect to the discussion regarding FIG. 1 and the old system. The air flow can also be directed to both bypass channel 95 and heat exchanger channel 97 by placing variable gate 81 in the neutral position thus allowing infinitely variable control for cooling.

The null heat exchanger 38 (HEIII) generally comprises an air flow inlet 41, an air flow outlet 44 and a hull directing system 39. The hull directing system 39 is comprised of lower interior hull 32b and a lower hull insulator wall 37 separated by a continuous wrap-around spiral spacer 40 to form a continuous wrap-around spiral air channel 40*a*. A condensate drain plug 99 is located in the lowermost part of the hull insulation wall 37 of the hull heat exchanger 38 (HEIII). The air flow enters at inlet 41 and is spiraled through the continuous spiral in a circular manner down to air flow outlet 44. The air flow outlet 44 is connected at the overhead air exhaust 47 via a narrow channel air duct 45 which is attached to the interior hull 32. A filter 49 is provided at the overhead air exhaust 47 to further filter the air. The outflowing air from duct 91 can be directed by gate 93 to the overhead air exhaust 47 by way of an air ducting system 45*a* or back into the hull heat exchanger 38 (HEIII) for cooling if desired, by closing gate 93, while conserving the stored cooling in the heat exchanger 51 (HEII). Also, the air flow 91 could be directed to the ventilation system through duct 45*a* without using heat exchangers 55 (HEI), 51 (HEII) or 38 (HEIII). The air cooled by heat exchanger 51 (HEII) is usually ducted directly into the overhead distribution system described above. However, the two heat exchanger systems could be used in conjunction with each other to provide cooling in series. This could be helpful to increase the heat absorption capacity if both heat exchangers were operating with a small temperature differential. The total cooling system efficiency is increased, which increases the total capacity of the cooling system. This is achieved by using the hull as heat exchanger 38 (HEIII) while bypassing the cabin heat exchanger 51 (HEII) and conserving the use of bilge heat exchanger 55 (HEI).

Various modifications and other applications of the improvements to the invention are contemplated and may obviously be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as hereinafter defined by the appended claims, as only a preferred embodiment thereof has disclosed. For example, the variable gates or flow directors can be operated manually as automatically regulated by temperature and humidity control devices with the proper circuitry.

What is claimed is:

1. In combination with a cooling component control device for a submersible vehicle life support system wherein said system includes a cabin hull and a false floor and first and second heat exchangers located in said cabin hull, the improvement comprises:

a. a third heat exchanger located adjacent to the hull wall of said cabin;

b. a means for directing air from said second heat exchanger to said hull wall;

c. a means for insulating said cabin from said hull wall;

d. said insulating material being separated from said hull wall to form an air path area therebetween;

e. said directing means connected to said air path area whereby the air from said second heat exchanger is directed by said directing means into said air path area.

2. The device recited in claim 1 wherein said insulated area is further divided by a plurality of continuous connected air directing flow channels.

3. The device recited in claim 2 wherein said insulated area extends over the lower portion of the cabin.

4. The device recited in claim 2 wherein said air path area is connected to an air flow exhaust port.

5. The device recited in claim 4 wherein said exhaust port is vented into the cabin.

6. The device recited in claim 1 wherein said means for directing air comprises a first air channel, a second air channel separated by a two position air directing gate, said first heat exchanger being located in said second channel and said hull being connected to said first air channel.

7. The device recited in claim 1 wherein said second channel has a bypass air channel connected to said first channel whereby the air is directed against said hull when said gate is in the first position and the air is directed to said second channel when said gate is in the second position.

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