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T. M. ELFVING

3,015,220

MECHANICALLY REFRIGERATED RAILWAY CAR

Filed Nov. 25, 1955

3 Sheets-Sheet 2

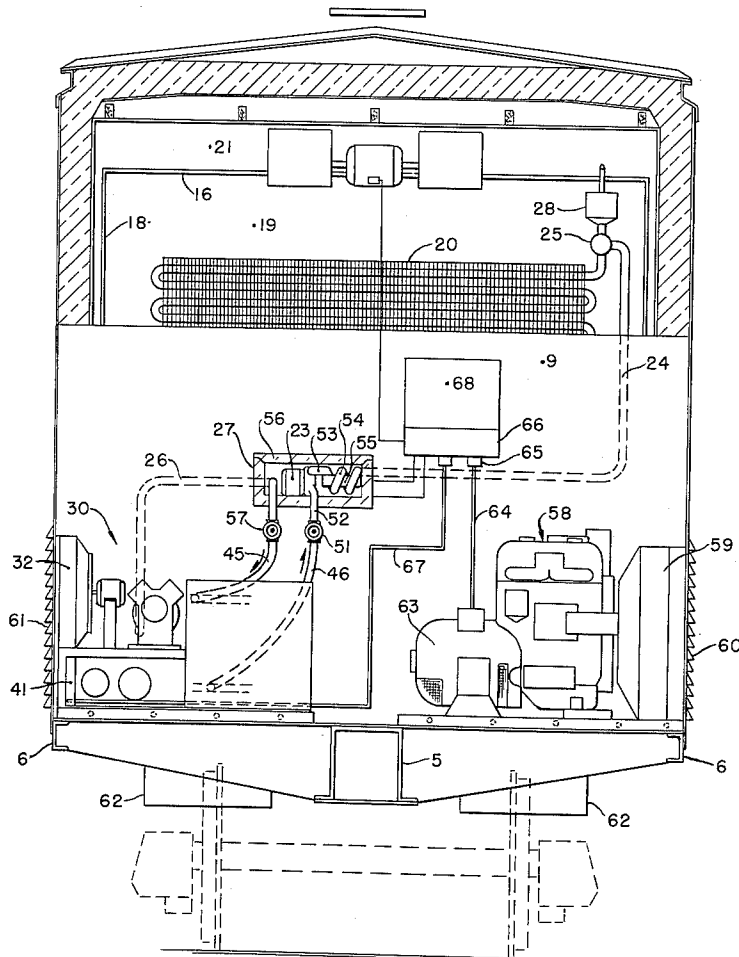


Figure 2

Thore M. Elfving INVENTOR.

BY

John W. Swain
ATTORNEYS

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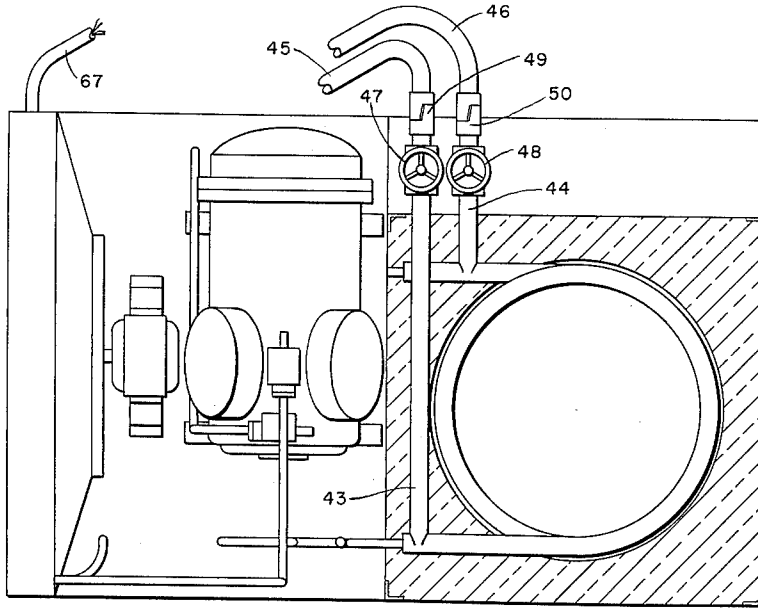


Figure 3

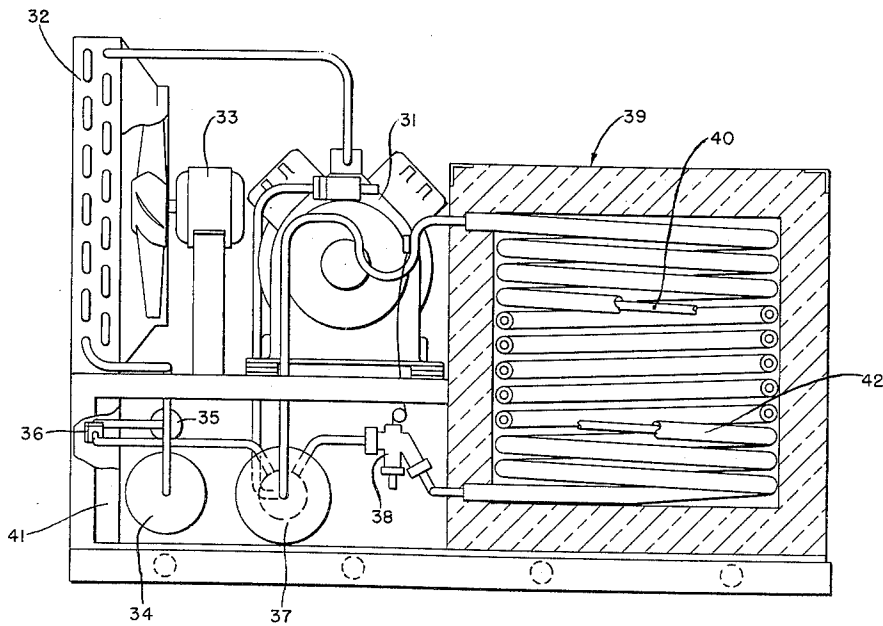


Figure 4

Thore M. Elfving INVENTOR.

BY

Flake & Surin
ATTORNEYS

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3,015,220

MECHANICALLY REFRIGERATED RAILWAY CAR

Thore M. Elfving, 433 Fairfax Ave., San Mateo, Calif.

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2 Claims. (Cl. 62-435)

The present invention relates generally to mechanically refrigerated railway cars, and more particularly to mechanically refrigerated railway cars which employ refrigeration package units.

Mechanically refrigerated railway cars should be general purpose cars, i.e., usable for transportation of commodities which must be maintained either above or below freezing temperatures. For example, the cars should be usable for the transport of frozen food products at low temperatures, and for the transport of various fresh produce and meats at temperatures above freezing. Such cars should include automatic temperature control means to maintain any desired temperature between 0° and +65° F. Since the ambient temperature may change rapidly en route, means for both refrigerating and heating the lading compartment are necessary. Cars of this type have hitherto been very costly to build and difficult to service because of the complicated equipment and complex controls required.

As is well known, railroad refrigeration is to a great extent a problem of air cooling. Generally, large heat transfer surfaces and large evaporator volume are required to permit efficient operation with a minimum of frost deposit. In mechanical refrigerator cars this presents a difficult problem, especially when the complete refrigeration system is mounted in a removable package unit. Package unit construction is desirable from a service point of view since the unit may be replaced en route and serviced or repaired later. Generally, the air cooling unit or heat exchanger in a package unit of this type is small and compact. To obtain a sufficient heat transfer surface in a small volume, the fins are spaced close to one another. The blower fan must be capable of circulating a large volume of air. When the fins are spaced close to one another, the blower is generally large and bulky. Refrigeration units of this type are sensitive to ice deposit and frequent defrosting is necessary. In certain instances the units are defrosted at intervals of 4 to 5 hours. Furthermore, the arrangement of air ducts and dampers for circulating the air between the commodity space and cooling unit becomes unduly complicated and expensive to construct. The car must be designed to receive the package unit. Designs of this type are very costly and weak with regard to heat intake and moisture influence.

In my copending application entitled "Mechanically Refrigerated Railway Car," Serial No. 362,775, filed June 19, 1953 (now Patent No. 2,881,600), of which this application is a continuation in part, there is described a mechanically refrigerated railway car employing two or more air cooling units operated at different temperatures and arranged in series in a vertical air flue. The high temperature return air first passes over a cooling section of relatively high temperature located at the lower part of the cooling unit and is pre-cooled. The air then passes over one or more succeeding evaporator or cooling units operating at lower temperatures where it is further refrigerated before it enters into the ceiling plenum. In one embodiment of the invention, there is described a refrigeration system which employs circulating fluid heat exchanger or cooling units in the air flue. A mechanical refrigerating unit including a double pipe heat exchanger is mounted external of the lading compartment. Pump means serves to circulate fluid through the cooling means located within the lading compartment and through the double pipe heat exchanger located outside the lading

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compartment whereby the circulating fluid medium absorbs the heat from the air and conducts it to the double pipe heat exchange unit of the mechanical refrigerator.

It is a general object of the present invention to provide an improved so-called general purpose type mechanically refrigerated railway car.

It is another object of my invention to provide an improved refrigerating system for cars of the above type.

It is still a further object of my invention to provide an improved refrigeration package unit.

It is still a further object of my invention to provide a removable refrigerated package unit of utmost simplicity, reliability and light weight for use in refrigerated railway cars.

It is still a further object of my invention to provide a strong, inexpensive refrigerated railway car structure in which the air cooling system forms an integral part of the car.

Additional objects and features of the invention will appear from the following description in which the preferred embodiment is described with reference to the accompanying drawings.

Referring to the drawing:

FIGURE 1 is a sectional elevational view of a refrigerator railway car, certain parts being illustrated diagrammatically;

FIGURE 2 is a sectional view taken along the line 2—2 of FIGURE 1;

FIGURE 3 is a plan view partly in section of the refrigeration package unit with certain parts shown diagrammatically; and

FIGURE 4 is a side elevational view partly in section of the refrigeration package unit of FIGURE 3 with certain parts shown diagrammatically.

A refrigerator car of the general purpose type is shown in FIGURES 1 and 2. The car includes the underframe with the centersill 5, sidesills 6, floor 7 and roof 8. An insulated transverse bulkhead 9 extends entirely across the car and is securely affixed to the floor and roof structure. Thus, a commodity or load compartment 10 and a machine compartment 11 are formed, the latter being located between the bulkhead 9 and the end wall 12.

According to my invention, the bulkhead 9 is constructed and affixed in the same manner as reinforced pressed steel car ends. It is therefore strong enough to take the impact of the load without support from the end wall 12. The end wall 12 is preferably fabricated with the same die as the bulkhead, but a lighter gauge material is used. On the commodity side of the bulkhead 9 and adjacent thereto there is an insulating structure 13 comprising vertical posts (not shown) and belt rails 14 covered by a suitable panel 15.

The load compartment is thermally insulated in the conventional manner. It has a false ceiling 16, a false floor 17 and false walls 18, thereby permitting circulation of air all around the commodity space, the spacing of the ceiling being relatively greater than the spacing at the side walls to form a plenum. Although complete envelope design is illustrated, it is to be understood that the invention is not to be limited in this respect.

A vertical wall flue 19, in which an air cooling unit in the form of a coil bank 20 is located, is formed between the bulkhead panel 15 and the false wall 18. A blower fan 22 is disposed above the coil bank 20 to circulate air past the coil bank. The air is circulated upward through the coil bank into the plenum. The air then travels through the remainder of the air envelope, returning to the wall flue 19 through the floor channels 23. As is well known, in other types of design, the air may be directed directly onto the load and returned to the wall flue 19 underneath the floor racks.

Preferably the coil bank 20 is made from galvanized

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steel tubing and iron fins whereby the false wall 13 can be placed directly against the coil bank, which is supported directly by the bulkhead 9 through the structure 13. This end of the load compartment is as strong as the other end of the car and able to withstand the impact of lading shifts during transport.

According to the invention, a liquid cooling medium or coolant is supplied to the coil bank in counterflow to the air passing the cooling unit. The liquid coolant is supplied by a suitable pump 23 located in the machine compartment. The coolant is carried by a pipe 24 to a manifold 25 at the upper part of the coil bank. The pump 23 is preferably of the self-priming type. The manifold 25 is connected with the tube branches of the fin pipe system constituting the coil bank. Liquid is withdrawn from the bottom of the cooling unit through the conduit 26 which pierces the bulkhead adjacent the insulated box 27. The pump 23 may be housed in the box 27. An expansion vessel 28 is arranged at the highest point of the liquid circulating system. A vent pipe 29 leads through the bulkhead to the machine compartment where the liquid system can be refilled, if necessary.

The liquid coolant system serves as a secondary heat transfer medium for cooling or heating the air cooling unit 20. Under refrigeration, the system absorbs heat from the circulating air and during heating it transfers heat to the circulating air. The secondary liquid system has a portion in heat exchange relation with the evaporator of a primary refrigeration system, for example, the refrigeration package unit designated generally by the reference numeral 30 in the machine compartment.

The refrigeration package unit 30 illustrated in FIGURES 3 and 4, includes a condensing unit with an evaporator-cooler serving to absorb heat from the liquid coolant. The condensing unit includes a motor-driven compressor 31 which is preferably of the 4 to 6 cylinder type to facilitate starting against load, an air-cooled condenser 32 with a condenser fan and motor 33, a receiver 34, a strainer 35, a sight glass 36, a heat exchanger 37, a thermostatic expansion valve 38, and a double pipe cooler 39 which may be in the form of a helical coil, the inner pipe 40 serving as the evaporator coil of the condensing unit. Since the condensing unit is conventional, other parts will not be described in detail, it being understood that all the parts are connected in the conventional manner.

Regulating devices of the usual type such as back pressure regulating valves, electric safety devices, high and low pressure cut-outs, etc., are mounted in the package control panel 41.

As previously described, the secondary liquid system has a portion in heat exchange relation with the evaporator of the primary system. Thus, the outer branch 42 of the double pipe cooler 39 is part of the liquid coolant system. The pipes 43 and 44 are connected to the upper and lower ends, respectively. The detachable flexible hoses 45 and 46 connect these pipes to the liquid circulation system at the bulkhead. Hand valves 47 and 48 are mounted in pipes 43 and 44. The hoses 45 and 46 are attached to the package by means of suitable couplings 49 and 50. The flexible hose 46 from the lower part of the double pipe cooler connects to a hand valve 51 and a pipe 52 leading to the circulating pump 23. From the circulating pump 23 a pipe connection 53 leads the fluid to the heater coil 54 in which the liquid coolant can be heated when needed by the electric heating element 55. The heater is in the same insulated box 27 as the pump and both can be inspected through the lid 56. From the heater coil 54 the liquid is carried through the pipe 24 to the coil bank as previously described and returned to the box 27 by the pipe 26 connected with the flexible hose 45 leading to the upper part of the double pipe cooler. The hand valve 57 is introduced at the upper end of the flexible hose 45. Thus, the liquid coolant circulates through the double pipe cooler 39 where it is cooled if the con-

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trol circuit demands cooling of the fluid, through the heating element 54 where it is heated if the control circuit demands heating, and through the heat exchanging coil bank 20 which serves to heat or cool the circulating air.

The use of a heat transfer liquid or coolant between the primary refrigeration package in the machine compartment and the heat transfer unit on the lading side of the bulkhead makes it possible to build a small lightweight refrigeration package and at the same time utilize a heat transfer unit which has sufficiently large surface and volume to eliminate the necessity for defrosting en route. Furthermore, by eliminating all refrigerant containing parts from the commodity side of the bulkhead, it is possible to build the cooling unit as a strong integral part of the very simple and permanently closed bulkhead.

Suitable means are provided for supplying electric power to the various motors, heaters, and controls. In FIGURE 2, I have indicated a diesel generator unit 58 mounted in the machine compartment. The power unit is removably mounted on sub-frames having rollers engaged in suitable frame channels attached to the car. The diesel engine has its radiator 59 facing louvers 60 in the side of the car in the same way as the condensing unit has its condenser 32 facing louvers 61 on the other side of the machine compartment. The diesel engine draws its fuel from one or more tanks 62 which may be mounted beneath the floor of the car. The refrigeration unit is likewise removably mounted on sub-frames having rollers engaged in suitable frame channels attached to the car.

The electric generator 63 of the power unit 58 supplies power having a suitable voltage through the conductor cable 64 having a plug 65 detachably engaging mating terminals carried by the terminal junction box 66 mounted on the bulkhead 9. A suitable conductor cable 67 connects to terminals of control panel 41 of the refrigeration package unit 30. This cable carries power for driving motors and electric controls. Power is also supplied from the terminal junction box 66 to the pump 23, the heater 55, the blower fan 22, and the control panel 68. The control box or panel 68 carries the controls necessary for starting and regulating the refrigeration and heating system.

The fuel connection to the diesel engine is easily disconnected and the electrical plug is readily removed. Thus, the diesel-electric power unit is easily and simply removed from the machine compartment. The refrigeration package unit is also easily removed from the machine compartment.

The package unit is disconnected from the liquid coolant system by closing the valves 47, 48, 51 and 57 and disconnecting the couplings 49 and 50, and detaching the cable 67 from the terminal junction box. No portion of the bulkhead nor of the air circulating system of the car form a part of the refrigeration package. The replacement of the refrigeration unit therefore need not take more than a few minutes. Since the bulkhead does not form any part of the refrigeration unit, there are no sealing problems encountered when the units are replaced.

The refrigeration system of the car is regulated by a temperature control switch having a sensitive bulb 69 located, for instance, in the return air stream below the air cooling unit. The range of the temperature control switch is preferably between -10° and $+70^{\circ}$ F. Cooling and heating pilot relays are connected to control power relays, contactors and safety devices for the compressor motor and the electric heater. The circuit is such that the compressor is kept running when the thermostat calls for cooling and the heater is on when the thermostat calls for heating. The blower motor, the liquid circulating pump and the condenser fan may run continuously. The automatic temperature control can

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also be accomplished in other ways, for example, by stopping and starting of the circulating pump whereby heating or cooling by the secondary liquid system can be interrupted and started.

The functioning of the electrical system is as follows: When the diesel engine is started, the generator supplies electricity to the terminal junction box. The condenser fan motor and blower motor are thereby started. After a predetermined time delay, the remainder of the electric system is energized. The pump motor then starts running. If the thermostat calls for refrigeration, the cooling relay closes and the compressor starts and is kept running until the circulating air is at a predetermined temperature. If the thermostat calls for heating, the heater relay closes rather than the compressor relay so that heat is supplied to the air until it reaches a predetermined temperature.

The heat transfer system for a refrigerator car functions in the following way: Assuming first that the thermostat calls for cooling and that the compressor and circulating pump are running. The liquid coolant, which may consist of trichlorethylene or similar non-corrosive liquids with low freezing point and relatively high boiling point, gives off heat to the inner evaporator coil in the double pipe cooler 39 and lowers its temperature. The cold liquid passes through the pump 23 and the idle heater and enters the air cooling unit at the upper end, passing downwards through the coil bank. Air is simultaneously pulled by the blower upwardly through the air cooling unit in counterflow with the liquid. The heat exchange between the air and the liquid coolant, for this type of air cooling unit, takes place with an approximately even temperature difference between air and liquid all along the cooling unit. Consequently, the air is efficiently cooled and the frost deposit is even on the heat exchanger. The amount and effects of the frost deposit are minimized by the large surface and volume of the coil bank. A heat transfer surface of 800-1000 square feet distributed over tubing and fins, with a fin spacing of approximately $\frac{3}{4}$ " is adequate to allow frost to deposit under all transportation conditions for a period of two to three weeks without significantly lowering the heat exchange between the air and the coolant. Thus, defrosting en route is not necessary. After each trip under refrigeration, the car is usually allowed to warm up whereby defrosting will take place by itself. However, sometimes it may be desirable to bring about defrosting immediately after a trip or after a pre-cooling period, and for this purpose, a hand-operated switch is included for energizing the heater to defrost the coil bank by circulating warm liquid.

Assuming that the thermostat calls for heating, the compressor is off and the heater is on. The circulating liquid enters the coil bank with a higher temperature than the air. The air is heated during the passage through the air "cooling" unit whereby the desired car temperature is maintained. It is noted that the direction of flow in the liquid circulating system is such that the cooler in the refrigeration package is ahead of the heater, whereby excessively high temperatures of the evaporator are avoided.

Although the heat exchange arrangement between the liquid coolant and the evaporator in the refrigeration package is shown and described as a double pipe cooler, it may be of any known types of closed liquid coolers. As indicated on the drawings, the cooler is preferably well insulated. This also applies to all parts of the liquid circulating system. The flexible hoses connecting the cooler with the bulkhead system should be of suitable non-conductive material and preferably be insulated.

It may be that in some instances it is preferred that the car have no machine compartment on the same level as the load. The refrigeration package, according to my invention, may be placed under the car and connected to the air cooling unit by suitable means. There may be

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a cooling unit at one or both ends of the commodity space in the car. The diesel-electric power unit can also be mounted under the car as well as the circulating pump and heater.

5 The provision of a refrigeration package unit, including a liquid cooler, and a secondary liquid heat transfer system, makes it possible to build the air cooling unit as an integral part of the car. The refrigeration unit may be readily and easily disconnected for service or repair by uncoupling two hoses and disconnecting an electrical cable.

10 Thus it is seen that I have provided a refrigerator railway car which includes a refrigeration package unit which is easily removed. The heat exchanger which serves to heat or cool the circulating air may be as large as desired since it is permanently installed in the car. Further, the heat exchanger may be made of material such as steel which can withstand the shock of shift in load during transport. The package unit is light and simple in construction whereby it is readily removed and replaced. Problems of sealing the lading compartment do not arise since it is not required to break the seal in order to replace a refrigeration unit. The cost of constructing a refrigerated railway car is considerably reduced because the heat exchanger or cooling unit is installed as an integral part of the bulkhead which is of a standard reinforced construction.

I claim:

1. In a refrigerated railway car, the combination of a refrigerator car body of heat insulating construction, a commodity accommodating compartment of substantially airtight construction spaced inwardly from the top, bottom, sides, and ends of the inner insulated surfaces of said car body and forming a substantially airtight envelope about which air may be circulated, the spacing between the top of said envelope being relatively greater than the spacing between the side walls of said envelope to form a plenum, fan means at one end of said plenum for maintaining a forced circulation of cold air thereinto and downwardly along the sides of said envelope, a reinforcing bulkhead extending transversely of said car body and providing a chamber for mechanical refrigeration producing apparatus externally thereof and within the limits of the body, a circulating fluid heat exchanger unit located adjacent the inner side of said bulkhead and occupying the space between the end of said envelope and said bulkhead through which air will be circulated upwardly to said plenum by said fan means, said heat exchanger unit being so constructed and arranged as to form a direct impact resisting bulkhead at the end of said envelope, mechanical refrigeration producing means including a double pipe heat exchanger mounted in the chamber externally of said bulkhead and means for circulating a fluid medium through said first heat exchanger unit and said double pipe heat exchanger, whereby said circulating fluid medium will act to conduct the heat absorbed by said first heat exchanger to the double pipe heat exchanger of the refrigeration producing means.

2. In a refrigerated railway car, the combination of a refrigerator car body of heat insulating construction, a commodity accommodating compartment of substantially airtight construction forming an envelope spaced inwardly from the top, bottom, sides, and ends of the inner insulated surface of said car body to provide a space thereabout through which cold air may be circulated, the spaced between the top of said envelope being relatively greater than the spacing between the side walls of said envelope to form a plenum, air circulating means at one end of said plenum for maintaining a forced circulation of air thereinto and downwardly along the sides of said envelope, a reinforced bulkhead extending transversely at one end of said car body and providing a chamber for mechanical refrigeration producing apparatus externally of said envelope and within the limits of the body, a heat exchanger unit located adjacent to the other side of said bulkhead

occupying a space between one end of said envelope and said bulkhead through which air will be circulated from the bottom of said car to said plenum by said air circulating means, a second heat exchanger unit mounted within said apparatus chamber having fluid circulating connections extending through said bulkhead to said first heat exchanger, pump means for circulating a secondary refrigerating fluid through said first and second heat exchangers in counter-flow to the circulation of air in the space occupied by said first heat exchanger, and mechanical refrigeration producing means mounted externally of said bulkhead for imparting a refrigerating temperature to said secondary refrigerating fluid as it circulates through said second heat exchanger unit.

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