Aug. 23, 1949. A. J. JOHNSON ET AL 2,479,840

PROCESS AND APPARATUS FOR REFRIGERATION

Filed Nov. 13, 1945

3 Sheets-Sheet 1

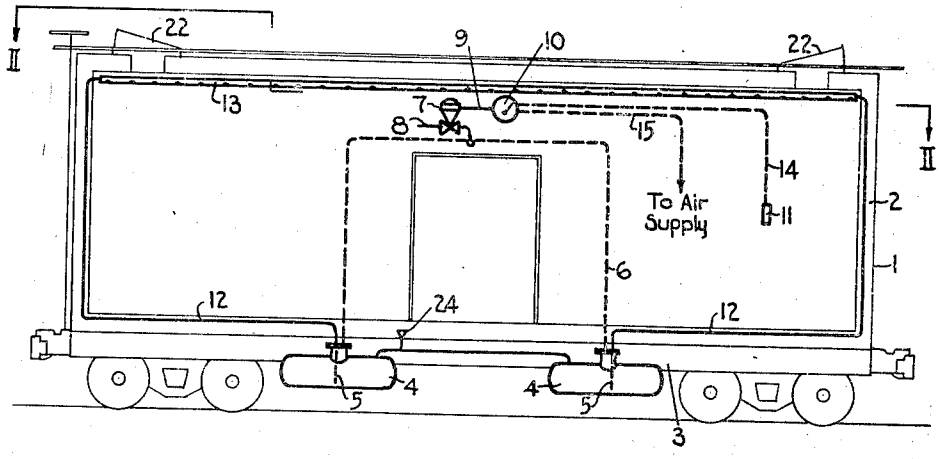


Fig. I

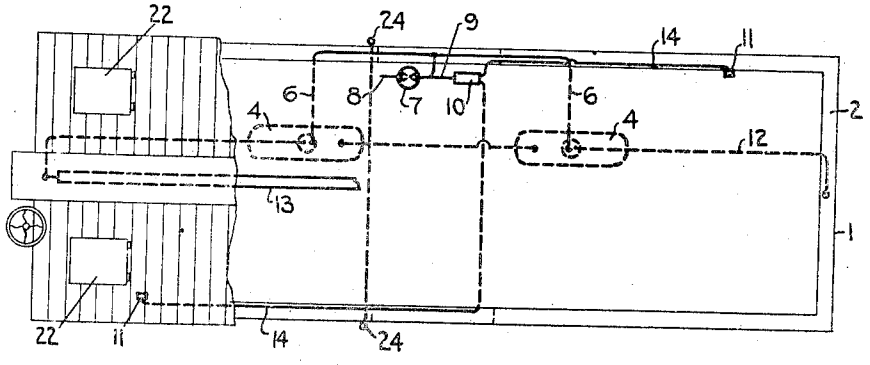


Fig. II

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3 Sheets-Sheet 2

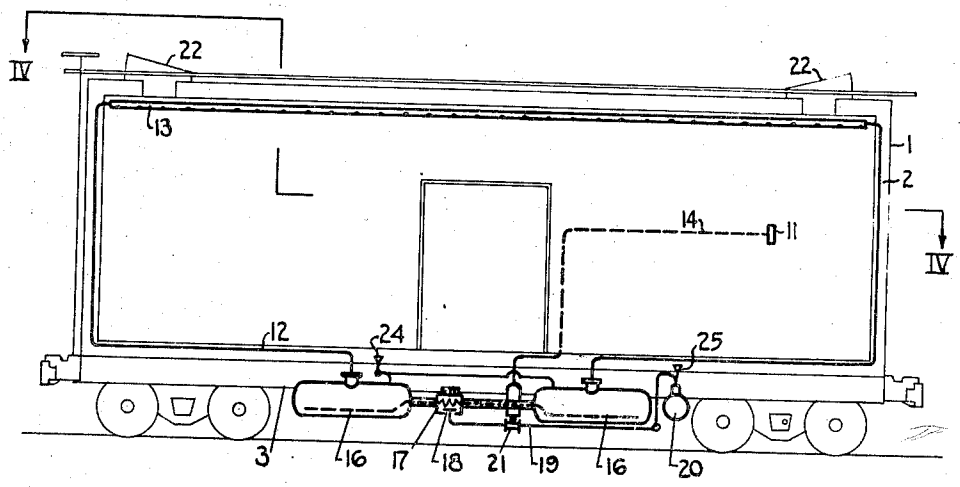


Fig. III

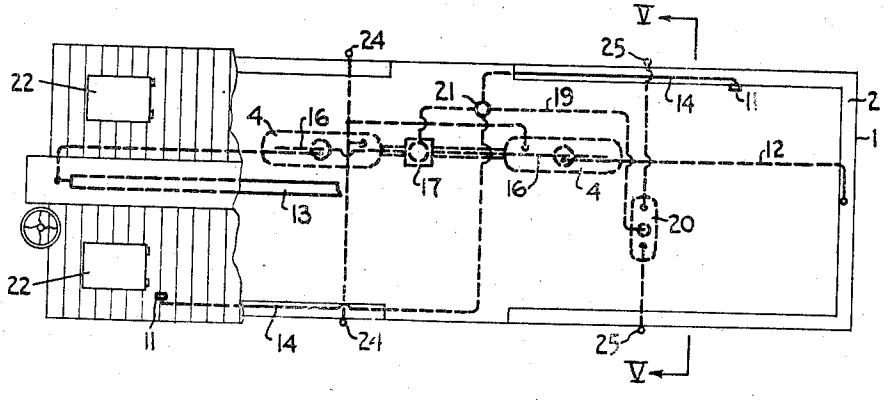


Fig. IV

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PROCESS AND APPARATUS FOR REFRIGERATION

Filed Nov. 13, 1945 3 Sheets-Sheet 3

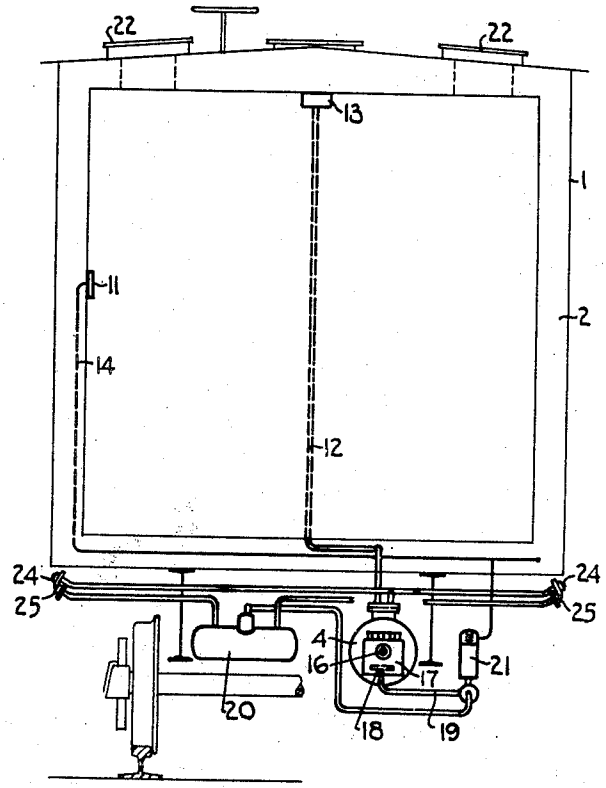


Fig. V

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PROCESS AND APPARATUS FOR REFRIGERATION

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Application November 13, 1945, Serial No. 628,054

26 Claims. (Cl. 62—92)

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This invention relates to the cooling or refrigeration of food stuffs and is particularly concerned with the safe and economical preservation of food stuffs during transportation from place to place; for example by various transport means such as railroad cars, motor trucks and cargo vessels.

The invention is primarily concerned with keeping fresh food stuffs at a sufficiently low temperature during transportation so that deterioration of the food stuffs is prevented.

As is well known, it is a usual procedure to transport fresh food stuffs both from production areas to distribution areas and from primary distribution areas to secondary distribution areas or to consumers in refrigerated compartments. In the case of railroad shipment, specially built refrigerator cars are used for this purpose. These usually comprise a well insulated, closed compartment similar in appearance to the usual box car, but having ice bunkers generally at each end for carrying of about five tons of ice and salt. The ice and salt being in close proximity to the contents of the storage section of the refrigeration car serve to keep the contents within the desired temperature range, principally by air convection.

The ice bunkers are provided with hatches in the roof of the refrigerator cars so that the ice may be replenished when necessary in order that the food stuffs being transported do not spoil due to the ice having melted.

Similarly refrigerated motor trucks are used to transport small quantities of food stuffs from place to place by highways. While the use of ice as a refrigerant in the manner above outlined has the advantage of simplicity, yet it has many disadvantages such as requiring frequent re-icing during long journeys (or where stoppages in traffic occur), the carrying of a large dead load with its attendant loss in usable space for pay load. In recent years the use of mechanical refrigerating units of the compression or absorption type has become almost universal on cargo vessels where one central plant can effectively cool the entire refrigerated cargo space. However, the application of such mechanical refrigeration systems to smaller transportation units, such as refrigerator cars and refrigerator motor trucks has not been adapted to any great extent. This situation has in part been due to the fact that such mechanical refrigeration systems require the supervision of an engineer or skilled mechanic to ensure the proper

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and continual working, and in part due to the high cost of such equipment.

It is the object of our invention to provide a new and useful process for the refrigeration of food stuffs.

It is another object of our invention to provide a simple and efficient apparatus for the refrigeration of compartments on mobile units such as railroad cars and motor vehicles.

It is a further object of our invention to provide a process and apparatus using liquid air as an expandable refrigerant.

Another object of our invention is to provide a process and apparatus whereby the food stuffs being transported are supplied with a continuous stream of cooled air to affect favorably the freshness of the food stuffs.

The further objects of our invention will be apparent from the following detailed description of specific embodiments of our invention, and by referring to the accompanying drawings.

Figure I is a longitudinal section of a refrigerator car showing one form of our refrigerating system.

Figure II is a sectional plan view of the refrigerator car taken along the line II—II of Figure I.

Figure III is a longitudinal section of a refrigerator car showing an alternate form of our refrigerator system.

Figure IV is a sectional plan view of the refrigerator car of Figure III taken along the line IV—IV of Figure III.

Figure V is an enlarged cross sectional view along line V—V of Figure IV.

Referring to Figures I and II, numeral 1 represents the outside sheathing of a railroad refrigerator car having insulation in space 2. This car it will be noticed is of conventional construction, except that the usual bunkers for the ice and salt are eliminated.

Located under the car floor along one side of a girder 3 are two double walled liquid air cylinders 4 of the dewar type having vacuum jackets. These cylinders are provided with baffles to prevent surging of the contents and have eduction pipes 5 leading to their lowest points. A manifold 6 is connected to the vapor space of the cylinders. The manifold 6 is connected to an air operated, controlled valve 7 of standard type. The valve 7 is in turn connected to an open ended pipe 8 which terminates in the upper portion of the refrigerator compartment. The controlled valve is also connected by a small air line 9 to a temperature recorder controller 10

of well known type. The controller is provided with two bulbs 11 which are preferably placed midway up the side wall of the refrigerator compartment as shown. The eduction pipes 5 of the cylinders 4 are connected to a pipe system 12 which passes around the car inside the insulation and terminates in a perforated distribution pipe 13 under the roof of the car as shown.

The operation of the above refrigeration system is as follows: The cylinders of liquid air gain some heat from the outside air so that there is a gradual ebullition of the liquid air contained therein.

As the liquid air changes into its normal gaseous state it will pass through the manifold pipe 6 and providing valve 7 is open it will discharge into the interior of the compartment. However in the event the valve 7 is closed then the vaporizing liquid air will create sufficient pressure on the surface of the liquid in the cylinders, so that liquid air will be forced up the eduction pipes 5 and into the piping 12. The liquid air being at a temperature of —315° F. serves to cool the interior of the refrigerator compartment in its passage through the piping system 12. So much heat is absorbed by the liquid air in the piping system 12 that it is changed to a gaseous state by the time it reaches the distributor pipe 13 under the roof of the compartment. The cold air is then discharged through the openings in the distributor pipe into the interior of the compartment. This cold air stream being at a temperature considerably below the prevailing temperature in the compartment is accordingly denser and flows to the bottom of the compartment, in filtrating through the load.

The operation of the temperature recorder controller 10 and the controlled valve 7 are well known, so that a detailed description thereof is not believed necessary to an understanding of the invention.

In brief however the bulbs 11 are temperature sensitive so that when a temperature above a predetermined maximum occurs in the vicinity, then through capillary piping 14 liquid pressure causes the mechanism in the temperature controller recorder to admit compressed air from the air line 15, (which is connected to the train brake system not shown), to one side of a diaphragm of the controlled valve, so as to close the valve in the manifold 6. When the valve is closed sufficient pressure will build up in the cylinders 4 and cause distribution of liquid air into the piping 12 as above described. Likewise, in the event the temperature in the refrigerator compartment approaches an undesirably low minimum, the liquid in the bulbs 11 contracts, causing mechanism in the temperature controller to release the air pressure on the controlled valve 7 so that spring pressure will open the valve. With the pressure released from the surface of the liquid air in the cylinders 4 no more liquid air is forced into the piping system to provide refrigeration. Consequently the temperature will rise in the compartment.

An alternate form of our invention is shown in Figures III, IV and V. In this alternate form like parts shown in Figures I and II are given like numerals.

Referring to the Figures III, IV and V instead of creating a pressure on the liquid air in the cylinders so as to force the same into a piping system, heat is added to the liquid in the cylinders. Copper or other highly heat conductive metal rods 16 extend into the cylinders 4 and terminate on the outside of the cylinders in a metal grid 17. Underneath the grid 17 is located a wind proof gas burner 18 of standard construction. The gas burner is connected by suitable piping 19 to the vapor space of a gas cylinder 20, which may contain liquefied petroleum hydrocarbon gas such as propane or some other suitable combustible gas under pressure. The vapor spaces of the cylinders 4 of liquid air are connected to piping system 12 which terminates in perforated distributor pipe 13, located near the roof of the compartment.

In the gas supply line connecting the combustible gas cylinder 20 with the burner 18 is a temperature controlled valve 21 which is of the self acting type, requiring no independent service of power to actuate the opening or closing of a valve.

The bulbs 11 are connected to the controlled valve 21 by piping 14 and are preferably located about midway up the side of the refrigerator compartment.

The operation of the system shown in Figures III, IV and V is as follows: With the controller of the control valve 21 adjusted for the particular temperature range desired, the valve in the gas line 19 will open and close according to temperature conditions influencing the bulbs 11 in the refrigerator compartment. If the temperature conditions are too high then the valve 21 will be opened permitting fuel gas to flow to the burner 18. This burner is provided with a pilot light of usual type. When the gas flame is ignited, the metallic grid 17 is heated and through conduction, heat passes to the rods 16 in the cylinders 4 and hence to the liquid air. This introduction of heat causes an ebullition of the liquid air. The cold air (in gaseous state) passes through piping 12 withdrawing heat from the interior of the refrigerator car and load and is eventually discharged into the car, through the openings in the distributor pipe 13 located near the roof of the car. The cold air descends through the length of the car and effectively reduces the temperature therein. At the same time this cold blanket of air serves to create a considerable circulation of air through the car. When the temperature is sufficiently low, the gas valve 21 closes and remains closed until a sufficient rise in temperature causes the gas valve to open again and thus causes more cold air to be forced through the piping system 12. Air leaves the compartment through vents 22.

Our refrigerating system has considerable advantages over known existing systems. We have described a system which is simple in operation and sufficiently rugged in construction to meet the requirements of refrigerator car service.

By the use of liquid air as an expandable refrigerant, we have eliminated the problem of handling ice which is commonly used. Additional pay load space can be provided using our system in existing refrigerator cars by the removal of ice bunkers now normally located in the end section of the cars.

While the cylinders of liquid air shown will be sufficient to keep a railroad refrigerator car at desired temperature for considerably longer than the normal ice loading, refilling of the cylinders will be necessary on long trans-continental journeys. Refilling is readily accomplished by introducing the liquid air into suitable fill spouts 24 connected to the cylinders 4. The liquid air can be transferred from tank trucks or cars specially designed for the transportation of liquid air or

direct from liquid air plants located near the right of way. The combustible gas cylinder 20 can be refilled through filling spouts 25.

In the above we have only described two specific embodiments of our invention. Variations of the arrangements shown will be apparent to those skilled in the art. For example, it will be apparent that instead of the temperature controllers shown, other temperature controllers of the bi-metallic type may be used.

It will further be appreciated that our refrigeration system can be applied to stationary use.

It should be fully understood that the term "liquid air" as used throughout this specification and claims includes mixtures of liquefied oxygen and nitrogen in various proporations as well as in the proportions in which air occurs in its normally gaseous state; for example, in certain industrial processes "liquid air" containing a greater proportion of nitrogen than occurs in nature is produced as a by-product while in other industrial processes "liquid air" containing a greater proportion of oxygen than occurs in nature is produced as a by-product. All such mixtures we contemplate by the use of the term "liquid air."

We claim as our invention:

1. A method of refrigeration comprising withdrawing liquid air from a container, at a temperature below the temperature of a heat insulated compartment to be refrigerated; conducting the liquid air to the interior of said heat insulated compartment within a confined flow passageway extending substantially throughout the height of said heat insulated compartment, vaporizing the liquid air within said confined passageway by transferring heat to the liquid air therein from the wall of said heat insulated compartment, discharging the vaporized air from said confined passageway throughout the length of said compartment, controlling the amount of liquefied air discharged from said container by the temperature existing in said compartment and continuously removing air from the compartment.

2. A method of refrigeration comprising supplying heat to the interior of a container of liquid air, vaporizing liquid air within said container by said supplied heat, controlling the amount of heat supplied by the degree of refrigeration required, withdrawing the cold vaporized air from the container, conducting said vaporized air to the interior of a refrigerator compartment and discharging said vaporized air into said compartment near the roof thereof.

3. In apparatus for effecting refrigeration the combination comprising a cylinder containing liquid air, an eduction pipe in said cylinder, a vapor outlet from said cylinder, piping from said eduction pipe, a perforated distributor pipe connected to said piping, and valve means for closing said vapor outlet from said cylinder, said valve means being responsive to variations in temperature conditions.

4. In apparatus for effecting refrigeration the combination comprising a cylinder for liquid air, an eduction pipe reaching to the bottom of said cylinder, a vapor outlet from said cylinder, an insulated compartment, piping connecting said eduction pipe with the interior of said compartment, a distributor pipe connected to said piping and valve means for closing said vapor outlet from said cylinder, whereby liquid air can be forced through said eduction pipe into the piping in said compartment.

5. In apparatus for effecting refrigeration the

combination comprising an insulated compartment, a cylinder for liquid air beneath said compartment, an eduction pipe for withdrawing liquid air from said cylinder, a vapor outlet from said cylinder leading into the compartment, a temperature controlled valve in said compartment and connected to said vapor outlet, piping connected to said eduction pipe and a perforated distributor in said compartment connected to said piping.

6. In apparatus for effecting refrigeration the combination comprising a refrigeration compartment, a cylinder for liquid air outside said compartment, a metal heat-conducting rod extending into said cylinder through the wall thereof, a vapor outlet from said cylinder, piping connected at one end to said vapor outlet and passing into said compartment, a discharge pipe in said compartment connected to the opposite end of said piping, a source of heat near the external end of said heat conducting rod, and control means for said source of heat responsive to the temperature in said refrigeration compartment.

7. A method of refrigerating a heat insulated compartment comprising the steps of withdrawing liquid air from a container, flowing said liquid air at a temperature below that of said compartment through a conduit which in heat exchange relation with and partially heat insulated from said compartment, and vaporizing the liquid air in said conduit by heat flowing from the compartment to said conduit.

8. A method of refrigeration comprising maintaining a body of liquid air within a closed container at a temperature below the temperature of a heat insulated compartment to be refrigerated, withdrawing cold refrigeration air from said container at a rate directly proportional to the pressure within said container, discharging the withdrawn refrigeration air into the interior of said heat insulated compartment, building up pressure within said container by introducing only heat into said container to cause vaporization of liquid air therein and regulating the pressure within said container in accordance with the temperature within said heat insulated compartment so as to reduce said pressure when said temperature falls.

9. The method according to claim 8 wherein the pressure is controlled by withdrawing vaporized liquid air in addition to said refrigeration air from said container to lower the pressure therein when the temperature in said heat insulated compartment falls, and reducing the withdrawal of vaporized liquid air from said container to permit the pressure therein to rise when the temperature within said heat insulated compartment rises.

10. The method according to claim 9 wherein the vaporized liquid air is discharged into the interior of the heat insulated compartment for additional refrigeration and the refrigeration air is withdrawn from said container in the liquid state.

11. The method according to claim 8 wherein the pressure is controlled by increasing the rate of introduction of heat into said container to raise the pressure therein when the temperature in said heat insulated compartment rises, and reducing the rate of introduction of heat into said container to permit the pressure therein to drop when the temperature within said heat insulated compartment falls.

12. The method according to claim 11 wherein heat is introduced into said container by generat-

ing heat outside of said container in response to the temperature within said heat insulated space and conducting said generated heat into said body of liquid air within said container.

13. The method according to claim 11 wherein the refrigeration air is withdrawn from the container in the vaporized state.

14. A method of refrigeration comprising maintaining a body of liquid air within a closed container at a temperature below the temperature of a refrigeration compartment, withdrawing cold liquid refrigeration air from said container at a rate directly proportional to the pressure within said container, discharging the withdrawn refrigeration air into the interior of said refrigeration compartment, and regulating the pressure within said container in accordance with the temperature within said refrigeration compartment so as to reduce said pressure when said temperature falls.

15. The method according to claim 14 wherein said body of liquid air is maintained at a low range of pressures, the minimum pressure being substantially equal to the ambient pressure within said refrigeration compartment.

16. The method according to claim 15 wherein the pressure within said container is maintained by introducing heat therein to vaporize a part of the liquid air therein, and venting the air thus vaporized into the refrigeration compartment to reduce the pressure within said container when the temperature within said compartment falls.

17. A method of refrigeration comprising maintaining a body of liquid air within a closed container at a temperature below the temperature of a refrigeration compartment, supplying only heat to the interior of said container, vaporizing liquid air within said container by said supplied heat, controlling the amount of heat supplied by the degree of refrigeration required, withdrawing the cold vaporized air from the container, conducting said vaporized air to the interior of said refrigeration compartment and discharging said vaporized air into said compartment.

18. The method according to claim 17 wherein the heat is introduced into said container by generating heat outside of said container in response to the temperature within said refrigeration compartment and conducting said generated heat into said body of liquid air within said container.

19. In apparatus for effecting refrigeration the combination comprising a cylinder liquid air, an eduction pipe in said cylinder, a vapor outlet from said cylinder, piping from said eduction pipe, distributor means connected to said piping, and valve means for closing said vapor outlet from said cylinder, said valve means being responsive to variations in temperature conditions.

20. In apparatus for effecting refrigeration of a heat insulated compartment the combination comprising a cylinder for liquid air outside of said compartment, an eduction pipe for withdrawing liquid air from said cylinder, a vapor outlet from said cylinder leading into the compartment, a valve in said vapor outlet responsive to the temperature within said compartment, piping connected to said eduction pipe, and discharge means within said compartment connected to said piping.

21. In apparatus for effecting refrigeration of a compartment having heat insulated walls the combination comprising a cylinder for liquid air outside of said compartment, an eduction pipe for withdrawing liquid air from said cylnder, a vapor outlet from said cylinder leading into the compartment, a valve in said vapor outlet responsive to the temperature within said compartment, piping extending through said heat insulated walls and connected to said eduction pipe, and distributor means within said compartment connected to said piping.

22. In apparatus for effecting refrigeration the combination comprising a refrigeration compartment, a cylinder for liquid air, an air outlet from said cylinder, piping connected at one end to said outlet, a discharge pipe in said compartment connected to the opposite end of said piping, means for introducing heat into the liquid air within said container, and control means responsive to the temperature in said refrigeration compartment for regulating the introduction of heat into said liquid air.

23. The apparatus according to claim 22 wherein the said refrigeration compartment has heat insulated walls and the said piping is located at least partly within said walls.

24. The apparatus according to claim 22 wherein the means for introducing heat into the liquid air comprises a heat generator and a conductor for conducting heat from the heat generator to the liquid air within said container.

25. The apparatus according to claim 24 wherein the control means comprises a regulator for regulating the heat generator.

26. The apparatus according to claim 22 wherein the outlet from said cylinder is a vapor outlet and is connected to said cylinder at an upper level thereof.

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THEODORE W. ROSEBAUGH.

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