March 16, 1971 H. E. GRAMSE 3,570,262

REFRIGERATION ARRANGEMENT

Original Filed Sept. 22, 1967 3 Sheets-Sheet 1

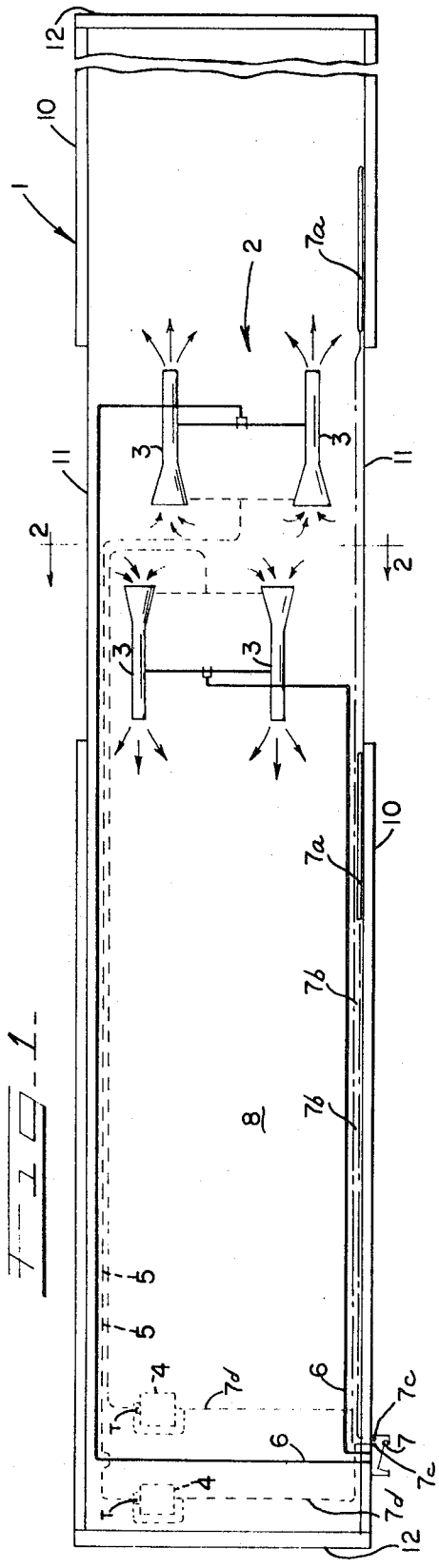

FIG. 1

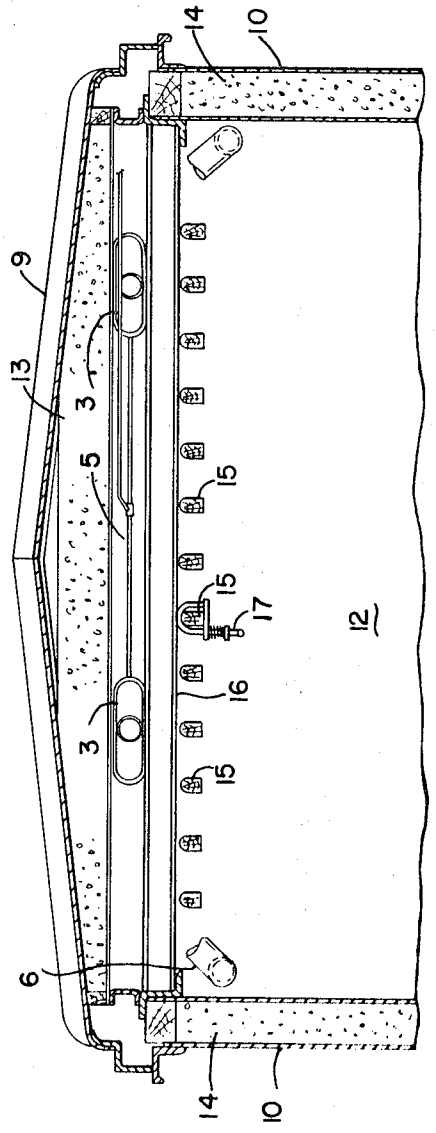

FIG. 2

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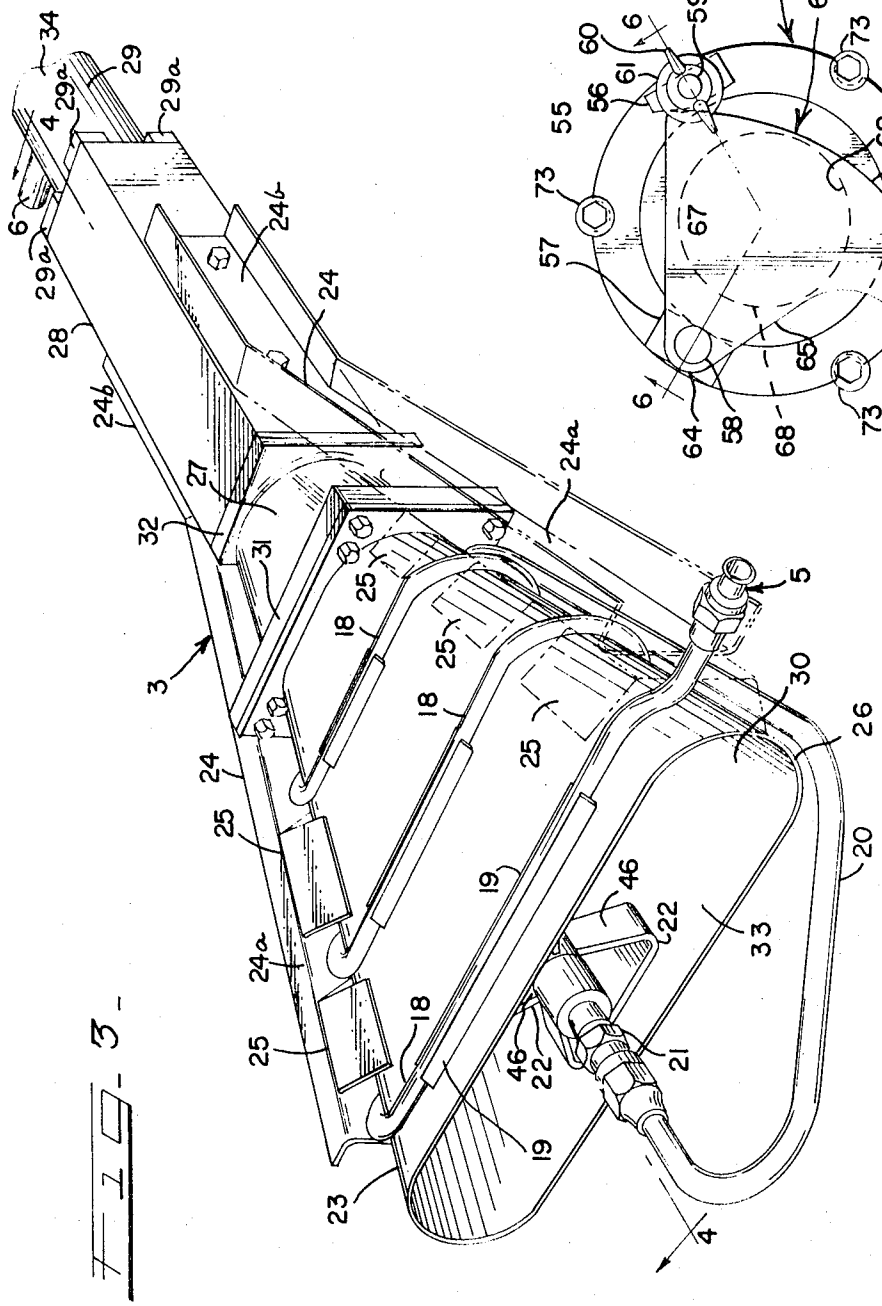

FIG. 3

FIG. 5

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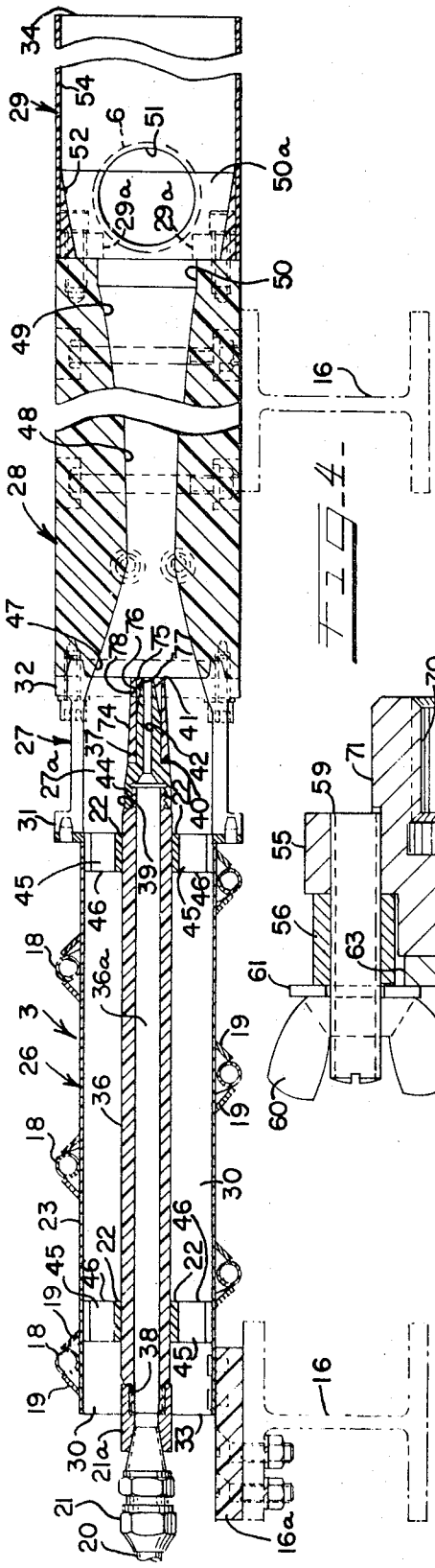

FIG. 4

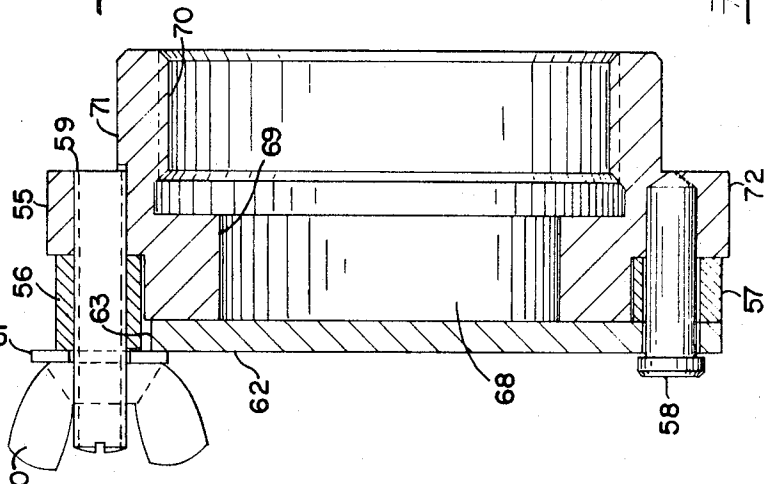

FIG. 6

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3,570,262

REFRIGERATION ARRANGEMENT

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Original application Sept. 22, 1967, Ser. No. 669,819, now Patent No. 3,447,336, dated June 3, 1969. Divided and this application Nov. 25, 1968, Ser. No. 785,847
Int. Cl. F25d 17/06
U.S. Cl. 62—89 6 Claims

ABSTRACT OF THE DISCLOSURE

A refrigeration arrangement for a railroad car comprising a source of liquid nitrogen under a vapor pressure attendant to delivery of the nitrogen, under thermostatic control, to a converging atmospheric collector disposed within the car, the collector comprising a heat exchanger including encircling coils of the liquid nitrogen about the collector's scoop, the trailing end of the coil being connected with a tube of low thermal conductivity and low coefficient of friction and extending into the scoop from its widened end to its shortened end, a venturi tube being connected to the end of the scoop and the exiting end of the tube having a nozzle being surrounded by the conical venturi tube end portion of the scoop to develop a venturi or suction action and drawing the atmosphere within the car into the scoop for cooling of the atmosphere and dehumidifying same and for depositing moisture in the form of ice and snow on the interior surface of the scoop which is of high thermal conductivity material, the venturi tube being of low thermal conductivity material and receives the atmosphere and the liquid nitrogen which expands to a gas in the venturi throat, the exit end of the venturi tube being coupled to an exhaust tube opening into the car, the exhaust tube being of low thermal conductivity and having an outside air tube connecting with its entrant part and with an outside air control valve on the car for mixing of outside air and the car atmosphere and nitrogen gas for dispersal into the car environment.

This is a divisional application of my co-pending application, Ser. No. 669,819 filed Sept. 22, 1967, now U.S. Pat. No. 3,447,336 granted June 3, 1969.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This relates to the refrigeration art and in particular relates to the refrigeration of foods, particularly meats and vegetables stored within a container or a so-called railroad reefer car. The invention is more particularly related to the use of a cryogenic medium, such as nitrogen gas within the container or car.

(2) Description of the prior art

The use of a cryogenic medium such as liquid nitrogen to cool the interior of a container or railroad car has been well known. It is also known to mix oxygen with the nitrogen within the container. However, the ratio of nitrogen to oxygen must be regulated and this must be done with a source of liquid nitrogen or other cryogenic medium at temperatures as low as approximately —264° Fahrenheit. At such low temperatures certain materials must be used that can withstand the cold. Further the operation of the refrigeration arrangement should be self-maintaining, requiring a minimum of maintenance and should be simplified in its structural components. It is also desired to reduce the temperature within the car from say 90° F. to 30° F. in order to keep the contents within the container or car just below the freezing point of water. In order to accomplish this with liquid nitrogen there must be a way to collect the moisture within the car atmosphere which will precipitate out in the form of ice or snow. This invention overcomes such difficulties.

SUMMARY

The invention provides for a refrigeration arrangement utilizing a cryogenic medium such as liquid nitrogen which is stored in tanks within the container or car. The nitrogen bearing tank contains the liquid nitrogen with a head of nitrogen gas that develops a vapor pressure within the tank and when the tank is open the liquid nitrogen leaves the tank under a force and is directed into the interior of the container by way of the novel apparatus of the invention which collects the moisture within the car atmosphere and sucks the car atmosphere therethrough and mingles it with the nozzle emitted nitrogen gas, the force of the flowing mixture sucking in a certain amount of air from the outside of the car. The apparatus to accomplish this is in the form of a heat exchanger venturi unit, the heat exchanger portion dehydrating and cooling the atmosphere and the venturi portion sucking in the atmosphere to co-mingle with the co-issuing nitrogen gas within the venturi section, the mixture moving with such velocity as to suck in conducted outside air for introduction into the ambient atmosphere within the car. The course of the liquid nitrogen within the heat exchanger is protected by material of low thermal conductivity and low coefficient of friction, the heat exchanger collector scoop being of high conductivity to form ice or snow on the latter rather than the former. The venturi exhaust arrangement is also made of material of low thermal conductivity for transference of the resultant gaseous mixture into the interior of the container or car. Further, there is provided a novel outside air intake arrangement for metering by mechanical operation a certain amount of outside air into the exhaust portion of the refrigerating arrangement. Further the heat exchanger is of such configuration as to be wide at the entrance end and narrow at the exit end for scooping up and transferring of the car atmosphere to the venturi at the point that the nitrogen in the form of liquid is emitted to expand to a gas for mingling with the atmosphere. Also the diameter of the outside air conduit to the exhaust portion of the arrangement is of less diameter than the exhaust portion to create a suction for drawing the outside air into the exhaust portion of the heat exchanger-venturi arrangement and into the car interior. These and other objects and purposes will become apparent from reference to the following description and drawings and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a refrigeration railroad car employing the novel refrigeration system and novel structure therefor;

FIG. 2 is a cross sectional view of FIG. 1 taken along line 2—2 thereof;

FIG. 3 is a perspective view of the heat exchanger-venturi arrangement of the refrigeration system;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3;

FIG. 5 is an enlarged view of the air intake valve shutter arrangement of FIG. 1; and

FIG. 6 is a sectional view taken along line 6—6 of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to the drawings and in particular with reference to FIGS. 1 and 2 there is shown a railroad car 1 which has a refrigeration arrangement or system 2 including a plurality of heat exchanger and venturi units 3

each supplied with liquid nitrogen from tanks 4 by way of lines 5. Each unit 3 is also supplied with outside air by way of an outside air line 6. The introduction of outside air is controlled by the air shutter valve means 7. Each tank 4 is provided with a thermal responsive valve T which opens in response to an increase in temperature to allow introduction of liquid nitrogen into its line 5 by the temperature responsive device 7*a* via line or wire 7*d* and line or wire 7*b* for each tank 4. The temperature may be set by the thermostat control 7*c*. The device 7*a* comprises a wire which will increase in length with increase in temperature which in turn mechanically operates lines 7*b* and 7*d* to open the valve T mechanically for emission of the liquid nitrogen. The control 7*c* is a bi-metallic thermostat spring which varies the spring tension on wires 7*b* or 7*d* to open valve T at a desired temperature. Thus no source of electricity is necessary. The thermostat control 7*c* varies the tension in the lines 7*b* and 7*d* to control the opening of the valve T at the desired temperature. It is desired to keep the temperature within the car at about 30° F. The ambient atmosphere within the car is designated as 8 and prior to operation of the unit 3 contains air which in warmer climes can be 90° F. or more.

The car 1 comprises a roof 9 and has sides 10 and door openings 11 and car ends 12. The roof 9 contains thermal insulation 13 and the sides 10 contain thermal insulation 14. Meat rails 15 are provided within the car and are supported by meat rail supports 16 to which is attached the units 4 by heat exchanger support brackets 16*a* (see FIGS. 2 and 4). A plurality of longitudinally disposed meat hooks 17 hang from each of the meat rails 15 although only one is shown.

The heat exchanger-venturi air mixing unit 3 is best shown in FIGS. 3 and 4 and comprises an atmosphere collector form of a housing or tube 23 having open ends, the housing being of general triangular shape and being widest at its atmosphere entrant portion and tapering to a narrow long tube of somewhat constant cross section. The housing 23 is composed of three sections, namely, the heat exchanger part or atmosphere collector scoop 26 which is triangular form in elevation and tapers from a widened entrant portion to a narrow exit portion, a transition cowl 27 which is generally rectangular in cross section, a venturi or venturi tube section 28 and a final mixing chamber or exhaust tube 29. Each liquid nitrogen containing copper line 5, as it approaches a pair of heat exchanger units 3 divides and its line portion encircles a respective triangular shaped collector or scoop 26 as a series of copper coils 18 thereabout from the widest portion to the narrow portion of the scoop and then comes forwardly as the liquid nitrogen containing heat exchanger copper entrant line 20, the coil 18 being held on the housing 23 by coil brackets 19. The liquid nitrogen conduit portion 20 is coupled to a fitting 21 which in turn has at its end a brass coupler 21*a* which extends into the hollow housing 23 and connects with the liquid nitrogen bearing pipe or tube 36 which extends centrally within the housing 23 and defines therewith an annular atmosphere passage 30. The liquid nitrogen tube or conduit 36 is supported by spider brackets 22 which attach themselves to the interior surface of the scoop 26. The outside of the housing 23 is provided with a pair of laterally spaced reinforcing or strengthening braces 24 each having sections 24*a* and 24*b* for reinforcing the connection between the transition cowl 27 and the scoop 26 and the venturi tube 28 which is attached to the final mixing chamber or exhaust tube 29 by exhaust tube gear flanges 29*a*, the transition cowl 27 being connected to the scoop 26 and the venturi 28 by brace structures 31 and 32. The strengthening braces 24 are attached to the heat exchanger units by attaching brackets 25. The atmosphere collector chamber or passage is provided with a widened atmosphere entrance end 33 and the exhaust tube 29 is provided with a gas mixture exit end 34. The chamber 30 of the scoop 26 is of uniform

vertical cross section and triangular shape in plan. The scoop 26 is made of brass which is a material of high thermal conductivity. The liquid nitrogen pipe 32 defines an elongated liquid nitrogen containing passage or chamber 36*a*, uniform in cross section. The tube 36 is composed of Teflon material which has a low thermal conductivity and a low coefficient of friction so that any ice or snow formed due to moisture formed within the scoop portion 26 will be deposited on the interior brass surface of the scoop 26 rather than on the Teflon tube 36. The tube 36 has at its entrant end a coupler end Teflon portion 38 connecting with the brass coupler 21*a* and at its exit end Teflon coupling portion 39 for coupling with the leading end or nozzle socket 44 of the nozzle 37. The nozzle 37 is also of Teflon material and is provided with a leading tapered bore 40 connecting with the nozzle tip bore 42 which is of a reduced uniform cross section and forms the inside of the nozzle tapered tip 41 of the nozzle 37. The atmosphere scooping passage 30 is provided with ports 45 in spider legs 46 in the spider leg structure 22 to allow for transference of the atmosphere to the transition cowl 27 which surrounds the nozzle 37 and is of generally uniform cross section to define a continuing air passage 27*a* which increases in cross sectional area as it approaches the exiting area of the tapered nozzle tip 41. The cowl 27 is also of material of low thermal conductivity and for purposes of observation is of transparent Lucite to enable a viewer to see the condition of the nozzle tip as to whether ice is forming about it and whether it is functioning properly in its emission of liquid nitrogen therefrom.

The venturi 28 of the unit 3 is also composed of a material of low thermal conductivity which in this instance is nylon. The venturi 28 comprises a leading forwardly converging or conical shaped entrant portion 47 and a reduced throat or bore portion 48 and a diverging bore portion or exit portion 49 the end of which becomes an enlarged bore 50 of generally uniform cross section. The end of the nozzle tip 41 extends just slightly or approximately into the conical portion 47.

The exhaust tube 29 has a larger internal diameter than the venturi tube 28 and provides an expansion chamber 50*a* for the nitrogen gas. The chamber 50*a* is provided with diverging tapered portion 52 to reduce turbulence of the gases coming from the venturi tube 28 and from the outside air which is introduced by the conduit portion 51 of the air inlet tube 6, the inlet 51 being of reduced cross section relative to the cross section of the chamber 50*a* and approximating the cross section of the bore 50 so that air may be sucked in to the expansion chamber 50 by the rapidly exiting atmosphere and gaseous nitrogen past the opening 51. The exhaust tube 29 is also composed of a material of low thermal conductivity which in this instance is poly-vinyl chloride. The expansion chamber portion 50*a* continues as the interior bore or passage 54 of the exhaust tube 29 to the end 34 of the unit 3 whence the mixture of nitrogen gas, atmosphere and outside air is introduced within the car space.

The shutter valve means 7 for introducing outside air into the car by way of the unit 3 is composed of a shutter valve body 55 and a shutter 62 which is a thin triangular shaped plate or body. As best seen in FIGS. 5 and 6, the valve body is provided with spacers 56 and 57 placed on the shutter facing side of the valve body 55. Pivot means or pivot pin 58 extends through one end portion of the shutter 62 through the spacer 57 and into the valve body 55 to allow pivotal movement of the shutter 62 with respect to the body 55. The body 55 at one end is also provided with a screw or stud 59 carrying a wing nut 60 for tightening the washer 61 which is about the screw 59 so that the washer 61 engages the shutter at its end portion to hold same in place against the valve body 55. The shutter plate 62 as viewed in FIG. 5 has an arcuate edge portion or guide edge portion 63 which travels between the washer or retainer 61 and the wing nut or fastening

means **60** and a shutter pivot arm portion **64** about which the entire plate **62** can pivot to allow various parts of the edge portion **63** to be gripped by the wing nut and washer and further has a concave shutter edge portion or leading edge portion **65** and a tip portion **66** defined by portions **63** and **65**. The valve body **56** defines the car air inlet **68** of the air line **6**. The car inlet **68** is defined by the front bore **69** of the body and the back bore **70** of the body which is formed by the air line coupling flange **71** which couples to the line **6**. The front bore **69** is defined by the mounting flange **70** having mounting bolts **73** for mounting the valve arrangement **7** on the car **1**.

In operation, the car **1** is loaded with meat by hanging the same from the hooks **17** within the car in climates that may be at 90° F. or better and the car doors are closed and the car sent on route. The thermostat means **7***a* reacting to the increased temperatures expand to operate, by means **7***b*, **7***c* and **7***d*, the valve T on each nitrogen tank **4** causing liquid nitrogen under its vapor pressure to be introduced into the refrigeration system **2**. The thermostat **7***c* being set for 30° F. with the car temperature being at a higher temperature permits valve T to be opened and nitrogen to be introduced into the atmosphere **8** within the car **2** until such time as the wires **7***b*, **7***d* are acted upon by the contraction of the temperature device **7***a* and the thermostat **7***c* due to the drop in temperature to a point that 30° F. is reached at which time the valve T is closed and nitrogen ceases to flow into the atmosphere within the car. Such thermostatic control permits the temperature within the car to be maintained approximately at 30° F. During the initial cycle, that is, when the car is being cooled down from 90° F. to 30° F. liquid nitrogen flows through the lungs **5** to the respective units **3** encircling the coils **18** and entering the nitrogen tube **36** as a liquid and through the venturi tube **28** to create a suction in the cowl **27** and the venturi **28** to suck the atmosphere within the car through passage **30** where the atmosphere is cooled. As the atmosphere cools within the passage **36** of each unit **3** any moisture in the atmosphere which is initially air precipitates in the form of ice-like snow on the interior surface of the scoop **26** and continues to build up inwardly toward the Teflon tube **36**. The triangular shape of the scoop allows a trailer buildup of the initial entrant atmosphere without touching the Teflon tube so that as the atmosphere gets towards the exit end of the scoop **23** less ice is built up. The brass scoop being highly thermal conductive accepts formation of ice thereon whereas the Teflon material being of low thermal conductivtiy rejects the formation of ice on the Teflon material and also since the Teflon material has a lower coefficient of friction it is difficult for the iced snow to form on the exterior surface of the Teflon tube **36**. The convergence of the nozzle tube in the area of the convergence of the entrant portion of the venturi **28** creates the venturi action because as the venturi velocity increases the venturi pressure decreases causing suction. In the area of the nozzle tip **41** and the converging portion **47** of the venturi **28** the liquid nitrogen and the atmosphere join and because of the decrease in pressure of the venturi eflect plus the ability of the liquid nitrogen to pass from the small nozzle bore **42** to the enlarged entrant portion **47** of the venturi **28** the nitrogen liquid is allowed to expand into a gas and continues to go from the liquid phase to the gas phase within the throat **48** into the venturi tube. The expanding gas in the throat **48** is added impetus to flow and as it exits from the venturi portion **49** the gas is allowed further expansion into the expansion chamber portion **50***a* of the chamber **54** of the exhaust tube **29**. Since the diameter of the air inlet **51** is less than the diameter of the expansion portion **50***a*, air is now sucked in from the outside by way of the valve means **7** and into the exhaust tube **29** co-mingling with the atmosphere and the nitrogen gas all of which exit from the exhaust tube and into the car and recirculate through the units

3 gradually cooling the car to the desired temperature for preservation of the meats. The opening of the valve means **7** by regulation of the shutter **62** with respect to the valve body opening **68** measures the quantity of air introduced relative to the amount of nitrogen introduced into the car atmosphere. A desired ratio would be 5% of air emitted relative to 95% of nitrogen within the car. Other ranges may also be attained by this mechanically adjustable shutter arrangement. The vapor pressure within the nitrogen tanks T may be in the range of 15 to 20 pounds per square inch (p.s.i.) and the line pressure in lines **5** may be about 15 to 20 p.s.i. and a relief valve may be cooperative with the thermal responsive valve P to prevent the pressure within the lines **5** from exceeding, say 22 p.s.i. The passage of the nitrogen through the unit **3** creates a double aspiration, one at the tapered nozzle tip and the other at the expansion chamber **50***a* of the exhaust tube. When the liquid nitrogen leaves the tank it is approximately at a temperature of —320° F. which is pretty cool and this accounts for the need for use of such low thermal conductive materials as Teflon, nylon and poly-vinyl chloride.

As the liquid nitrogen exits from the nozzle tip **41** it sprays outwardly in a diverging cone in the cone portion **47** of the venturi tube **28** but the cone is of narrow limits so that it is projected to the throat area **48** and given sufficient time to expand to the gaseous phase. The atmosphere passing by the end of the nozzle tip **41** could cause in some cases some formation of ice-snow. A removable sleeve **74** placed about the nozzle tip **41**, as shown in FIG. 4, defines a space **75** between the surfaces **76** of the sleeve **74** and outside surface **77** of the nozzle tip **41**. This space becomes a vacuum under the influence of the atmosphere rushing by the converging venturi portion **47** so that no ice can form therein. The outside surface **78** of the sleeve **74** is convergingly tapered to minimize restriction of flow of the atmosphere into the venturi **28**.

The foregoing description of the appended drawings is given merely to explain and illustrate the invention and the invention is not to be limited thereto except insofar as the inventive claims are so limited since those skilled in the art who may have the disclosure before them will be able to make modifications and variations therein without departing from the scope of the invention.

What is claimed is:

1. A method of cooling the atmosphere within the railroad refrigeration car by the use of a cryogenic medium under pressure comprising the steps of:

(1) introducing a cryogenic liquid into a heat exchanger coil arrangement which passes in heat exchange relationship with and around an atmosphere intake scoop cooling and dehumidifying the atmosphere within said scoop thereby;

(2) sending the liquid through the end of the coil into an inlet tube which extends into said scoop and ejecting the liquid from the nozzle end of the tube near the exit end of the scoop, the liquid expanding to a gas approximately at the juncture of the end of the scoop with a venturi tube;

(3) passing the gas through the venturi tube and sucking the atmosphere within the scoop around the nozzle end and into the venturi tube; and

(4) the venturi tube connecting with an exhaust tube and passing the mixture of atmosphere and cryogenic gas into the exhaust tube for passage into the car.

2. The invention according to claim **1**, and sending the atmosphere and gas past an outside air intake tube which is smaller in diameter than the exhaust tube and sucking air into the exhaust tube and exiting same with the atmosphere and the gas.

3. The invention according to claim **1**, and said cryogenic liquid being nitrogen.

4. The invention according to claim **1**, and said inlet tube being of a material of low thermal conductivity and low co-efficient of friction.

5. The invention according to claim 1, and said intake scoop being enlarged at its inlet end and being reduced at its exit end to define a tapered scoop.

6. The invention according to claim 1, and the intake scoop being of material of high thermal conductivity.

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U.S. Cl. X.R.

62—514, 239, 52, 121, 122