Oct. 20, 1959 C. A. RICHARDSON 2,909,039

LIQUEFIED GAS REFRIGERATION SYSTEM

Filed Aug. 22, 1957 2 Sheets-Sheet 1

Fig. 1.

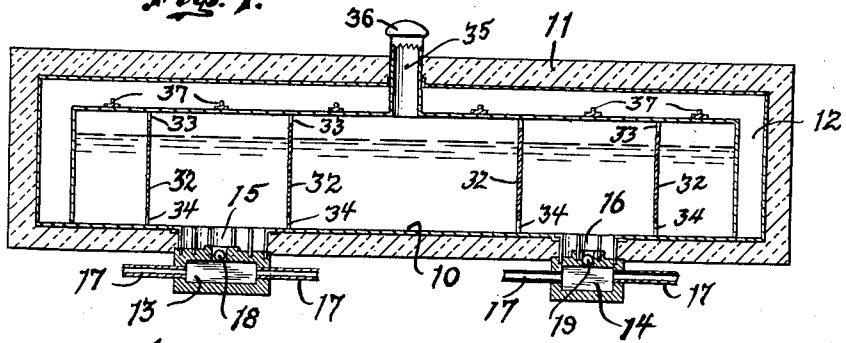


Fig. 2.

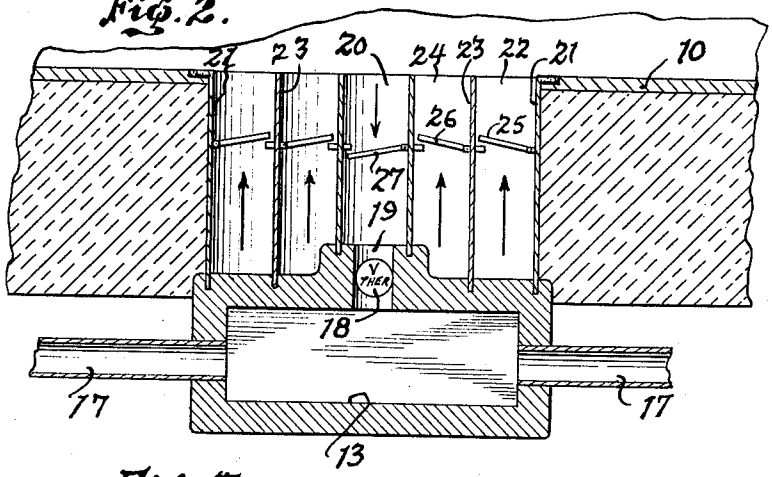


Fig. 3.

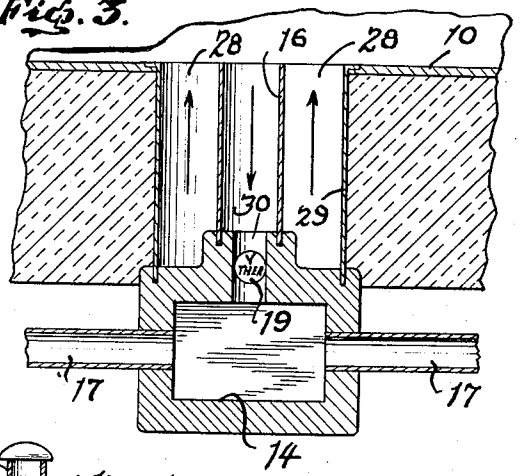
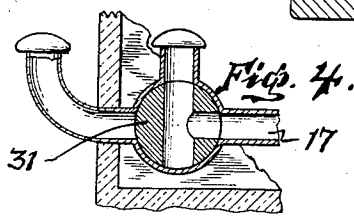


Fig. 4.

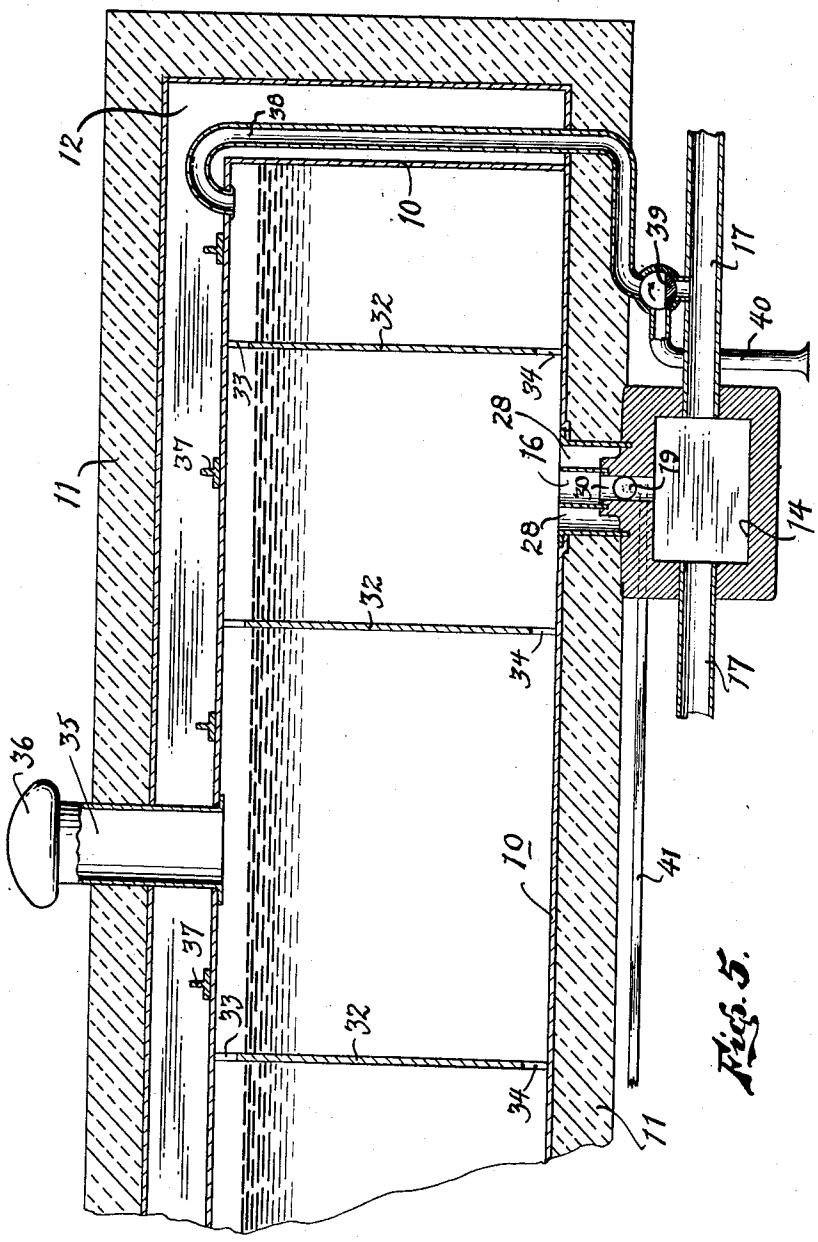


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Oct. 20, 1959 C. A. RICHARDSON 2,909,039

LIQUEFIED GAS REFRIGERATION SYSTEM

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2,909,039

LIQUEFIED GAS REFRIGERATION SYSTEM

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7 Claims. (Cl. 62—45)

My present invention relates to refrigerating systems and more particularly to a refrigerating system for transport vehicles such as refrigerated trucks and railway cars employing a liquified gas and it has for its principal object the provision of a refrigerating system for such vehicles employing a free circulating liquified gas such as liquid air, nitrogen, oxygen or combinations of such gas without the employment of mechanical liquid or gas circulating means such as fans, pumps or other such means.

Another object of the invention is to provide a system in which a liquified gas in a heat insulating container is conducted to a heat absorbing flash chamber in a free flowing manner by gravity without interference from bubbles of gas arising from such flash chamber.

Another object of the invention is to provide a novel heat insulating means for a conduit through which liquified gas is conducted under the control of thermostatic means from a heat insulated liquified gas container to the refrigerating system without interference from countercurrent flowing gas bubbles resulting from the absorption of heat in said system.

A further object of the invention is to provide a liquified gas refrigerating system in which liquified gas is discharged in liquid form into a heat absorbing flash chamber having heat absorbing coils disposed within a compartment to be refrigerated and in which the flow of liquified gas is introduced into said flash chamber by thermostatic valve means responsive to the temperature changes within said compartment in periodically controlled quantities as determined by said thermostatic valve means.

Other objects and advantages will be in part evident to those skilled in the art and in part pointed out hereinafter in connection with the accompanying drawing, wherein there is shown by way of illustration and not of limitation a preferred embodiment of the invention.

In the drawing wherein like numerals refer to like parts throughout the several views:

Figure 1 is a vertical sectional view diagrammatically illustrating an arrangement by which the advantages of my invention may be realized,

Figure 2 is an enlarged fragmentary sectional view taken from the lower left hand portion of Figure 1,

Figure 3 is a view similar to Figure 2 taken from the lower right hand portion of Figure 1,

Figure 4 shows a further detail of the invention, and

Figure 5 is an enlarged fragmentary view showing a modification of the arrangement of Figure 1.

For a better understanding of the invention reference is now made to the accompanying drawings in connection with which it would be stated that the arrangements herein disclosed are designed to utilize liquid air, liquified nitrogen, oxygen or combinations thereof as the refrigeration producing agency in a closely regulated refrigerant distributing system from which the inert qualities of said gases may be employed to retard the development of the ripening process in fruits and/or vegetables within a refrigerated compartment or the spent gas may be allowed to escape to the atmosphere externally of the refrigerated compartment as conditions require.

As illustrated in Figure 1 of the drawing, the numeral **10** designates a container for a liquified gas refrigerant which is completely surrounded by a heat insulating jacket **11** that is spaced outwardly from the ends, sides and top of the container **10** to provide a space which may be evacuated to further insulate the contents of the container **10** from ambient temperature conditions. In this connection, it is also contemplated that instead of the space **12** as noted above, I may employ a "Dewar" type of container. In the present instance the bottom of the container **10** is shown as directly contacting the heat insulating jacket **11**. As alternate forms, I have shown two different flash boxes **13** and **14** as mounted externally of the heat insulating jacket **11** with connecting central conduits **15** and **16** for the flow of liqified gas from the container **10** to the interiors thereof. The flash boxes **13** and **14** have evaporator coils or expansion lines **17** extending therefrom through which gases generated within the flash boxes **13** and **14** are circulated about the interior of the refrigerated compartment to absorb heat as is well understood in the art. To control the flow of liquid gas to the flash box **13** which is of good heat conducting construction, there is a thermostatically controlled valve **19**. Each of these valves **18** and **19** are responsive to temperature changes within the commodity accommodating chamber.

As shown in more detail in Figure 2 of the drawing, the thermostatically controlled valve **18** is mounted in a throat **19** formed in the upper wall of the flash box **13** which conductively communicates with the interior of the liquified gas container **10** by a central conduit **20**. The upper end of the conduit **20** terminates flush with the bottom of the liquified gas container **10** so that liquified gas, as regulated by the thermostatic valve **18**, may flow by gravity downwardly therethrough. In this arrangement, it will be also noted that substantially the entire top wall of the flash box **13** is exposed to the interior of the liquified gas container **10** through two annular chambers that are open at their upper ends and are bottomed on the exposed upper exterior wall of the flash box **13**. One of these annular chambers is formed within a conduit **21** that forms an outer annular chamber **22** and a temperature gradient zone. Spaced inwardly from the chamber **22** there is a second conduit **23** which forms an intermediate annular chamber **24** and a second temperature gradient zone immediately around the central conduit **20**. In this arrangement, the annular chambers **22** and **24** are shown as having flap valves **25** and **26** that open upwardly to permit the escape of any gas bubbles in the direction shown by arrows as they may be developed by the absorption of heat through the upper wall of the flash box **13**. Likewise, the central conduit is shown as having a downwardly operating flap valve **27** which will operate to permit a downward flow of the liquified refrigerating gas and at the same time retard the free flow of gas bubbles upwardly through the central conduit **20** to the container **10** when the thermostatic valve **19** is open.

In the variation of the invention when used in conjunction with the flash box **14**, as shown at the right of Figure 1, and in more detail in Figure 3 of the drawings, it will be noted that this flash box is of somewhat smaller dimensions and instead of two outer annular heat insulating chambers the central conduit **16** is surrounded by a single annular chamber **28** that is formed by an outer conduit **29**. In this arrangement, the inner conduit **16** communicates with the flash box **14** through a restricted throat **30** in which the thermostatically controlled valve **19** operates. A further dif-

ference in this arrangement is that the flap valves as described above have been omitted from the central conduit **16** and the annular chamber **28**. In each of the shown arrangements, it will be noted that the annular conduits or chambers **22**, **24** and **28** which surround the central conduits **15** and **16** are bottomed upon the upper wall of the associated flash boxes and to enhance the heat insulating characteristics of these annular chambers, the conduits by which they are formed are mounted in good heat conducting contact with the upper wall of the flash boxes.

As shown in Figure 4 of the drawing, the extreme ends of the expansion coils or pipes **17** may be provided with a 3-way valve **31** at their extreme ends through which the expanding gases may be conducted directly to the atmosphere externally of the refrigerated compartment or to the interior of the refrigerated compartment as a perishable commodity protecting agency or as a further provision the heat ladened gases may be conducted in part to the interior of the refrigerated compartment and in part to the atmosphere externally thereof. The use of a 3-way valve as here illustrated, however, is not a definite requirement unless it is desired to alter the direction of discharge for the spent gases from the expansion coils or pipes **17**. For extremely low temperatures, it would be desirable to discharge the spent gases directly to the atmosphere externally of the refrigerated compartment and when used in this manner, it will be understood that no valve of any character may be required.

Where the installation of my refrigeration system requires the employment of a relatively large quantity of the liquified gas, as for example in a refrigerated railway car for transcontinental shipments, the liquified gas container **10**, as shown in Figures 1 and 5 of the drawings will be provided with surge limiting baffles **32** which will reduce surging of the liquified gas contained therein. At their upper limits these baffles **32** are shown as having openings **33** by which the flow of air and/or gas will be permitted between the several compartments and along the lower edges these surge baffles have fluid passageways **34** for the free flow of the liquid refrigerant from each of the spaces between the several baffles **32** to the particular flash box employed therewith. The container **10** also has a filling pipe **35** that carries a vented cap **36** and the container **10** may be also reinforced with external ribs **37** that extend over the top and down the sides of the container **10**.

In the operation of my improved refrigerating system, as in the case of a railway express car or truck-trailer, the liquified gas storage container **10** will be located along the ceiling of the refrigerated chamber either centrally or at the ends thereof. While I have shown two different types of flash boxes **13** and **14**, it will be understood that two flash boxes of a similar type or in some cases only one of these flash boxes may be employed. For operation of the thermostatically controlled valves **18** and **19**, I employ temperature responsive thermostatic elements (not shown) of bi-metallic or of the expansion or contraction type which will extend throughout substantially the entire length of the refrigerated compartment. Where two similar flash boxes are employed, this temperature responsive means may operate to simultaneously control the flow of liquified gas to each of the flash boxes or I may connect the temperature responsive valve operating means to control the operation of the valve for these flash boxes independently of each other. In either event, the temperature responsive elements of the valve operating means will be located along the ceiling of the refrigerated compartment where changes in the temperature of the refrigerated compartment will be most pronounced. In this manner the temperature of the refrigerated compartment can be maintained at a finely controlled temperature without moving parts except for the expansion and/or contraction of the temperature responsive thermostatic element and the movements imparted thereby to the valves **18** and/or **19**. When the temperature of the refrigerated compartment raises liquidfied gas is permitted to flow by gravity to the flash boxes and heat from the refrigerated compartment will turn this liquified refrigerant to a gas and thus create a force that will circulate cold liquid and gas through the expansion or evaporating coils or pipes **17** which extend along the ceiling and/or about the side walls of the refrigerated compartment and this gas will eventually escape to the atmosphere or to the interior of the refrigerated compartment as conditions warrant.

In Figure 5 of the drawings, there is shown a further improvement by which a more efficient use of the refrigerating gases and particularly in the case of liquid air is possible. From experience, it has become apparent that when first placing liquid air into the tank **10**, this liquid would all turn quickly to gas and escape to atmosphere in the filling operation and through vent cap **36**. Also some heat will penetrate the insulating walls of the tank **10** and create gas, which in turn would be lost as a refrigerant at the filler cap. As one step toward a remedy of this situation, it is proposed to provide the filling pipe **35** with a special fitting to which the original source of supply may be connected without loss of gases during the tank charging operation. To render this mode of operation possible, there is shown an auxiliary by-pass conduit **38** at one or both ends of the tank **10** with a discharge controlling valve **39** through which gases evolved during the tank filling operation and/or when in transit the evolved gases in the tank **10** may be directed through an extension pipe **40** to the interior of the compartment being refrigerated. As an alternative, the operation of the valve **39** may be made to direct this evolved gas into the expansion coils or pipes **17**. As a further feature, not previously stressed and to insure exhaust of these evolved gases above the liquid refrigerant in the tank **10**, I propose to provide the vented cap **36** with a pressure responsive valve, not shown, that will permit the escape of gas should a dangerous pressure be established above the liquid refrigerant in the tank **10** either by normal evaporation or by the generation of gas bubbles in the outer annular chambers **22**, **24** and **28** which respectively surround the central conduits **15** and **16** which direct the flow of liquid refrigerant from the interior of the tank **10** and under the control of the thermostatically controlling valves **18** and **19** to the flash boxes **13** and **14** as shown in Figure 1 of the drawing.

In connection with the thermostatically responsive valve **19**, there is shown an elongated thermo-sensitive bar **41** which may have either expansion or contraction characteristics that will produce a sufficient mechanical movement at the end thereof to operate the valve **19** with which this element is connected. At its other end, the thermo-sensitive bar **41** will be secured to a fixed point, as for example, the end of the car body. By providing such an elongated thermo-sensitive element **41** which extends preferably along the ceiling of the refrigerated compartment, it will be possible to get a very sensitive temperature control.

With the liquid gas filling device exactly fitting into the filling pipe **35**, pressure will be created by expanding gases and force this gas down to the expansion or cooling coils **17**. This means of utilizing gases created by heat infiltration to liquefied gas tank **10** will be effective during the duration of a trip except for the first few minutes of initially introducing liquid air to a warm car and tank **10**. During these first few minutes a volume of gas will be instantly created. To avoid excessive pressure it will be desirable to open the valve **39** at the point where the by-pass conduit **38** enters the expansion coils or pipe **17**. This will permit cooling gases to by-pass the expansion coils and enter directly

into the car body. In this manner, the car body will be quickly cooled. It might be ultimately necessary to double the number of the by-pass conduits 38 from two to four with a header at either end so that operator may use the cooling coils or pipes 17 for pre-cooling purposes or open the valve 39 for direct entry of the cooling gases to the interior of the car body.

A safety valve or rupture plate may also be provided to operate effectively as a safety device in the event a refrigerator car equipped with liquid air is returned empty and meets with wet weather when going down grade in cold weather. Under these conditions moisture might be drawn into exhaust end of by-pass conduit 38 and freeze. This chain of circumstances, however, is remote and can be corrected by an operator inspecting and cleaning this conduit before the next use if necessary.

The construction and use of this automatic refrigeration system will be found especially suitable for use in refrigerated truck-trailers where operational functions involve vibration and more or less rugged transportation features that render the use of mechanical refrigerating systems expensive to operate and maintain. In my improved system there is a minimum of mechanically working parts and, therefore, the installation may be used for years without maintenance or repair.

While I have, for the sake of clearness and in order to disclose my invention so that the same can be readily understood, described and illustrated a specific form and arrangement, I desire to have it understood that this invention is not limited to the specific form disclosed, but may be embodied in other ways that will suggest themselves to persons skilled in the art. It is believed that this invention is new and all such changes as come within the scope of the appended claims are to be considered as part of this invention.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In a liquified gas refrigerated system of the character described, the combination of a liquified gas containing chamber having a bottom of heat insulating construction, a heat absorbing flash box mounted below said liquified gas containing chamber and at the outer limits of said heat insulation, a central conduit through which liquified gas may flow by gravity from said liquified gas containing chamber to the interior of said flash box, a thermostatically controlled valve in said conduit responsive to temperature conditions externally of said liquified gas container, means forming an annular recess about said central conduit communicating at its top with said chamber and bottomed on said flash box forming a cold heat insulating zone with a temperature gradient surrounding said central conduit, and a flap valve in said central conduit for preventing the escape of gas bubbles into said liquified gas container when said thermostatic valve is open.

2. In a liquified gas refrigerating system the combination of a heat insulated container for liquified gas, a heat absorbing flash box located below said liquified gas container having gas conducting expansion conduits extending therefrom and disposed about the interior of a chamber to be refrigerated, a conduit through which liquified gas may flow from said container to the interior of said flash box, a temperature responsive valve in said conduit responsive to the temperature in said chamber for controlling the flow of liquified gas therethrough, and means surrounding said conduit forming an annular recess in communication with said container into which liquified gas may accumulate as a heat insulating medium about said conduit through which liquified gas flows to said flash box.

3. In a liquified gas refrigerating system, the combination of a liquified gas container having a heat insulating jacket completely surrounding same, a flash box of heat absorbing construction disposed below and externally of said heat insulating jacket where it will be exposed to the absorption of heat from the interior of a compartment to be refrigerated, heat absorbing expansion conduits extending from said flash box, the extreme ends of said expansion conduits being open to allow the flow of spent gas into said compartment and/or to the atmosphere, a connection between said liquified gas container and said flash box comprising a central conduit through which liquified gas may flow by gravity from said container to the interior of said flash box, means forming an annular chamber about said central conduit in heat absorbing relation with said flash box and opening into the interior of said liquified gas container, whereby liquified gas in said annular chamber will have a temperature gradient and form a cold heat insulating zone about said central conduit.

4. In a liquified gas refrigerating system, the combination of a liquified gas container having a heat insulating jacket completely surrounding same, a flash box of heat absorbing construction disposed below and externally of said heat insulating jacket where it will be exposed to the absorption of heat from the interior of a compartment to be refrigerated, heat absorbing expansion conduits extending from said flash box, the extreme ends of said expansion conduits being valved to allow the flow of spent gas into said compartment and/or to the atmosphere externally of said compartment, a connection between said liquified gas container and said flash box comprising a central conduit through which liquified gas may flow by gravity from said container to the interior of said flash box, means forming an annular chamber about said central conduit in heat absorbing relation with the top of said flash box and communicating with the interior of said liquified gas container, whereby liquified gas in said annular chamber will provide a temperature gradient zone and form a cold heat insulating medium throughout said central conduit, whereby liquified gas will flow by gravity through said central conduit to said flash box without interference from rising gas bubbles, and a thermostatic valve responsive to temperature changes externally of said flash box for controlling the flow of liquified gas through said central conduit.

5. In a liquified gas refrigerating system, the combination of a liquified gas container having a heat insulating jacket completely surrounding same, a flash box of heat absorbing construction disposed below and externally of said heat insulating jacket and exposed in heat absorbing relation with the interior of a compartment to be refrigerated, heat absorbing expansion conduits extending from the interior of said flash box and disposed within said compartment, the extreme ends of said expansion conduits being vented to permit the escape of evolved heat ladened gas, a central conduit connecting the interior of said liquified gas container with said flash box through which liquified gas may flow by gravity from said container to the interior of said flash box, a thermostatically controlled valve in said central conduit for regulating the flow of liquified gas to said flash box in response to temperature changes externally of said flash box, means forming an annular chamber about said central conduit in heat absorbing relation with said flash box and communicating with the interior of said liquified gas container, whereby liquified gas in said annular chamber will have a temperature gradient and operate as a cold heat insulating medium about said central conduit, and a thermostatically controlled valve for regulating the flow of liquified gas through said central conduit in response to temperature changes externally of said flash box.

6. In a liquified gas refrigerating system, the combination of a liquified gas container having a heat insulating jacket completely surrounding same, a flash box disposed below and externally of said heat insulating jacket and exposed to the interior of a compartment to be refrig-

erated, heat absorbing expansion conduits extending from the interior of said flash box and disposed within said compartment, the extreme ends of said expansion coils being valved to direct the flow of gases evolved in said flash box and said expansion conduits to escape into said compartment and/or to the atmosphere, a central conduit connecting said liquified gas container and said flash box through which liquified gas may flow by gravity to the interior of said flash box, a thermostatically controlled valve in said central conduit for regulating the flow of liquified gas to said flash box in response to temperature changes externally of said flash box, and means forming an annular liquified gas retaining chamber bottomed on and in heat conducting relation with said flash box extending around said central conduit with its upper end open and in communication with the interior of said liquified gas container, whereby liquified gas in said annular chamber will form a temperautre gradient cold heat insulating zone about and throughout the length of said central conduit, whereby a free gravity flow of liquified gas to said flash box will result under control by said thermostatic valve without interference from rising gas bubbles.

7. In a free flowing liquified gas refrigerating system, the combination of a liquified gas container having a heat insulating jacket completely surrounding same, a flash box disposed below and externally of said heat insulating jacket and exposed to the absorbtion of heat from an area to be refrigerated, heat absorbing conduits extending from the interior of said flash box and disposed for the absorption of heat, the extreme ends of said conduits being vented to permit spent gases to escape therefrom, means forming a central conduit through which liquified gas may flow by gravity from said liquified gas container to the interior of said flash box, a thermostatically controlled valve in said central conduit for regulating the flow of liquified gas to said flash box in response to temperature changes, means forming a plurality of annular heat absorbing chambers bottomed on said flash box and extending concentrically around said central conduit with their upper ends open and in communication with the interior of said liquified gas container, whereby said annular chambers will retain liquified gas and form cold heat insulating zones with different temperature gradients about said central conduit, and a valved by-pass conduit extending from above the level of liquified gas in said liquified gas container having a valve for controlling the flow of gas evolved within said container directly to said heat absorbing conduits or to the area surrounding said conduits, a flap valve in said central conduit for preventing the flow of gas bubbles to the interior of said liquid container when said thermostatically controlled valve is open, and additional flap valves in said concentric annular heat absorbing chambers for permitting the flow of gas bubbles therefrom and into said liquified gas container.

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