Dec. 4, 1934. W. G. CLARK 1,982,791

REFRIGERATION APPARATUS

Original Filed Feb. 8, 1932 2 Sheets-Sheet 1

Fig. 1.

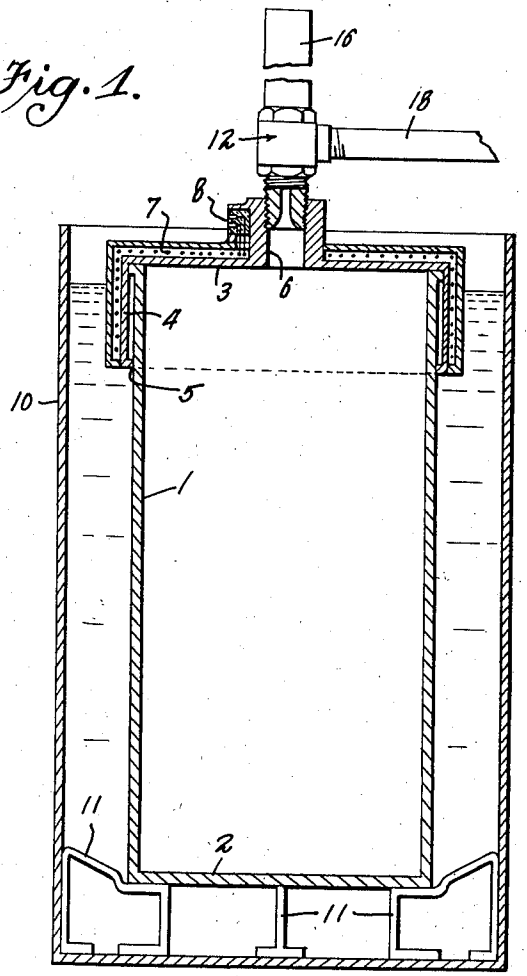
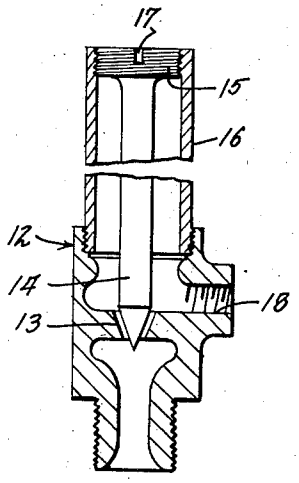


Fig. 2.



Inventor

Walter Gordon Clark

By Lyon & Lyon

Attorneys

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Fig. 3.

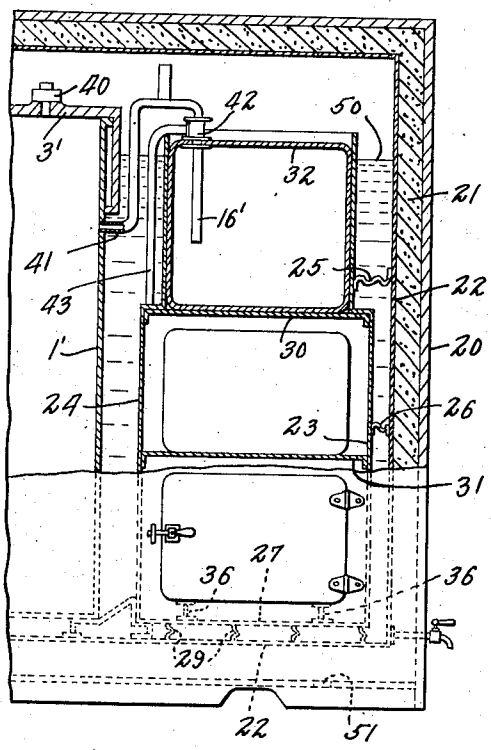
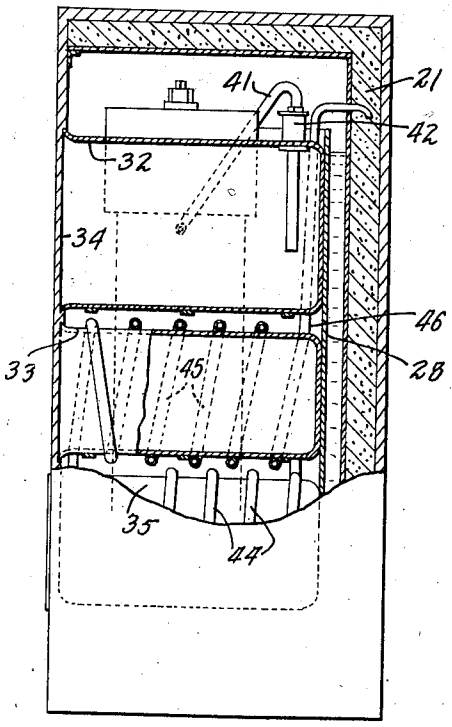


Fig. 4.



Inventor

Walter Gordon Clark

By Lyon & Lyon

Attorneys

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UNITED STATES PATENT OFFICE

1,982,791

REFRIGERATION APPARATUS

Walter Gordon Clark, Los Angeles, Calif., assignor to Air Ice Research & Development Corp., Los Angeles, Calif., a corporation of Delaware

Original application February 8, 1932, Serial No. 591,524. Divided and this application October 3, 1932, Serial No. 635,916

7 Claims. (Cl. 62—1)

This invention relates to novel methods of utilizing gasifiable refrigerants and to certain forms of apparatus wherein the methods of this invention may be effectively carried out. The invention also relates to methods and apparatus in which various physical properties of gasifiable refrigerants and of liquids are made available in the performance of novel functions and results. This application is a division of a prior co-pending application, Serial No. 591,524, filed February 8, 1932, entitled "Method of refrigeration and apparatus therefor".

By the term "gasifiable refrigerants" as used hereinafter, reference is made to material such as liquefied or solidified carbon dioxide, sulfur dioxide, methyl chloride, etc. For purposes of lucidity, the subsequent description of the methods and apparatus embraced by this invention will be particularly directed to methods and apparatus capable of being carried out or used with solidified carbon dioxide, although it is to be understood that any of the other gasifiable refrigerants come within the scope of these inventions.

Numerous obstacles have been encountered in the economic use of solid carbon dioxide as a refrigerant. For example, solid carbon dioxide develops a pressure of approximately 900 pounds per square inch by evaporating at normal atmospheric temperatures. For this reason, if solid carbon dioxide is enclosed in a gas-tight container in such manner that it may be subjected to atmospheric temperatures, it is necessary to provide a container of sufficient strength to withstand pressures of 900 pounds or more, with an additional satisfactory margin of safety. A container of dimensions sufficient to receive blocks of solid carbon dioxide of commercial size, would under the above state of conditions, be exceedingly heavy. Furthermore, it is extremely difficult to provide a gas-tight seal without resorting to threaded or bolted joints which are slow and difficult to manipulate.

In addition, although solid carbon dioxide has been available for refrigerating purposes, those skilled in the art have not been able to devise methods or means whereby the refrigerating effect of solid carbon dioxide and similar gasifiable refrigerants, can be made available for household use, or for use in refrigerated railway cars, dining or buffet cars, aircraft, etc. The heretofore proposed methods of using refrigerants of this nature either contemplated extremely heavy and complicated devices, or did not fully utilize the refrigerating capacity of the materials.

This invention, on the other hand, provides means for storing and dispensing gasifiable refrigerants such as solid carbon dioxide, in a simple and effective manner. The pressure generated by vaporization or sublimation of a gasifiable refrigerant is utilized in sealing, strengthening and heat-insulating the containers in which it is kept. The vaporization or sublimation of the refrigerants is controlled so as to maintain the refrigerant at any desired and predetermined maximum pressure. Furthermore, the expansion of the gasifiable refrigerant is controlled for the purpose of regulating the production of further quantities of gasified refrigerant in quantities commensurate with the amount of refrigeration required.

Moreover, the invention relates to a method of regulating the pressure of gasifiable refrigerants within a container by means of secondary refrigerants or freezable liquids. It concerns itself with novel methods of heat-insulating refrigerators, refrigeration chambers or other compartments which it is desired to maintain at a low temperature. The methods of this invention may be applied to the insulation of cold storage receptacles, dispensing containers, refrigeration chambers, etc. and with the regulated supply of gasified refrigerants to enclosures, rooms, box cars, and the like, for the purpose of keeping such enclosures cool.

The invention also concerns itself with novel arrangements of elements whereby the various objects and results to which the methods of this invention are directed, may be attained. It relates, for example, to the production of means whereby gasifiable refrigerants may be maintained at any predetermined maximum pressure within light weight dispensing containers; to the construction of refrigerators; to the provision of means whereby the expansion characteristics of gasifiable refrigerants may be utilized to best advantage; to the provision of means whereby gasified refrigerants may exert a controlled refrigerating effect and thereafter function to produce and maintain heat insulators, etc.

An object of this invention is to disclose and provide methods of utilizing gasifiable refrigerants for the refrigeration of chambers, cold storage containers, enclosures, and the like.

Another object of this invention is to disclose and provide a method of storing and dispensing gasified refrigerants.

An object of this invention is to disclose and provide a method of storing and dispensing refrigerants from limited containers in which said

refrigerants are maintained at or below a predetermined maximum pressure.

A further object of this invention is to disclose and provide a method of utilizing the heat-absorbing capacity of vaporization of gasifiable refrigerants for maintaining said refrigerants at a desired pressure and for utilizing refrigerating capacity of said refrigerants most effectively.

Another object is to disclose and provide a method of utilizing the heat-absorbing capacity of vaporization of gasifiable refrigerants for the purpose of maintaining a secondary refrigerant in refrigerating relation to the gasifiable refrigerant, said secondary refrigerant acting as a structural material and at the same time acting as a heat-insulating material.

Moreover, it is an object of this invention to disclose and provide means whereby the various objects enumerated hereinabove, as well as others, may be readily attained. For example, it is an object of this invention to disclose and provide a novel and effective construction for dispensing containers for gasifiable refrigerants.

These and other objects, uses, advantages, functions and results of this invention will become apparent to those skilled in the art from the following description of the invention.

Although the invention may assume great varieties of forms and may be applied to a plurality of different uses, the detailed description will be limited to certain illustrative embodiments shown in the appended drawings, in which

Fig. 1 is a vertical section through one form of dispensing container for gasifiable refrigerants.

Fig. 2 is an enlarged longitudinal section through a form of thermostatically controlled valve regulating means.

Fig. 3 is a front elevation, partly broken away, of a portion of a refrigerator embodying the invention.

Fig. 4 is a side elevation, partly broken away, of the refrigerator illustrated in Fig. 3.

As shown in Fig. 1, a suitable dispensing container for gasifiable refrigerants may consist of a cylindrical container 1 provided with a bottom 2. The container 1 may be provided with an inlet and in the case of cylindrical containers, the open end of the cylinder may comprise the inlet. A suitable closure member or cap is provided for the inlet to the container. Preferably, the closure member is in the form of a cap adapted to encircle a portion of the container adjoining the inlet. As shown in Fig. 1, the cap 3 may be provided with a downwardly extending flange 4. The cap preferably fits loosely over the inlet to the container. A plurality of circumferentially arranged spacing pins or other suitable spacing means, such as protuberances 5, may extend inwardly from the flange 4 so as to space the flange 4 from the container 1. A plurality of outwardly extending circumferentially spaced pins or flange segments may extend from the upper edge of the container 1. The purpose of these spacing means 5 will be evident from the subsequent description.

The closure member 3 may be provided with an outlet 6. Furthermore, the closure member may be provided with a suitable heating means such as, for example, an electrical resistance coil 7 carried within a cavity within the closure member. Preferably, the resistance coil is carried both in the top and in the flange of the closure member.

A suitable terminal or plug 8 is carried by the closure 3, facilitating the supply of electrical energy to the coil 7 whenever it is desired to heat the coil. The container 1 is preferably positioned in a case 10. The case 10 may well be made of light metal and provided with expansion joints or corrugations capable of permitting the case to expand slightly. The container 1 is preferably spaced from the walls of the case 10, suitable spacing means being provided to insure this result. Although any form of spacing means may be used, Fig. 1 indicates bent metal spacers 11 for this purpose. Any suitable liquid is placed in the space between the container 1 and the case 10, the liquid extending up to about the top of container 1 and being permitted to enter the space between the flange 4 of the closure and the container 1.

If a container of this general character is filled with a gasifiable refrigerant, such as solid carbon dioxide, and a closure placed over the inlet, (it being assumed for purposes of discussion that the closure is provided with an aperture or outlet such as the outlet 6), and the filled container then inserted into a case filled with a freezable liquid, such as an aqueous solution, the vaporization of the solid CO_2 within the container 1 will quickly cause the liquid to freeze. The ice thus formed substantially encloses the container 1 and seals the closure 3 upon the inlet to the container 1. In this manner, the temperature within the container 1 is maintained at about 32° F. and for this reason the pressure within the container is automatically limited to approximately 500 pounds per square inch. It has been found that an ice seal of the character employed between the container and the closure has a strength of about 250 pounds per square inch and, therefore, pressures which are much in excess of 500 pounds per square inch could be maintained within a container and the container sealed with ice, whenever ice is the seal between a closure member and the container. Furthermore, it has been found that ice below 32° F. has a thermal conductivity of only about 1.88 B. t. u. per square foot per hour per 1 inch thickness per 1° F., and is, therefore, comparable to cork insulation in effectiveness. Moreover, the ice encircling and substantially enclosing the container 1 materially increases the strength of the container.

It is evident, therefore, that the container construction described hereinabove employs a frozen liquid to perform a plurality of novel functions. The frozen liquid not ony acts as a seal, but insulates the container and strengthens it. Furthermore, the maximum pressure capable of being developed within the container is regulated by the freezing point of the liquid exteriorly of the container. Instead of using water, saturated or supersaturated solutions, brine, alcohol solutions, glycerine solutions, and other freezable liquids or mixtures may be employed. In this manner, the maximum pressure of a gasifiable refrigerant within a limited container may be regulated by varying the freezing point of a body of liquid substantially enclosing said container. The heat absorbing capacity of vaporization or sublimation of the gasifiable refrigerant is, therefore, utilized in maintaining a secondary refrigerant in refrigerating relation to the gasifiable refrigerant, and as long as sufficient heat absorbing capacity exists within the container 1 to maintain the liquid frozen, a pressure corresponding to the vapor pressure of the refrigerant at the freezing temperature of the liquid surrounding the container will be maintained in the container.

Moreover, by changing the characteristics of the liquid surrounding the container 1, its volumetric changes during freezing may be controlled to an extent sufficient to maintain the capping member 3 in proper sealing relation to the container 1, so that substantially no difference between the volumetric changes of the metallic container and that of the sealing liquid exists.

As the maximum pressure capable of being generated within the container is thus controlled, it is not necessary to employ heavy construction for the container 1. When handling the solidified CO_2 and using water ice as the sealing means, it has been found that the container may be made of steel 1/8" to 1/4" in thickness. The exterior case 10 may be extremely light, being capable of only withstanding a pressure of 4 or 5 pounds per square inch.

When the frozen liquid seal melts so that the cap is moved upwardly by the action of the gas pressure within the container 1, the cap is prevented from being completely blown off by interengagement of the inwardly extending flange sections 5 and the outwardly extending flange sections or pins carried by the upper edge of the container 1. It is to be understood that it is necessary to partially rotate the cap upon the container 1 before the cap may be removed.

Whenever it is desired to refill the container 1, a current may be supplied to the resistance coil 7 in the closure member, thereby melting the seal and permitting the cap to be removed. Preferably, a pressure release valve is carried by the closure member 3 so that a pressure, of say 500 pounds, is liberated before the closure is heated and unsealed from the container.

Although in the description given hereinabove reference has been made to a cylindrical container 1, it is to be understood that the containers may be of any desired shape or size. Cylindrical forms are preferred because of their compactness, adaptability and high strength.

Dispensing units of the type illustrated in Fig. 1 may be utilized wherever it is desired to store or dispense a gasifiable refrigerant. For example, they may be installed in refrigerated showcases, soda fountains and carbonated beverage dispensers, refrigerators, cold storage rooms, and the like. When it is desired to dispense carbon dioxide from a container of this sort in regulated quantities so as to maintain a desired low temperature in an enclosure, such as a refrigerator, the container may be inserted into the refrigerator, the closure member being then provided with a thermostatic valve 12 positioned in a conduit leading to the container 1. For example, the valve 12 may be connected to the outlet 6 formed in the closure member 3. The body portion of the valve 12 may be provided with a conical seat 13 and a conical valve 14 adapted to cooperate with said seat. The valve member 14 may be in the form of a rod made of a metal having negligible coefficient of expansion. The upper end of the rod may be provided with an exteriorly threaded head 15 held in position within a tubular member 16 attached to the body 12 of the valve. The tubular member 16 may be made of brass or other metal or alloy, having appreciable coefficient of expansion. Means may be provided for adjustably positioning the valve member 14 within the tubular member 16, as, for example, the groove 17, whereby the head 15 and the rod 14 may be rotated within the tube 16, thus longitudinally moving the valve member 14. An outlet 18 may lead away from the valve body 12.

By exposing the thermostatic valve 12, and particularly the tubular portion 16 thereof, to the action of gases within the chamber which it is desired to refrigerate or cool, the volume of carbon dioxide or other gasified refrigerant discharged from the container 1 through the outlet 18 into expansion conduits, cooling coils, or the like, may be automatically controlled. Variations in the temperature of the gases within the chamber being refrigerated cause the member 16 to expand and contract, thus changing the setting of the valve and regulating the passage of gasified refrigerant therethrough.

Figs. 3 and 4 illustrate one form of refrigerator of high capacity, embodying forms of construction and methods embraced by this invention. A refrigerator of the type there shown is particularly adapted for use in hotels, homes, railroad dining cars, etc. It preferably comprises a suitable exterior housing 20 lined with insulating material 21. A thin metallic but water-tight liner 22 is positioned within the case. Vertical partitions 23 and 24 are then positioned within the refrigerator, the partition 23 being spaced from the interior sheathing 22 as by means of tie members 25 and 26. The tie members 25 and 26 may be corrugated so as to permit expansion. The sheathing or liner 22 as well as the partitions 23 and 24 may also be of corrugated metal.

A horizontal member 27 may connect the lower ends of partitions 24 and 23 as well as the lower end of a rear vertical partition 28 joining the rear portions of side partitions 23 and 24. In effect, therefore, partitions 23, 24 and 28 form an enclosure connected to the front of the refrigerator and supported above the inner liner 22 by means of expansible supporting members 29.

The vertical side partitions 23 and 24 may be connected together by means of members 30 and 31, these members supporting suitable glazed or enameled refrigeration chambers 32 and 33. The open ends of these refrigeration chambers 32 and 33 may be fastened to the front wall 34 of the refrigerator and be provided with suitable doors by means of which access may be gained thereto. The refrigeration chamber 35 may be supported above the bottom partition 27 by means of suitable supports 36.

A suitable container for gasifiable refrigerants, such as the container 1', may be positioned in the refrigerator, said container being provided with a closure member 3' bearing a relief valve 40. Conduit means may communicate with the interior of the container 1', such as, for example, the conduit 41, said conduit leading to a thermostatically controlled valve 42 exposed to the gases in one of the refrigerating chambers of the refrigerator.

As shown in Figs. 3 and 4, the thermostat tube 16' of the thermostat valve 42 extends into the refrigeration chamber 32; the gasified refrigerant passing through the valve 42 passes through suitable coils surrounding the refrigeration chambers 33 and 35. The refrigerant, after passing through thermostat valve 42, may be discharged by conduit 43 and pass through a series of coils 44 around the lowermost refrigeration chamber 35 and then through coils 45 around the intermediate refrigeration chamber 33. The partially expanded refrigerant may then pass by conduit 46 into the upper part of the refrigerator and be discharged into the insulation 21 therein.

In actual operation, the space within the refrigerator, that is, the space within the inner

lining or sheathing 22 and between said sheathing and the interior partitions 23, 24, 28 and 27, is filled with water or other suitable liquid. Such water preferably extends upwardly to a height sufficient to substantially encircle and cover the container for gasifiable refrigerants 1'. The liquid level is indicated in Figs. 3 and 4 at 50. The gasifiable refrigerant vaporizes in the container 1' and is discharged through conduit 41. The vaporization of the refrigerant causes the water or other liquid surrounding the container 1' to freeze, thereby sealing the closure member 3' and permitting the generation of pressure within the container 1'.

The thermostatic valve 42 responds to the temperature of the air within the refrigeration compartment 32 and permits the discharge of gasified refrigerant through the valve 42 and through conduit 43 into the coils 44 and 45, thereby reducing the temperature in refrigeration chambers 35 and 33 to a desirable low point. Inasmuch as the refrigerant is being expanded in close proximity to the water-filled walls of the refrigerator, the water or other liquid therein freezes, forming a heat insulating layer surrounding the refrigeration chambers 33 and 35. The partially expanded refrigerant is then discharged by conduit 46 into the layer of insulating material 21 contained in the outer envelope of the refrigerator. Preferably, the heat insulating material 21 is porous and permits the passage of carbon dioxide therethrough.

It has been found that layers of corrugated paper, loosely packed mineral wool, and similar materials form very effective insulation. Insulating boards or panels made of corrugated paper are particularly effective. The carbon dioxide sinks downwardly through the insulation, displacing the moisture laden air generally existing in the pores of any insulating material, and eventually the expanded carbon dioxide or other gasifiable refrigerant is discharged through suitable apertures 51 formed in the sub-floor of the refrigerator.

It will be noted that in a refrigerator of the type shown in Figs. 3 and 4, the refrigeration chambers are insulated by means of a freezable liquid. Furthermore, the freezable liquid assists in retaining and forming a container for the gasifiable refrigerant. The gasified refrigerant controls its own rate of escape from the container 1' as the thermostatically controlled valve 42 responds to variations in temperature changes and such temperature changes are occasioned by the expanding refrigerant. Furthermore, the vaporization or sublimation of the refrigerant in container 1' forms a body of ice or secondary refrigerant around said container, the further expansion of the refrigerant in the expansion conduits or coils reduces the temperature of the refrigeration chambers and freezes the insulating layers of ice, and the final stage of expansion of the refrigerant in the insulating lining 21 materially assists in maintaining the contents of the refrigerator at a uniformly low temperature. Ordinary heat insulating materials contain moisture laden air, as has been stated hereinbefore, and moisture laden air has a relatively high specific heat and is not an effective insulator. When solid carbon dioxide is the refrigerant used, the carbon dioxide gas is not only inherently at a low temperature when passing through the insulation 21, but in addition it is dry and therefore has a relatively low specific heat. It displaces the moisture laden air originally existing in the insulation.

The appreciable quantity of ice surrounding the refrigeration chambers and the container 1' not only acts as a heat insulator, but in addition functions as a cold storage so that in the event the supply of carbon dioxide becomes depleted, a conditioned refrigerant is available from the ice.

It is to be understood that whenever reference has been made to ice, other freezable liquids are also contemplated. Furthermore, the arrangement of refrigeration chambers, coils and other details of construction may be materially altered without departing from the invention, the form of apparatus shown in the drawings being merely illustrative of one type of device. Moreover, it is not necessary that the specific form of gasifiable refrigerant be employed in conjunction with refrigeration chambers which include wall spaces filled with a freezable liquid. A mechanical refrigeration unit could be substituted for the container for gasifiable refrigerants in a refrigerator of the type shown in Figs. 3 and 4, and merely the freezable liquid surrounding the refrigeration chambers utilized.

Refrigeration control units of the type described hereinabove employ the heat absorbing capacity of the gasifiable refrigerants most effectively. It is to be noted that the heat absorbing capacity of the refrigerants is utilized in creating a desirable pressure within the containers, in forming a body of secondary refrigerant such as ice, which seal said containers and insulates them against heat transfer, in generating power and in cooling an enclosure. Solidified or liquefied carbon dioxide is particularly adapted for use in devices of this type, as, for example, in maintaining controlled temperatures in passenger compartments of railway cars or steamships, or in the refrigeration of ship compartments or railway cars containing perishables, as the carbon dioxide not only acts as a refrigerant, but in addition exerts a preservative effect.

Having thus fully described the invention and a number of its modifications, it is to be understood that the invention is not limited to the specific embodiments described hereinabove, but instead includes all such changes, modifications, uses and adaptations as come within the scope of the appended claims.

I claim:

1. In a dispensing container for liquefied or solidified gases, a container provided with an inlet, a closure member for the inlet of said container encircling a portion of said container adjacent said inlet, and a freezable liquid between said closure member and container adjacent said inlet, said freezable liquid being adapted to hold said closure member in operative relation with said container while said freezable liquid is maintained in frozen condition by reason of heat absorption due to presence of liquefied or solidified gases in said container.

2. In a dispensing container for liquefied or solidified gases, a container provided with an inlet, a liquefied or solidified gas in said container, a closure member over the inlet of said container and encircling a portion of said container adjacent said inlet, said closure member being provided with an electric heating means carried thereby, and a freezable liquid between said closure member and container adjacent said inlet, said freezable liquid being adapted to hold said closure member on the inlet to said container

while said freezable liquid is maintained in frozen condition.

3. In a dispensing container for liquefied or solidified gases, a container provided with an inlet, a case for said container, a closure member for the inlet of said container, a freezable liquid in said case and in contact with said container and closure member for releasably holding said closure member in operative relation with said container, a gas conduit leading from said container, and a thermally responsive valve in said conduit.

4. A storage device for gasifiable refrigerants, comprising a container provided with an inlet, a cap member for said inlet, and a liquefiable holding means for releasably holding said cap member on said inlet whereby the maximum pressure of gasified refrigerant in said container is controlled by said holding means.

5. A storage device for gasifiable refrigerants comprising a container provided with an inlet, a cap member for said inlet, and a frozen fluid between the cap and the container when the cap is in position on said inlet, said liquid being frozen by gasifiable refrigerants in the container and holding the cap in place over said inlet.

6. A storage device for gasifiable refrigerants, comprising a container provided with an inlet, a gasifiable refrigerant in said container, a cap member for said inlet, and a frozen fluid substantially surrounding said container and in contact with said cap whereby said cap is sealed in position on said inlet.

7. A storage device for gasifiable refrigerants comprising a container for gasifiable refrigerants, an inlet into said container, a closure member over said inlet and loosely encircling a portion of said container adjacent said inlet, a case for said container, a freezable aqueous liquid in said case and extending between said closure member and container, said freezable aqueous liquid being maintained in frozen condition within said case by a gasifiable refrigerant in said container to maintain said closure member in position over said inlet and to act as an insulator around said container and thereby control the maximum pressure developed by the gasifiable refrigerant in said container.

WALTER GORDON CLARK.