Oct. 5, 1948. R. L. BRUNSING 2,450,713

REFRIGERATING SYSTEM USING DRY ICE AND INCLUDING A SECONDARY HEAT EXCHANGE CIRCUIT

Filed July 13, 1946

2 Sheets-Sheet 1

Fig-1

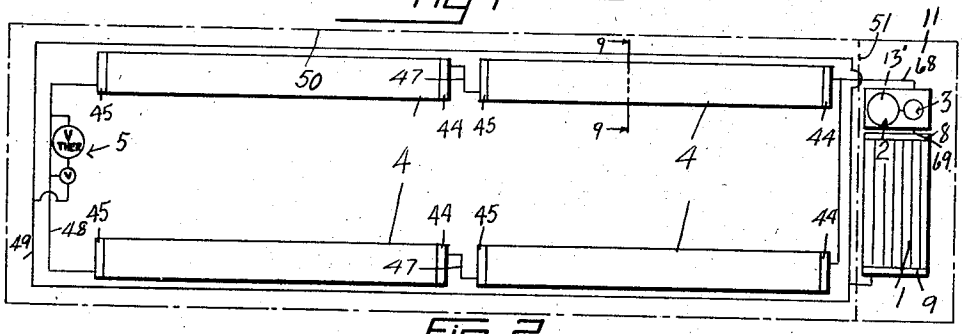



Fig-2

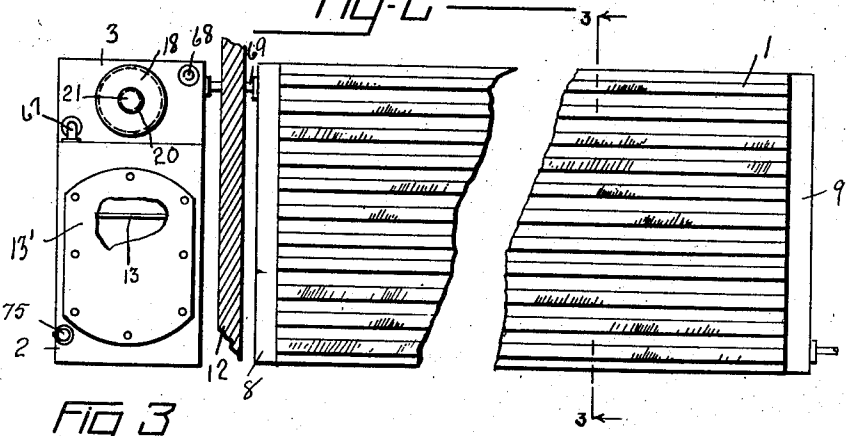



Fig 3




Fig-4

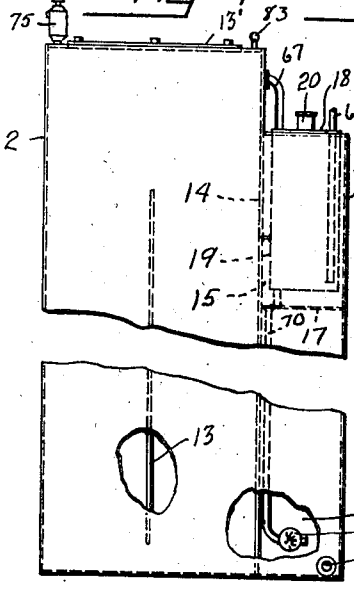



Fig-5

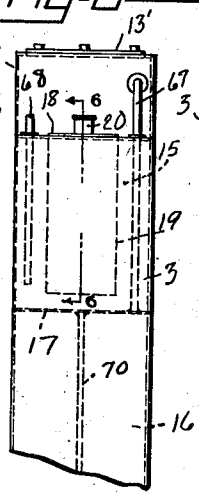
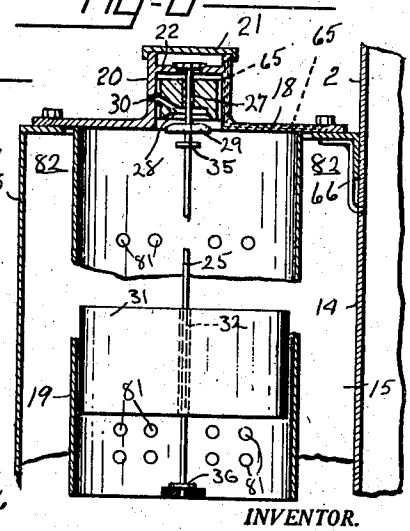



Fig-6




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REFRIGERATING SYSTEM USING DRY ICE AND INCLUDING A SECONDARY HEAT EXCHANGE CIRCUIT

Filed July 13, 1946 2 Sheets-Sheet 2

Fig-7

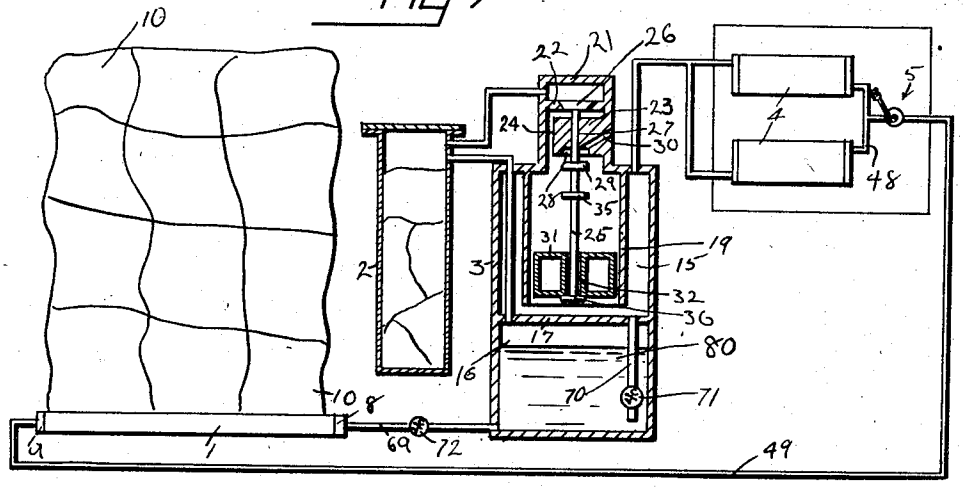



Fig-8

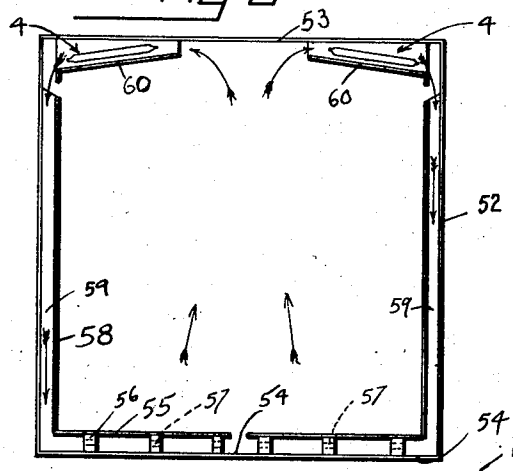
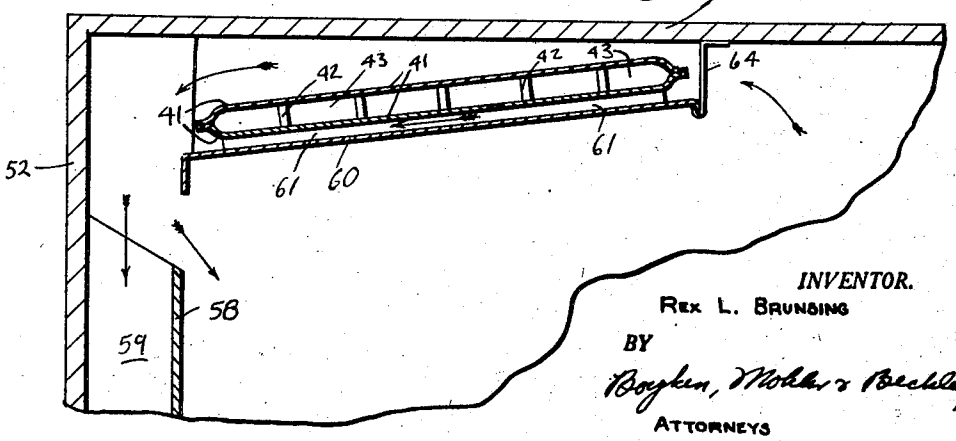



Fig-9




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Patented Oct. 5, 1948

2,450,713

# UNITED STATES PATENT OFFICE

2,450,713

## REFRIGERATING SYSTEM USING DRY ICE AND INCLUDING A SECONDARY HEAT EXCHANGE CIRCUIT

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Application July 13, 1946, Serial No. 683,511

12 Claims. (Cl. 62—91.5)

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This invention relates to a refrigerating system, and more particularly to an improved apparatus and method for utilizing solid carbon dioxide ($CO_2$), commonly called "dry ice," or very cold materials of that general character having the property of changing from a solid state directly into a gaseous state and absorbing heat during the change.

One of the objects of this invention is the provision of a system that is more efficient than heretofore and which system employs a fluid or liquid refrigerant that is chilled or cooled by being brought into heat transfer relationship with the dry ice and that is then conducted to the space or region to be refrigerated for cooling such region, and that is then returned to the dry ice for re-cooling and for repeating the cycle.

Another object of the invention is a refrigerating system that employs dry ice for cooling the refrigerant to be circulated in the region to be cooled, and which system uses a more efficient and reliable means for effecting such circulation than heretofore.

For the most part, prior systems of the general type to which this invention relates, have included a liquid refrigerant or fluid of very low freezing point, which fluid has been chilled by dry ice and then carried to cooling coils or units in the region to be refrigerated after which the fluid has been returned for re-cooling or chilling and for recirculation. This circulation has been effected by the use of gas pressure developed in the container for the dry ice used for cooling the fluid, or else the circulation has been effected mechanically, and thermostatic controls have been used to regulate the flow of the fluid.

Among the disadvantages of the system that employs the gas pressure for circulating the fluid has been the fact that the procedure of replenishing the supply of dry ice in the large containers resulted in loss of the gas pressure, and also at any time the large tank might be vented to the atmosphere (which has been the common practice in using the gas for moving the fluid), the gas pressure is lost or radically reduced, and must be built up again before the system is operative.

Another objection is the fact that dry ice under gas pressure has less cooling efficiency than where it is under atmospheric pressure. Dry ice in subliming under atmospheric pressure produces a temperature of —108.8° F. while under even a five pound pressure it will produce a temperature of only about —90° F. or about 18 degrees higher than were the same at atmospheric pressure.

A still further disadvantage in using the gas pressure from the prime cooling agent (solid $CO_2$) is the fact that the large tanks used must be made to withstand far greater pressures than are

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normally used, with the result that they are very heavy and expensive.

There are other disadvantages, but the above are perhaps among the principal ones.

With the present invention the above objections are entirely overcome. The full cooling efficiency of the dry ice at atmospheric pressure is obtained. No large, expensive, and heavy pressure tanks are required, and there is no wasteful venting of gas pressure nor is there an objectionably long delay between reductions in the gas pressure and the re-building of such pressure to the working point.

Other objects and advantages will appear in the description and in the drawings.

In the drawings, Fig. 1 is a diagrammatic plan view of a system embodying the present invention as applied to a refrigerator car, the outline of the walls of the latter, including the wall between the ice bunker and the main body of the car being indicated in dot-dash lines.

Fig. 2 is an enlarged plan view of the support for the main body of dry ice and the auxiliary pressure tank and control device.

Fig. 3 is an enlarged fragmentary sectional view taken along line 3—3 of Fig. 2.

Fig. 4 is an enlarged side elevational view, partially broken away, showing the control chamber and pressure tank.

Fig. 5 is an elevational view of the control chamber of Fig. 4, as seen from a side thereof at right angles to the point of view of Fig. 4.

Fig. 6 is an enlarged sectional view through the upper part of the control chamber taken along line 6—6 of Fig. 5.

Fig. 7 is a diagrammatic view clearly showing the system and manner of operation.

Fig. 8 is a diagrammatic view across a car.

Fig. 9 is an enlarged sectional view along line 9—9 of Fig. 1.

In detail, the system, in its broad aspect, comprises a support 1 for holding a quantity of dry ice that functions solely for chilling or cooling the fluid refrigerant. The latter may be alcohol, brine, or any other suitable fluid. The dry ice on said support is under atmospheric pressure, and in a standard refrigerator car the amount of dry ice so supported may be about 6000 lbs.

Adjacent the support 1, but not necessarily a part of the same, is a closed tank or container 2 for holding a relatively small amount of dry ice. Where 6000 lbs might be held on support 1, only about 500 lbs. would be in container 2, assuming the system were used in a standard refrigerator car. In any event, a relatively small amount of dry ice is in container 2 and the container is relatively small as best indicated generally in Fig. 1.

Alongside container 2 is a control chamber 3. This chamber 3 is connected with a cooling unit or units 4 for receiving a fluid refrigerant from

said unit or units. Chamber 3 is in communication with the gas in container 2, which gas results from sublimation of the dry ice in container and is under pressure. The gas, under pressure, is utilized to force the fluid refrigerant from the control chamber past the main body of $CO_2$ through support 1, and to the cooling coils or units 4 and back to control chamber 3. Cooling units 4 are in the space to be refrigerated, and thermostatic means 5, which includes a valve, functions for opening or closing the fluid line to flow of fluid to the control chamber.

The support 1, container 2, and control chamber 3, may all be positioned in a conventional ice bunker at one end of a refrigerator car. The dry ice on support 1 will sublime at atmospheric pressure producing a temperature as low as —108.0° F., while there is preferably about a 5 lb. pressure in tank 2. Therefore, when such pressure exists, a temperature of only about —90° F. will be produced by the dry ice in the tank 2. However, the ice in tank 2 is not used for cooling the liquid refrigerant, although it tends to precool said refrigerant as will later be explained.

Taking up the elements more in detail, the support 1 preferably is formed to provide a corrugated upper surface of adjoining tooth-like ridges of inverted V-shape and formed by corrugating a piece of sheet metal of the desired size. This sheet is secured on a flat sheet whereby a plurality of elongated parallel passageways 6 of triangular cross section extend between two opposite edges of the sheet at the ends of the ridges. Headers 8, 9 extend across the ends of said passageways. The dry ice 10 (Fig. 7) supported on the upper corrugated side of support 1 has a considerable area in heat exchange relationship with the two upper sides of said passageway. Substantially two thirds of the walls of each passageway are in heat exchange relationship with the dry ice and this can be increased by increasing the area of the upper sides of the support by making the apices of the corrugations sharper.

The closed container 2 may be of any desired shape, such as cylindrical or square, but it is preferably oblong and extends vertically for convenience in fitting in the end portion of a car and to give as much capacity as is possible for its size. This container may be in one end of the conventional ice bunker 11 (Fig. 1) in a refrigerator car adjacent one end of support 1 and it may be spaced from the support 1 by a wall 12 (Fig. 2) if desired to protect the same from possible injury in loading dry ice onto support 1, and a central baffle or separator plate 13 in the tank 2 and terminating short of the bottom of the latter may be provided to prevent objectionable shifting of the dry ice in the container during movement of the car. A removable gas tight closure 13' on container 2 is provided to enable loading the container with dry ice.

The control chamber is preferably alongside the container 2 and secured to the latter. In fact, one of the side walls 14 of container 2 is also a side wall of control chamber 3 (Figs. 4, 6). Control chamber 3 is separated internally into an upper compartment 15 and a lower compartment 16 by a horizontal partition 17 (Figs. 4, 5, 7).

A removable, gas tight closure plate 18 closes on opening in the top of the upper compartment, which plate carries a depending cylinder 19 that is open at its lower end, and which lower end is spaced above partition 17 (Figs. 5, 6).

Concentric with cylinder 19, the head or closure 18 is formed with an upstanding cylindrical



boss 20 that is closed at its upper end by a cap 21, and that is formed with a horizontal wall 22 spaced slightly below said cap. Spaced slightly below the wall 22 is a relatively thick block 23 secured to said boss and having one or more of its sides grooved to provide a passageway 24 communicating between the spaces above and below said block respectively.

The block 23 and wall 22 are coaxially apertured for passing a vertical rod 25 that extends to about the lower end of cylinder 19 and coaxially with the latter.

The opening in wall 22 is relatively large and has beveled edges for seating a poppet type valve 26 secured on the upper end of rod 25 when said rod is moved downwardly, and which valve will move away from the opening upon moving the rod 25 upwardly.

The aperture 27 through the block 23 may be provided with a bushing for making a sliding fit with rod 25, but the said aperture is counterbored at its lower end to form an enlarged recess 28 that opens downwardly, the edges of said recess are beveled to form a seat for a second poppet type valve 29, also secured on rod 25, and which valve closes the recess upon upward movement, but opens it when rod 25 moves downwardly.

A passageway 30 communicates at one of its ends with recess 28 and at its opposite end with the atmosphere. Within the cylinder 19 is a drum-like float 31 having a central passageway 32 through which rod 25 freely passes, and the periphery of said float is relatively close to the inner sides of said cylinder whereby the latter will function as a guide for the float as the latter moves vertically up or down, as will later be explained.

A collar 35 is secured on rod 25 at a point adjacent to, but preferably spaced below the valve 29, while a second collar 36 is secured on rod 25 adjacent the lower end of the latter. The float 31 moves between these collars as the liquid level in the upper compartment 15 rises or falls. When the level of such liquid rises sufficiently, the float will engage the collar 35 and move the valve 29 to closed position closing off the passageway 30, and opening valve 26, and when the liquid level falls sufficiently, the float moves down until it strikes the collar 36, causing the valve 29 to open and valve 26 to close.

The cooling units 4 are preferably several in number, according to the space to be refrigerated, and in the case of a refrigerator car, they are disposed along the two opposite sides of the car adjacent the roof (Figs. 1, 8, 9).

Each of the units 4 comprises a pair of oblong flat plates 41 (Fig. 9) that are elongated in direction of the length of the car (Fig. 1), and which plates are spaced apart by parallel strips 42 (Fig. 9) extending longitudinally of said plates thereby providing a passageway 43 between each adjacent pair of strips. Headers 44, 45 are at opposite ends of each cooling unit and at diagonally opposite corners.

Where, as in Fig. 1, there are two cooling units along each of the two longitudinally extending sides of the car, the said units are in end to end spaced relationship along each side and the adjacent headers 44, 45 of each pair are joined by a pipe 47 while the corresponding headers 45 at the end of the car opposite the bunker 11 are connected by a pipe 48 in which the thermostatic device 5 including the valve is interposed for controlling the flow of a liquid refrigerant through

said units, and to a pipe 49 that connects with the header 9 of the support 1.

The outline of the inside of the car, in plan view, is indicated at 50 (Figure 1) in dot-dash line, and the partition dividing the bunker from the main space to be refrigerated is indicated at 51. The sides of the car are indicated at 52 in Fig. 9 while the roof or top is designated 53 and the floor 54. Floor racks 55 are spaced above floor 54 by stringers 56 that are cross bored at 57 for ventilation. A false side wall 58 may be spaced from each side wall 52 to provide air passageways 59 that extend to points slightly below the cooling units. Deflectors 60 may be positioned across the upper open ends of passageways 59 at spaced points to deflect some of the air into the space between walls 58 as will be explained.

The cooling units are supported on baffle plates 60 (Fig. 9) in parallel relation to the latter and spaced above said plates on spacers 61, which spacers may also function as part of the securing means for securing the cooling units to the baffle plates. The baffle plates are below the cooling units and are suspended from the top 53 by hangers 64. Said hangers suspend the baffle plates and cooling units in transversely inclined position with the elevated elongated edges thereof nearest a medial vertical plane extending longitudinally through the car, generally in the same manner as the cooling units and drip pans are suspended in United States Letters Patent to Brown, No. 2,287,492 of June 23, 1942.

The space between top 53 of the car and the cooling units, and the spaces between the cooling units and the baffle plates 60 provide air passageways for generally downward movement of air from inside the car to the upper open ends of the passageways 59 at the sides of the car. The air then moves from the lower ends of said passageways 59 to below the flow racks and then through said racks to the top of the car for re-circulation in the same path, as seen by the arrows in Figs. 8, 9.

Referring back to the control chamber, the closure 18 and boss 20 are preferably drilled to provide a passageway 65 for gas, which passageway opens at one end into the space between the wall 22 in boss 20 and the cap 21, the latter being threadedly secured on the boss. The opposite end of said passageway connects with a pipe 66 that opens into the container 2.

A pipe 67 opens at one end into container 2 and at its opposite end into the upper end of the lower compartment 16 of the control chamber (Figs. 5, 7).

A pipe 68 connects at one end with the control units 4 that are nearest the bunker 11 (Figs. 1, 7) and a pipe or passageway 69 connects header 8 with the lower end of the lower compartment 16.

A drain tube 70 extends from the partition 17 to the lower end of lower compartment 16 and is provided with a check valve 71 at its lower end. A check valve 72 is also preferably in the line 69 (Fig. 7).

In operation, the lower compartment 16 contains a supply 80 (Fig. 7) of a liquid refrigerant and the cooling units and pipes 48, 49 also contain the refrigerant.

As long as the valve 5 is open (which would indicate a sufficiently high temperature in the storage space that is to be refrigerated to require circulation of the refrigerant) the control chamber will function to effect intermittent circulation of the refrigerant through the cooling coils. The position of the parts in the control chamber as



seen in Fig. 7 is one in which a circulation of the refrigerant through the cooling units is ready to occur, assuming valve 5 is open.

As seen in Fig. 7, the gas pressure in container 2 is on the liquid 80 in lower compartment 16 and will force the liquid refrigerant through pipe 69, support 1 (where it will be cooled), and pipe 49 to the cooling units. The liquid in said units will be caused to flow into the upper compartment 15 causing float 31 to rise until the float strikes collar 35 and lifts the valve rod 25 with valves 26, 29. The valve 26 will open admitting gas under pressure into the upper compartment, and valve 29 will close vent 30, whereby the pressures in the upper and lower compartments will be equalized thereby permitting the liquid in the upper compartment to flow by gravity into the lower compartment. The float 31 will then move downwardly as the liquid drains from the upper compartment, until it strikes the lower collar 36 overcoming the back pressure exerted on valve 29, which pressure has held valve 29 on rod 25 in place thereby closing valve 26 and opening valve 29. This will vent the gas in the upper compartment through the vent 30 and the cycle above described will be repeated until valve 5 is closed.

The provision of the cylindrical guide 19 in the control chamber insures operation of the float under all conditions. The said guide is perforated at 81 to permit free drainage of the liquid refrigerant, but the walls of the guide member are imperforate for a substantial distance above the uppermost perforations with the result that a substantial quantity of gas is trapped in the space 82 (Fig. 6) in the upper end of the upper compartment after the float 31 has lifted the valve rod, hence the opening of the valve 29 does not effect a venting of all the gas in the control chamber. There is an appreciable saving of gas by this structure, which is quite important.

The sublimation of the dry ice in the container 2 will produce a temperature as low as −90° F., when the said ice is under 5 lbs. pressure, which is about the desired maximum pressure for forcing the refrigerant through the circuit. However, the dry ice in support 1 will produce a temperature of practically −109° F., since it is under atmospheric pressure. A much greater cooling is thereby obtained than were the dry ice that is used for cooling also used to produce the gas pressure.

The use of dry ice to produce the gas pressure is important for several reasons. It is easily controlled and its temperature is such as to not raise the temperature of the liquid refrigerant that passes through the control chamber.

It is also apparent from the description that the main supply of dry ice may be replenished at any time without causing the slightest delay in the functioning of the circulating system.

Furthermore, the smallness of the container 2 makes it relatively cheap and light in weight even if made to withstand a relatively high pressure, which is made imperative by many public carriers even though a much lighter tank or container would be safe. A conventional safety valve 75 that is adjustable for maximum pressure insures against any possible danger from excessive pressure.

While the provision of the control chamber 3 directly adjoining the container 2 is preferable from the standpoint of economy of manufacture, said container 2 may be separate from the control chamber and spaced any desired distance from it. The rate of sublimation of the

dry ice in the container 2 is adequate to maintain a working pressure of gas in the control chamber irrespective where the container 2 may be placed relative to the control chamber, although there are times where it may be desirable that there be a small transfer of heat between the liquid refrigerant and the dry ice in container 2 to accelerate sublimation of the dry ice.

It is to be understood that the detailed description and drawings are not to be considered restrictive of the invention, but merely illustrative thereof.

I claim:

1. In a refrigeration system, a support for holding a body of solid $CO_2$ in communication with the atmosphere for maintaining said body at substantially atmospheric pressure during sublimation thereof, a closed container for holding a substantially smaller amount of solid $CO_2$ than said body and under the pressure of the $CO_2$ gas resulting from sublimation of said smaller amount, a liquid refrigerant, a continuous conduit, including a cooling unit, enclosing said refrigerant for movement thereof in one direction in a closed path of travel, one of the walls of said conduit being in direct heat transfer relationship with said body at a point in the length of said conduit for cooling said refrigerant at said point, means comprising a body of said refrigerant in said conduit disposed in direct pressure contact with the $CO_2$ gas from said container for effecting said movement of said refrigerant in said path under the influence of the pressure of said gas.

2. In a refrigeration system, a support for holding a body of solid $CO_2$ in communication with the atmosphere for maintaining said body at substantially atmospheric pressure during sublimation thereof, a closed container for holding a substantially smaller amount of solid $CO_2$ than said body under the pressure of the $CO_2$ gas resulting from sublimation of said smaller amount, a liquid refrigerant, a continuous conduit, including a cooling unit, enclosing said refrigerant for movement thereof in one direction in a closed path of travel, one of the walls of said conduit being in direct heat transfer relationship with said body at a point in the length of said conduit for cooling said refrigerant at said point, means comprising a body of said refrigerant in said conduit disposed in direct pressure contact with the $CO_2$ gas from said container for effecting said movement of said refrigerant in said path under the influence of the pressure of said gas, said container, support and means being adjacent each other.

3. In a refrigeration system, a support for holding a body of solid $CO_2$ in communication with the atmosphere for maintaining said body at substantially atmospheric pressure during sublimation thereof, a closed container for holding a substantially smaller amount of solid $CO_2$ than said body under the pressure of the $CO_2$ gas resulting from sublimation of said smaller amount, a liquid refrigerant, a continuous conduit, including a cooling unit, enclosing said refrigerant for movement thereof in one direction in a closed path of travel, one of the walls of said conduit being in direct heat transfer relationship with said body at a point in the length of said conduit for cooling said refrigerant at said point, means comprising a body of said refrigerant in said conduit disposed in direct pressure contact with the $CO_2$ gas from said container for effecting said movement of said refrigerant in said path under the influence of the pressure of said gas, a refrigerator car having a compartment at one end thereof, said container, support and means being in said compartment and said cooling unit being in the remaining portion of said car adjacent the junctures between the side walls and roof of such car and extending the length of the latter.

4. In a refrigeration system, a support for holding a body of solid $CO_2$ thereon in communication with the atmosphere for maintaining said body at substantially atmospheric pressure during sublimation thereof, a closed container for holding a substantially smaller amount of solid $CO_2$ than said body under pressure of the $CO_2$ gas resulting from sublimation of said smaller amount, a liquid refrigerant, a continuous conduit, including a cooling unit, enclosing said refrigerant for movement thereof in one direction in a closed path of travel, said support comprising a portion of one of the walls of said conduit whereby said refrigerant will be cooled upon passing said support, another portion of said conduit being enlarged and alongside said container, means comprising a body of said refrigerant in said enlarged portion disposed in direct pressure contact with the $CO_2$ gas in said container for effecting said movement of said refrigerant in said path under the influence of the pressure of said gas, a passageway for conducting said gas from said container into said enlarged portion, heat responsive control means disposed in the region of said cooling unit including a valve in said conduit for opening and closing said conduit to flow of said refrigerant upon predetermined changes of the temperature in said region.

5. In a refrigeration system, a support for holding a body of solid $CO_2$ thereon in a communication with the atmosphere for maintaining said body at substantially atmospheric pressure during sublimation thereof, a closed container for holding a substantially smaller amount of solid $CO_2$ than said body under pressure of the $CO_2$ gas resulting from sublimation of said smaller amount, a liquid refrigerant, a continuous conduit, including a cooling unit, enclosing said refrigerant for movement thereof in one direction in a closed path of travel, said support comprising a portion of one of the walls of said conduit whereby said refrigerant will be cooled upon passing said support, another portion of said conduit being enlarged and alongside said container, means comprising a body of said refrigerant in said enlarged portion disposed in direct pressure contact with the $CO_2$ gas in said container for effecting said movement of said refrigerant in said path under the influence of the pressure of said gas, a passageway for conducting said gas from said container into said enlarged portion, heat responsive control means disposed in the region of said cooling unit including a valve in said conduit for opening and closing said conduit to flow of said refrigerant upon predetermined changes of the temperature in said region, one of the walls of said enlarged portion being one of the walls of said tank.

6. In a refrigeration system, a support for holding a body of solid $CO_2$ thereon in communication with the atmosphere for maintaining said body under atmospheric pressure during sublimation thereof, a closed container for holding a smaller amount of solid $CO_2$ than said body under pressure of the $CO_2$ gas resulting from sub-

limation of said smaller amount, an endless conduit, including a cooling unit, enclosing said refrigerant for movement thereof in one direction in a closed path of travel, the upper side of said support on which said body is held being corrugated with passageways in the ridges of such corrugations extending longitudinally thereof and headers at opposite ends of said passageways, said passageways and said headers being part of said conduit, a portion of said conduit adjacent said support and adjacent said container being enlarged, means comprising a body of said refrigerant in said enlarged portion disposed in direct pressure contact with said $CO_2$ gas for effecting said movement of said refrigerant in said path under the influence of the pressure of said gas.

7. In a refrigeration system in which there is a closed tank for solid $CO_2$, a cooling unit, a control chamber, a support for holding a relatively large body of solid $CO_2$ in communication with the atmosphere, and a passageway through said support one of the walls of which is in direct heat transfer relation to said body, said cooling unit, control chamber, and passageway being connected in series to form an endless conduit for a liquid refrigerant, a $CO_2$ gas pressure line communicating between said tank and said chamber for providing gas pressure in said chamber and on the liquid refrigerant therein for causing movement of the liquid refrigerant through said conduit under the influence of said gas pressure, control means for said gas including a float in said chamber and a guide element around said float for guiding the latter during vertical movement thereof, said float being supported on the liquid refrigerant in said chamber for vertical movement upon rising and falling of the level of the liquid in said chamber, and means actuated by said movement of said float for controlling the flow of gas into and out of said chamber.

8. In a refrigerating system of the character described, a vertically disposed chamber having vertical side walls, a top, and a bottom, a horizontal partition dividing said chamber into an upper compartment and a lower compartment, an inlet in said upper compartment for admitting a liquid refrigerant into the same, a discharge outlet in said lower compartment for discharge of a liquid refrigerant therefrom, a valved passageway communicating between said upper compartment and said lower compartment for passing liquid from the upper one to the lower one, a cylindrical wall depending from said top, a cylindrical float vertically reciprocable within said wall upon rising and falling of the float as the liquid level rises and falls, said wall having drain holes formed therein spaced from the upper end thereof and being imperforate above said holes for providing a gas trap between the uppermost of such drain holes and said top, a gas pressure line communicating with said lower compartment and a vent for establishing communication between said upper compartment and its lower one, valve means actuatable by said float upon rising and upon falling to predetermined limits for opening and closing said vent.

9. In a refrigerating system of the character described, a vertically disposed chamber having vertical side walls, a top, and a bottom, a horizontal partition dividing said chamber into an upper compartment and a lower compartment, an inlet in said upper compartment for admitting a liquid refrigerant into the same, a discharge outlet in said lower compartment for discharge of a liquid refrigerant therefrom, a valved passageway communicating between said upper compartment and said lower compartment for passing liquid from the upper one to the lower one, a cylindrical wall depending from said top, a cylindrical float vertically reciprocable within said wall upon rising and falling of the float as the liquid level rises and falls, said wall being imperforate adjacent upper end thereof providing a gas trap between the uppermost of such drain holes and said top, a gas pressure line communicating with said lower compartment and a vent for establishing communication between said upper compartment and the lower one, valve means actuatable by said float upon rising and upon falling to predetermined limits for opening and closing said vent, said wall being provided with openings below its upper end for free passage of a liquid refrigerant therethrough.



10. The method of cooling and circulating a liquid refrigerant in an endless enclosed path that includes the steps of effecting a heat exchange between said refrigerant and a body of solid $CO_2$ that is under atmospheric pressure at a point in said path and utilizing the $CO_2$ gas from a confined body of solid $CO_2$ for forcing said refrigerant around said path, and precooling said refrigerant by causing the latter to flow alongside said confined body of $CO_2$ before reaching said point.

11. The method of cooling and circulating a liquid refrigerant in an endless enclosed path that includes the steps of effecting a heat exchange between said refrigerant and a body of solid $CO_2$ that is under atmospheric pressure at a point in said path and utilizing the $CO_2$ gas from a confined body of solid $CO_2$ for forcing said refrigerant around said path, and accelerating sublimation of the said confined body of solid $CO_2$ by causing the liquid refrigerant to flow closely alongside thereof immediately prior to said refrigerant reaching said point and after said refrigerant has passed through the region to be refrigerated.

12. The method of refrigerating a storage space that comprises simultaneously subliming a relatively large amount of dry ice at atmospheric pressure and a relatively small amount of dry ice in a confined space under pressure of the gas so sublimed from said small amount, circulating a liquid refrigerant in an enclosed path that extends into said storage space and past said large body of dry ice in direct heat exchange relationship to the latter by means of the gas under pressure from said confined space, and maintaining said gas at a substantially uniform relatively low pressure.

REX L. BRUNSING.


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