

June 23, 1942.

H. A. B. BROWN
REFRIGERATING SYSTEM

2,287,492

Filed May 27, 1940

2 Sheets-Sheet 1

Fig. 1

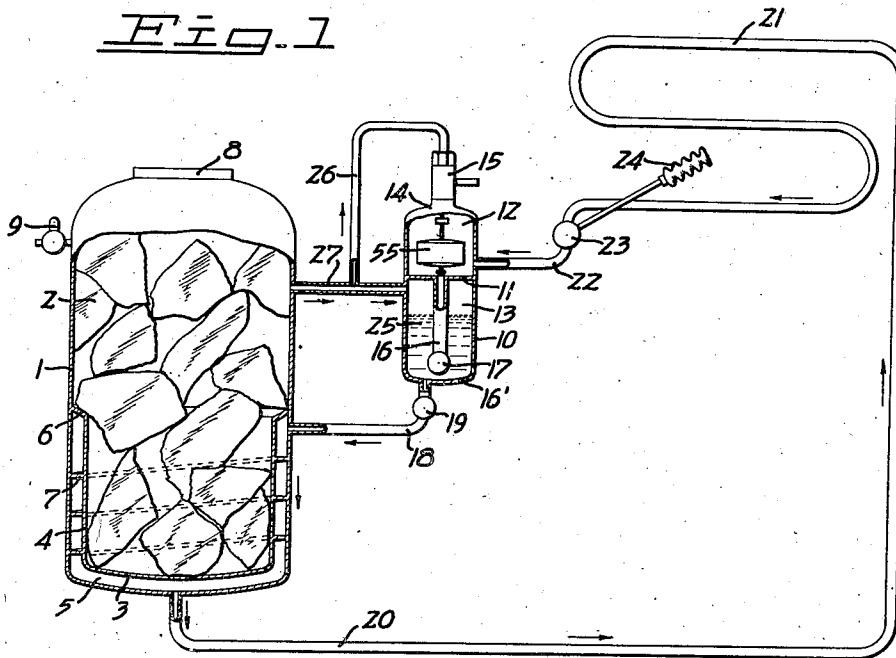
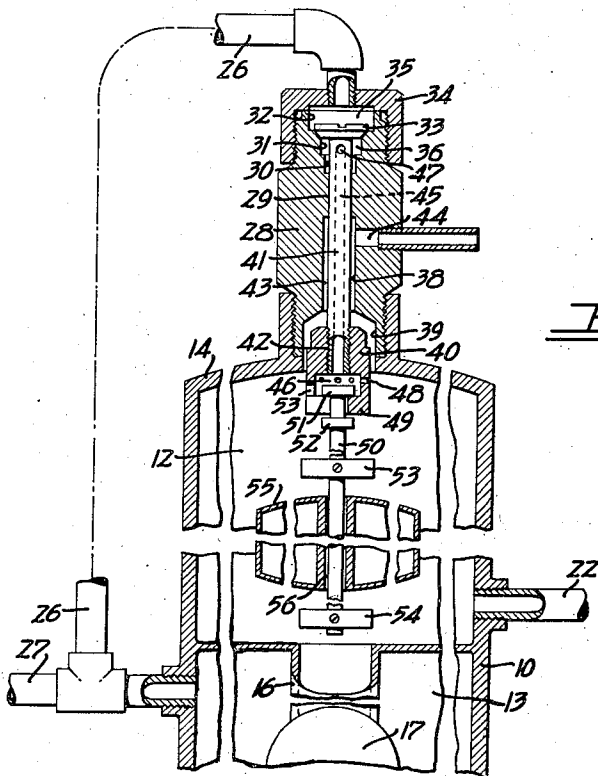


Fig. 2



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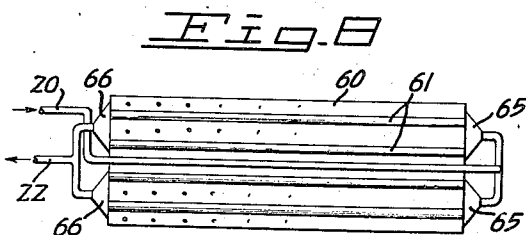
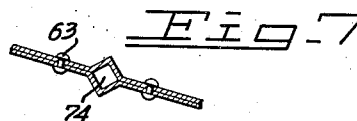
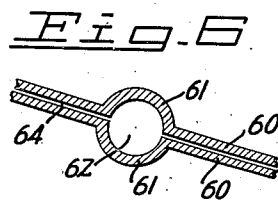
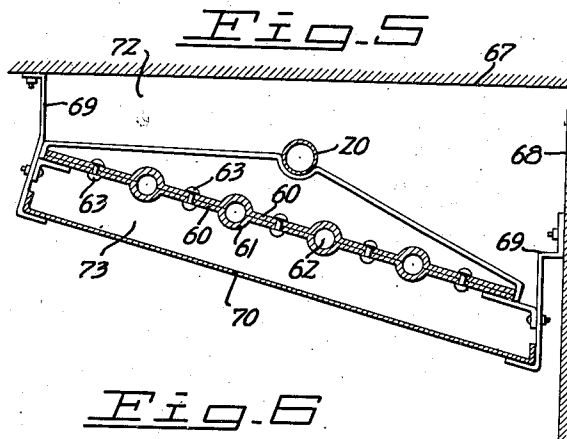
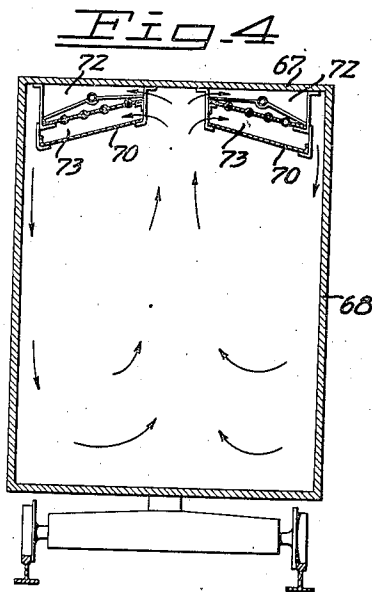
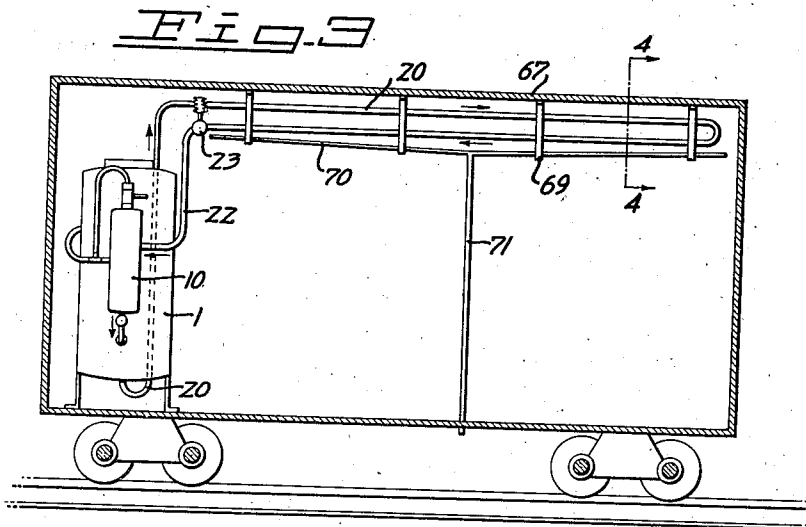
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2,287,492

REFRIGERATING SYSTEM

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Application May 27, 1940, Serial No. 337,464

10 Claims. (Cl. 62-91.5)

This invention relates to refrigerating systems, particularly of the type in which a circulating liquid refrigerant is cooled by the employment of solidified CO₂ and in which the gas resulting from sublimation of the CO₂ is utilized to circulate the liquid refrigerant.

One of the objects of the invention is a simple arrangement of relatively few elements in a system of the above character, that is more dependable under all conditions than heretofore.

Another object of the invention is improved control means and improved heat transfer means, in a system as described above for more efficiently controlling the temperature in the area to be cooled.

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

In the drawings Fig. 1 is a schematic view of the refrigerating system.

Fig. 2 is an enlarged sectional view of the main control valve in the refrigerating system, with part of the tank to which it is attached being shown.

Fig. 3 is a semi-diagrammatic view of the refrigerating system in a refrigerator car.

Fig. 4 is a sectional view as seen from line 4-4 of Fig. 3.

Fig. 5 is an enlarged cross-sectional view of one of the cooling elements in position along one corner of a room or car.

Fig. 6 is an enlarged fragmentary sectional view of a portion of the element shown in Fig. 5.

Fig. 7 is a reduced sectional view of a portion corresponding to that of Fig. 6, but showing a different shape of conduit.

Fig. 8 is a reduced plan view of one of the cooling elements to indicate the inlet and outlet thereto.

The system, as described hereafter, is an improvement of the invention described in my co-pending application, Ser. No. 271,052, filed May 1, 1939.

In refrigerator cars, or vehicles, one of the principal disadvantages heretofore has been the lack of dependability in the control system in those instances where the use of solid CO₂ has been attempted in conjunction with a liquid refrigerant. After a refrigerator car is loaded with produce and serviced for a trip, any failure in the refrigerating system while the car is in transit is disastrous, since the produce is either a partial or total loss. While moving from its point of origin to its destination the car is subjected to appreciable vibration and rocking. The refrigerating system, however, must continue to

function during the movement of the car as well as during periods when the car is stationary, or on a siding.

In actual practice, I have found that a control means in a refrigerating system that is subjected to the abuse and lack of constant attention, such as occurs in refrigerator cars, should be substantially independent of spring power, or have an electrical or mechanical motor for its successful operation. Springs are too readily broken, and are too variable in operation to be sufficiently dependable. Mercury controlled systems have been contemplated, but the tendency of mercury to become displaced during rolling of the car when in movement is not satisfactory. Also mercury is susceptible to appreciable changes in volume during temperature changes, and is liable to leak.

The foregoing objections have been overcome in this invention by eliminating springs and by other arrangements.

In Fig. 1 I show a tank 1 for solid CO₂, also known as "dry ice," designated 2, which tank is formed with an inner bottom 3 and side walls 4 at its lower end, forming an enclosed chamber 5 between the inner tank and side walls, and the bottom and sides of the main tank. The upper edges of sides 4 connect with the sides of tank 1, as at 6. Between the sides of the tank and wall 4, is a helically shaped spacer 7 commencing at one end near to, but spaced slightly from the upper end 6 of the chamber 5 and terminating adjacent the space between the double bottom, thus forming a helically shaped passage around the walls 3. At the upper end of tank 1 is an opening provided with a tight, removable closure 8 for filling the tank with the solid CO₂, and a pressure relief valve 9 is also provided at the upper end of the tank for maintaining the gas within the tank at a predetermined pressure of say, about 6 or 8 pounds.

The main control apparatus for causing circulation of a liquid refrigerant (later to be described) is a relatively small tank 10 provided with a horizontal partition 11 dividing the interior of the tank into an upper chamber 12 and a lower chamber 13. This tank is preferably cylindrical and vertically disposed, and centrally in the upper head 14, thereof, is a control device 15, while a vertical tube 16 extends downwardly from the partition 11 to adjacent the lower end of the bottom 16, the upper end of said tube extending through the partition and opening into the chamber 12, while a check valve 17 at the lower end of said tube (the purpose of which will

later be described) functions to prevent upward flow of liquid in said tube while permitting a downward flow from chamber 12 into the chamber 13.

A pipe 18 communicates between the lower end of chamber 13 to the upper end of the helical passageway formed between the inner wall 3 in tank 1 and the sides of the latter, a check valve 19, in said pipe permitting flow of liquid from chamber 13 to said passageway, but preventing back flow.

From the bottom of the chamber 5 that is at the lower end of tank 1, a pipe 20 extends to the inlet end of a cooling coil 21, the outlet end of said coil communicating with the lower portion of chamber 12 by a pipe 22. In said pipe 22, adjacent said coil, is a thermostatically actuated valve 23 connected with a thermostat 24, such as a siphon, the latter being disposed in the area to be cooled by heat transfer to said coil 21. When a desired lowered temperature is reached in said area, the thermostat 24 will cause the valve 23 to close, while a rise in the temperature will result in actuation of the valve to open the same. The tube 16, chamber 13, pipe 18, chamber 5 (including helical passageway), pipe 20, coil 21, pipe 22 and chamber 12, form a closed circuit for a liquid refrigerant 25, indicated in chamber 13. The normal flow of such refrigerant is in the direction of the arrows, from chamber 13 back to chamber 12 after passage through the chamber 5 and cooling coil 21. However, there can be no such flow, unless the valve 23 is open.

A conduit 26 for gas communicates between the device 15 and the upper end of chamber 13, while a branch 27 extends from said conduit to the upper end of tank 1. By this arrangement it will be seen that the liquid in chamber 13 will always be subjected to gas under pressure from tank 1, while a gas pressure line carrying gas under the same pressure will lead to device 15.

Since the device 15 and the elements directly associated therewith is an important feature of this invention, the same is shown in detail in Fig. 2. This device comprises a vertically extending body 28 externally threaded at its upper and lower ends and formed with a central open-ended cylindrical bore therethrough coaxial with the longitudinal axis of the body. The uppermost end of said bore progressively enlarged upwardly from a restricted diameter length 29 of the bore, such enlarged portions being concentric with the central axis of the portion 29. These enlarged portions, commencing with the upper end of the portion 29, are designated 30, 31, 32, there being shoulders between adjacent portions, and the shoulder between portions 31, 32 is beveled to form a conical valve seat for seating the correspondingly tapered lower side of a disk-like valve element 33.

A cap 34 is threadedly secured to the threads at the upper end of body 28, the top of which is interiorly recessed to correspond to the uppermost enlargement 32 of the bore that extends through said body 28.

One end of conduit 26 is secured in a central aperture in the top of said cap, communicating with the recess formed in the under side thereof, and the sides of enlarged portion 32 coacts with said recess to form a chamber 35 above disk valve 33, while the sides of enlarged portion 30 in cooperation with the valve forms a chamber 36 below said valve, which latter chamber is separated from the chamber 35 by the valve 33 when the

valve is closed. As the diameter of the valve 33 is less than the diameter of chamber 35, when the valve 33 is moved vertically from its seat, there is a free communication between the conduit 26, chamber 35 and chamber 36.

Below the restricted diameter length 29 of the bore through body 28, the said bore is uniformly enlarged at 38 for a substantial distance, which enlarged portion 38 terminates at its lower end in a still further enlarged portion 39. The shoulder at the juncture between said portions 38, 39 is beveled to form a conical seat for the correspondingly tapered upper and outer edge of a cylindrical, vertically extending valve member 40.

The valve 33 and valve member 40 are connected by a stem 41 that is secured at one end to valve 33 and threaded into a central bore 42 extending through the member 40. This stem is nicely fitted in the portion 29 of the bore through body 28 for sliding longitudinally, and to prevent escape of gas past the stem and portion 29.

The lower threaded end of the body 28 is threadedly secured into an aperture in the upper end 14 of the tank 10, and the lower end of the enlarged portion 39 of the bore through body 28 opens directly into chamber 12 of said tank. It will accordingly be seen that when valve member 40 is seated against its seat, a chamber 43 will be formed thereabove around the stem 41 and below restricted portion 29, but when member 40 is lowered, there is a communication between the chamber 12 in tank 10 and chamber 43. The body 28 is ported at 44, which port communicates between chamber 43 and the atmosphere, hence when valve 40 is open, the chamber 12 is open to the atmosphere, but otherwise it is closed.

The valve 33 and valve member 40 are so positioned at the ends of stem 41 that upon the closing of valve 33, the member 40 will open, and vice versa.

The stem 41 is hollow from its lower end to a point below the valve 33, thus providing a passageway 45 therein that opens at its lower end into an enlarged lower end 46 of the bore 42, said enlargement being formed in the valve member 40. The upper end of passageway 45 communicates with the chamber 36 by a lateral port 47 in the stem 41, which port 47 is below the valve element 33.

In the side walls of enlarged portion 46 is a row of openings 48 and below said row, the valve 40 is provided with a lower end wall 49 formed with an opening in which is flexibly secured the upper end of a rod 50 depending therefrom.

The upper end of rod 50 is formed with a pair of vertically spaced collars 51, 52, between which is the margin of the opening in the lower end wall 49 of valve member 40. One side of said opening is slotted out, as at 53 to permit lateral insertion of the upper collar 51 into the opening, after which the sides of the outer end of the slot may be slightly swayed toward each other to prevent withdrawal of the collar.

A collar 53 is secured on rod 50 at a point spaced below the valve 40 a relatively short distance and another collar 54 is secured at the lower end of said rod, said latter end terminating a short distance above partition 11. Between collars 53, 54 is an annular hollow float 55, the central passageway 56 through said float freely passing the rod so as to permit the float to freely rise and fall with the rise and fall of liquid in chamber 12. The length of passageway 56 is such as to prevent any possibility of the float gripping the rod 50 to any appreciable degree should the float

at any time be tilted relative to horizontal, although the flexible connection between the upper end of rod 50 and valve member 40 is sufficient to permit the rod to swing slightly to compensate for any tendency of the axis of the passageway 56 to become disaligned with the axis of rod 50. Also the outer lateral sides of float 55 are spaced from the sides of tank 10 a sufficient distance to prevent any scraping of the float along the sides of the tank.

The operation of the float and valve device 15, including the parts in the latter, is as follows:

Upon the rise in the level of a liquid in chamber 12, the float will be raised until it strikes collar 53, at which time it will lift the valves 33, 40, opening the former and closing the latter, thus establishing a communication between gas conduit 26 and chamber 12. Assuming that the valves 33, 40 will remain in the above position, unless forceably changed, upon lowering of float 55 the latter will strike lower collar 54, thus closing the valve 33 and opening the valve 40, and thereby closing the communication between conduit 26 and chamber 12, and opening the chamber 12 to the atmosphere through port 44. Since the pressure of gas in chamber 12 against valve 40 is sufficient to overcome the weight of the valves 33, 44, and stem 41, together with rod 50 and the collars therein (by reason of the relatively greater area of valve 40 exposed to the pressure in chamber 12) the valves 33, 40 will remain in a position with valve 40 closed, until the falling float positively pulls the valve 40 open.

The cooling coils of my invention are best shown in Figs. 3 to 8 while the coils are shown adjacent opposite upper corners in a refrigerator car or vehicle, they may, of course, be positioned in any enclosed area, whether in a steamship, or in a storage room.

Each of these coils comprises a pair of opposed, elongated sheets 60 of suitable rustless metal, formed with complementary grooves or channels 61 with their concave sides opposed so as to provide spaced passageways 62 extending longitudinally of the sheet. The corresponding edges of the sheets are preferably secured together, as by welding or the equivalent, so as to be leak-proof at the edges, and between the said passageways, the sheets are merely riveted together by spot welding, or by rivets 63. In the latter instance the rivets are, of course, sealed by any suitable means to prevent leakage at the heads. However, in either instance, the spaces between the rivets and between the adjacent passageways 62 is not sufficiently tight to prevent the refrigerant from seeping therebetween adjacent passageways through cracks 64 (Fig. 6).

These coils virtually form flattened elongated strips, and in a car preferably extend longitudinally thereof along each of the longitudinally extending upper corners for substantially the length of the car. There may be a separate tank 1 and tank 10 for each strip at one end of the car, with a pipe 20 extending from each tank over one of the strips to the end remote from the tank for supplying the liquid refrigerant to the passageways 62 at said end. In the drawings there are four passageways between the metal sheets 61, and an inlet manifold 65 for each pair connecting with each pair of passageways (Fig. 8). The refrigerant then returns through passageways 62 toward the tanks and similar outlet manifolds 66 connect with pipe 22 extending to tank 10, the thermostatic valve 23 being in pipe 22.

The strip forming each coil is inclined transversely of its length with the high edge adjacent the roof 67 of the car and the low edge adjacent the adjacent side 68 of the car at the corner thereof. The high and low edges are spaced from the roof and side, respectively, and brackets or hangers 69 support the strips in position.

Spaced below each coil is an elongated drip pan 70, inclined similarly to the coil adjacent thereto, but also slightly inclined longitudinally from opposite ends toward a low point where a drain pipe 71 (Fig. 3) is provided to draw any moisture of condensation dropping from the coil thereabove. These pans are also spaced from the side of the car adjacent thereto. The form of the coils and pans and their relation to each other and to the car sides and roof, form flues 72, 73 above and below the strip forming the coil, which flues facilitate the formation of the desired air currents in the car for most efficiently cooling the area therein, as best indicated by the arrows in Fig. 4.

In Fig. 7 I show a modified form of passageway 74 formed in sheet metal strips, instead of the cylindrical form illustrated in Fig. 6. This modified form is rectangular in cross-section, and in some instances is desirable over the cylindrical form in that it appears to give a better support to the strip or coil, against sagging, and a lesser number of hangers 69 can be used where longer coils are desired.

The provision of pipe 20 extending over the sheet metal coils to the far end of the latter relative to the tanks 1, 10, is found to be highly desirable from the standpoint of a control in the temperature within the car, since the cold refrigerant flowing through this pipe before being spread over the area of the coils, functions to lower the temperature of the air before the larger heat transfer surfaces become effective. Supporting brackets may support the pipe 20 spaced above the cooling coil, as best indicated in Fig. 5. It has been found that with this arrangement in conjunction with the particular form of cooling coil the circulating system as described, the temperature of the air within the car is maintained substantially uniform from end to end of the car, and this temperature is maintained within a range of only several degrees, which is phenomenal in the use of solid CO₂ as the primary cooling means. Heretofore the cooling has been "spotty," that is, one end of the car may be from 10 to 20 degrees cooler than the other end, and the temperature at the ends may rise and fall within a range of about 10 degrees between cycles of the secondary refrigerant.

Referring to Figs. 1, 2, the operation is as follows: Assuming the thermostatic valve 23 is closed and chamber 10, chamber 5, and the cooling coil with interconnecting pipes carries a conventional liquid refrigerant having a low freezing point, and the tank 1 contains the solid CO₂. The float 55 is at the lower end of its movement in chamber 12 and valve 33 is closed while valve 40 is in open position. With this condition existing, the CO₂ gas from tank 1, at the predetermined pressure of say 6 lbs. per square inch, is effective on the body of the refrigerant in chamber 13 and is also effective in chamber 35 over the valve 33, while the chamber 12 is vented to the atmosphere. Now assuming that the temperature of the air in the car rises sufficiently to cause the thermostatic valve 23 to open. It will be seen that upon the opening of said valve 23, the liquid refrigerant is forced through the

chamber 5 and cooling coil into chamber 12, causing the float 55 to move upwardly on rod 50 until it engages collar 53 and lifts the valves 33, 40, thus opening valve 33 and closing valve 40. This opening of the valves is a quick opening since the pressure of gas on valve 33 must be overcome as well as the force of gravity. As soon as the valve 33 is opened and valve 40 is closed, the pressures in chambers 12, 13 are equalized through establishment of communication between chamber 35 (above valve 33) and chamber 12, and the liquid in chamber 12 will flow by gravity into chamber 13, thus lowering the float 55. Valve 40 will remain closed and valve 33 open until float 55 strikes collar 54 on rod 50, by reason of the greater exposed area on valve 40 being subjected to the pressure of gas in chamber 12 than is above the valve. The float upon encountering collar 54 causes the valve 40 to open and valve 33 to close, and the cycle is repeated so long as valve 23 is open. It is manifest that the control device 15 is operative at any time valve 23 is opened irrespective of the arrangement of the elements in said device 15, and irrespective of the position of the float 55 in chamber 12. Also there are no springs to weaken, or to depend upon, and no mercury or other variable medium than the gas the liquid refrigerant is relied upon for operation of the system.

Having described my invention, I claim:

1. In a refrigeration system in which there is a tank of solid CO₂, a cooling coil, a control chamber, and a passageway in heat exchange relationship with the solid CO₂ in said tank; said cooling coil, control chamber and passageway being connected in series to form an endless conduit for a liquid refrigerant, a CO₂ gas pressure line communicating between said tank and chamber providing for gas pressure in said chamber for causing periodic circulation of the liquid refrigerant through said conduit under influence of said gas pressure, control means for said gas comprising a valve body in said line provided with a single, movable valve element therein, ducts in said body for said gas controlled by movement of said element and arranged and adapted to establish gas communication between said tank and chamber, and the venting of gas in said chamber to the atmosphere, alternately upon movement of said valve element between two predetermined positions on said body, a float supported on the liquid refrigerant in said chamber responsive for movement between two predetermined levels of the liquid refrigerant in said chamber, separate spaced means secured to said valve element positioned for engagement by said float at said levels for moving said valve element to one or the other of said two positions according to the level of the liquid in said chamber.

2. In a construction as defined in claim 1, a by-passageway communicating between said gas line and said chamber open at all times for communicating between said chamber and tank, a single partition in said chamber dividing said chamber into an upper and a lower compartment only, said by-passageway communicating directly with said lower compartment, and said control means communicating directly with said upper compartment, said cooling coil communicating directly with said upper compartment, a pipe communicating between said tank and said lower compartment, and an open-ended tube extending from said partition to the point adjacent the lower end of said lower compartment establishing

communication between said upper compartment and said lower compartment.

3. In a refrigeration system in which there is a tank of solid CO₂, a cooling coil, a control chamber, and a passageway in heat exchange relationship with the solid CO₂ in said tank; said cooling coil, control chamber and passageway being connected in series to form an endless conduit for a liquid refrigerant, a CO₂ gas pressure line communicating between said tank and chamber providing for gas pressure in said chamber for causing a periodic circulation of the liquid refrigerant through said conduit under influence of said gas pressure, control means for said gas comprising a valve body in said line provided with a single, movable valve element therein, ducts in said body and element for said gas controlled by movement of said element and arranged and adapted to establish gas communication between said tank and chamber, and the venting of gas in said chamber to the atmosphere, alternately, upon movement of said valve element between two predetermined positions in said body, a float supported on the liquid refrigerant in said chamber responsive for movement between two predetermined levels of the liquid refrigerant in said chamber, an extension from said valve element vertically extending relatively loosely through said float for permitting relative movement between the extension and float upon said movement of the float, float engaging members secured on said extension above and below said float adjacent said predetermined levels in positions to be engaged by said float at said levels for actuating said valve between said two positions.

4. In a construction as defined in claim 2, said valve body having a straight bore therethrough and a pair of valve seats at opposite ends of said bore, said valve element comprising a stem slidably fitted in said bore for reciprocation, a pair of members at opposite ends of said stem adapted to alternately engage said seats, enlarged chambers adjacent opposite ends of said bore, said gas line communicating between said tank and one of said enlarged chambers, the opposite chamber communicating with the control chamber, a port communicating between said opposite chamber and the atmosphere when said valve element is in one position at one end of its movement, and a passageway through said stem communicating between said gas pressure line and control chamber when said valve is in its other position at the other end of its movement.

5. In a refrigeration system including a tank for solid CO₂, a cooling coil for a liquid refrigerant, a passageway through said tank in heat relationship with CO₂ in said tank having an inlet and an outlet with the outlet communicating with one end of said cooling coil; liquid circulating means for circulating liquid refrigerant through said passageway and to said cooling coil and back to said inlet, said circulating means comprising a single control chamber having a single partition therein dividing the chamber into an upper and a lower compartment only, the other end of said cooling coil communicating with said upper compartment and a conduit communicating between said lower compartment and said inlet, an open ended vertically disposed tube in said chamber establishing a communication between said upper compartment and said lower compartment with its upper open end terminating at said partition and its opposite end terminating adjacent the bottom of said lower com-

partment, said bottom comprising the lower end of said chamber, a check valve in said tube permitting flow of liquid refrigerant from said upper compartment to said lower compartment, a gas line leading from said tank to the upper portion of said lower compartment open at all times for conducting gas under pressure to said lower compartment, control valve means in the top of said upper compartment and a by-pass communicating between said valve means and said gas line, a vent to the atmosphere communicating with said valve means; said valve means including a movable valve element, ducts associated with said valve means arranged and adapted to be controlled by movement of said valve element for alternately establishing balanced and unbalanced gas pressures in said upper and lower compartments for intermittently forcing said liquid refrigerant from said chamber through said passageway and cooling coil and back to said chamber, and a float in said upper compartment supported on liquid refrigerant in said compartment floatingly connected with said valve element for causing movement of said valve upon raising and lowering of the level of the liquid refrigerant in said compartment.

6. In a refrigeration system in which there is a tank of solid CO₂, a cooling coil, a control chamber, and a passageway in heat exchange relationship with the solid CO₂ in said tank; said cooling coil, control chamber and passageway being connected in series to form an endless conduit for a liquid refrigerant, the lower portion of said tank, including the sides and bottom thereof, having double walls with the space between said walls forming said passageway, and a helical spacer between the double side walls extending around the tank whereby the portion of said passageway formed by said double side walls is substantially helical in form, an inlet at the upper end of the helical portion of the passageway in communication with the said control chamber, and an outlet to the space between the double bottom of the tank communicating with one end of said cooling coil and the opposite end of said cooling coil communicating with said control chamber.

7. In a construction as defined in claim 6, a gas pressure line communicating between said tank and control chamber providing CO₂ gas under pressure to said control chamber for providing power means to cause circulation of the liquid refrigerant through said endless conduit.

8. In a refrigerating car, container means at one end of said car for solid CO₂, a circulating system for a liquid refrigerant including a cooling coil extending lengthwise of the car along and spaced the upper corner of the car defined by the juncture of the top with one lateral side of the car, said cooling coil comprising a flattened elongated conduit having one of its elongated edges adjacent the top of the car and the other elongated edge adjacent the said lateral side of the car for forming a passageway between the said upper corner of the car for passing the convection currents caused by cooling of the air by said conduit, and a flattened elongated drip pan extending below said conduit and spaced therefrom forming a second passageway for such currents between said conduit and pan, a passageway in heat exchange relationship with the solid CO₂ to be held in said container, the opposite ends of said conduit communicating with said passageway for completing the circulating system for said liquid refrigerant, and means in said system actuated by CO₂ gas from said container and by the liquid refrigerant in said system for causing the liquid refrigerant to circulate in said system.

9. In a refrigerator car, a cooling coil, comprising a pair of flattened sheets formed with oppositely disposed, elongated grooves providing passageways for the liquid refrigerant, said coil being positioned longitudinally of said car adjacent the roof and one of the side walls of said car, and extending slantingly downward in a transverse direction toward said side wall.

10. In a refrigerator car as defined in claim 9, another of said cooling coils, positioned longitudinally of said car adjacent the roof and the other of the side walls of said car, and extending slantingly downward in a transverse direction toward the other of the said side walls.

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