

Aug. 28, 1945.

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2,383,486

REFRIGERATION MECHANISM

Filed Feb. 8, 1939

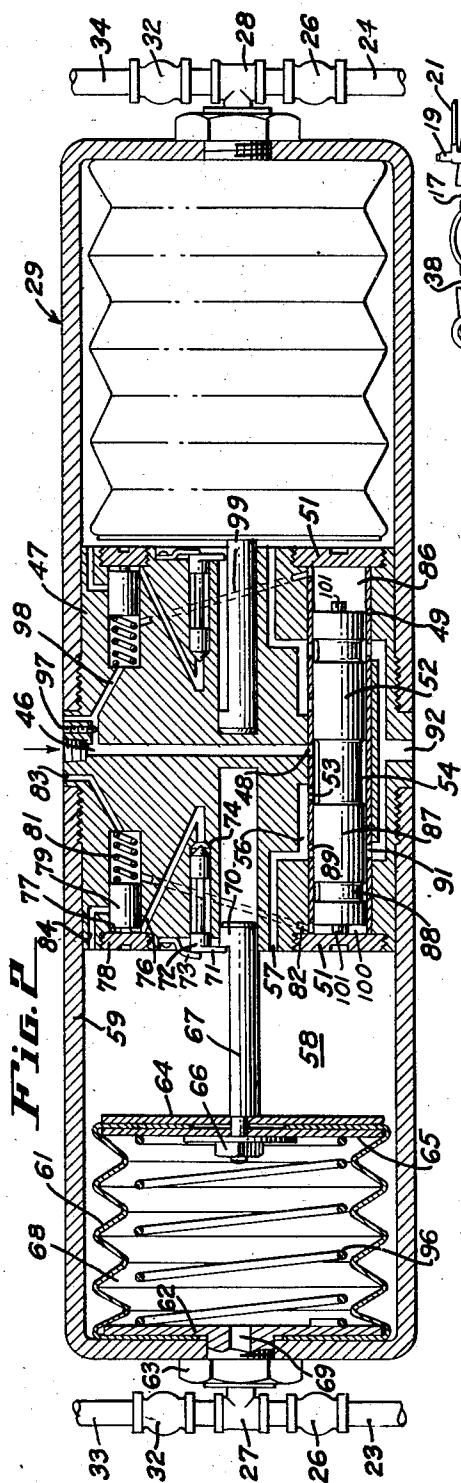
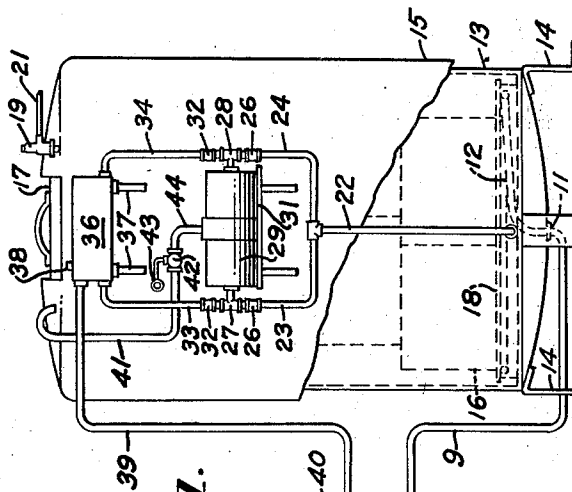
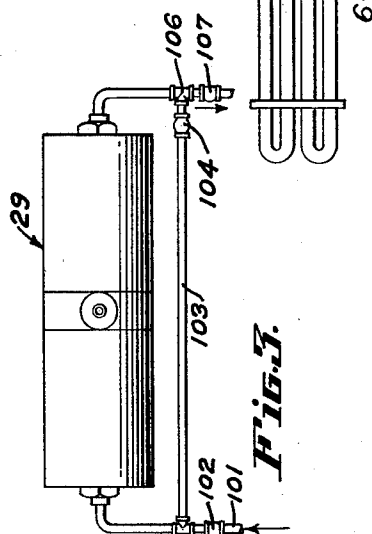


Fig. 1.



UNITED STATES PATENT OFFICE

2,383,486

REFRIGERATION MECHANISM

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Application February 8, 1939, Serial No. 255,244

12 Claims. (Cl. 62—91.5)

The present invention relates to means for exchanging heat in order to lower the temperature within a compartment, for example a refrigerator car or other enclosed refrigeration space, and is particularly concerned with a refrigeration mechanism which is designed to utilize solid carbon dioxide, hereinafter referred to as "dry ice."

An object of the present invention is to provide a refrigeration mechanism which is entirely self-contained and self-operating, without requiring the utilization of additional heat energy for its operation.

Another object of the present invention is to provide a refrigeration mechanism in which the heat-absorbing medium is also effective to provide mechanical work.

Another object of the present invention is to provide a refrigeration mechanism utilizing Dry Ice in which substantially constant refrigeration temperatures are maintained.

Another object of the present invention is to provide a refrigeration mechanism of simple and reliable characteristics.

The foregoing and other objects are attained in the embodiment of the invention illustrated in the drawing in which

Fig. 1 is a side elevation of a refrigeration mechanism constructed in accordance with our invention, parts being broken away to show the interior construction;

Fig. 2 is a cross-section on a vertical median plane, through the motor pump unit, of the refrigeration mechanism;

Fig. 3 is a detail in elevation showing a modified circuit connection for the refrigeration mechanism.

In its preferred form, the refrigeration mechanism of the invention includes a closed heat-exchange circuit through which a heat-exchanging fluid is circulated by a pump, so that in one part of the circuit heat is absorbed and in another part of the circuit heat is released to a sublimating refrigerant the gas from which operates the pump.

In a preferred installation of the refrigeration mechanism, which is described herein as typical although the mechanism can be adapted to operation in very different environments and in many different forms, the structure is installed in a refrigeration space, such as the interior of a refrigerator car, containing produce or other material to be refrigerated. In order to reduce the temperature of the space there is provided a heat-absorbing coil 6 or a series of such coils which can be of any desired construction suitably

mounted, but in the present instance the coil structure incorporates a plurality of sinuous passes 7 and 8 to afford a portion of a circuit for a heat-exchange fluid, preferably a fluid which will remain in liquid form at extremely low temperature, i. e. -100° F. and also remain a liquid at ordinary atmospheric temperatures, such as alcohol, oil and the like. The heat exchange fluid passing through this circuit is here termed the secondary refrigerant. By using such a liquid, instead of a substance which becomes a gas at ordinary temperatures, the necessity of gas proof lines and connections, back pressure valves and such is eliminated. However, the use of one of the well known fluids such as sulphur dioxide, ethyl chloride, "freon," or the like, is likewise within the scope of this disclosure. The absorber coils 6 are of adequate surface to absorb sufficient heat from the space in which they are located to maintain the desired low temperature therein as long as the exchanging fluid is circulated there-through. It is contemplated that a plurality of absorber coils 6 may be connected together in the system.

One of the elements of the system is the closed container 14. This container is mounted on supporting feet 14 in any appropriate location, either outside of or preferably within the same refrigerated or cooled space within which the coils 6 are disposed. The container 13 is preferably entirely closed, except for certain openings specified later, and is fabricated of metal capable of withstanding an internal pressure in the neighborhood of 15 lbs. per square inch or above or below this depending on the factor of safety desired or required. The container is protected against thermal transfer by a surrounding layer of insulation 15.

Disposed within the container 13 is a sublimating refrigerant, such as blocks 16 of Dry Ice which material is termed the primary refrigerant. These blocks are introduced through a charging door 17 which can be secured against the internal pressure, and the blocks 16 rest upon the coil 12 either directly or upon a plate 18 interposed between the Dry Ice and the coil. It is obvious that the coils 12 may also be arranged vertically or in any other suitable manner. In either event, a good thermal relationship is established so that heat is readily released from the coil 12 to the Dry Ice 16.

The absorption of heat by the Dry Ice blocks 16 causes sublimation of the carbon dioxide, and the gas evolved increases the pressure within the tank 13. It is preferred that this pressure be kept

at a value not to exceed approximately 15 lbs. per square inch, and hence there is disposed on the container 13 a relief valve 19 which is adjustable to discharge through pipe 21 a sufficient quantity of gas to maintain the pressure within the tank at a selected value. The gas released from the relief valve 19 can either be discharged into the same enclosure within which the heat-absorbing coil 6 is disposed, to the insulation surrounding the space to be refrigerated or to atmosphere as may be desired. Certain commodities are beneficially affected by the CO₂ gas, whereas others are detrimentally affected thereby, and whether or not the gas from the relief valve 19 is diverted to atmosphere depends upon its effect upon the commodity being cooled. The device is made so that the adjustment can be made instantly depending upon the commodity cared for at the time. It is well known that upon sublimation solid carbon dioxide passes immediately into a gas and increases in volume approximately 500 times at a like temperature. Thus pressure is built up rapidly and in the present system there is always a plentiful supply of the gas.

The heat-exchange fluid flows in a closed circuit and for convenience in description the flow will be described as starting from the balancing tank or reservoir 36 located adjacent the closed container 13. The fluid is here shown as leaving the tank 36 through ducts 33 and 34 and passing through check valves 32 to the connections 27 and 28 of the pump mechanism, generally designated 29, disposed on a bracket 31 mounted on the tank 13 or placed in any other suitable manner. The pump mechanism 29 establishes the circulation of the fluid through the system. From the pump unit the fluid, having had its pressure increased, is discharged through check valves 26 into ducts 23 and 24 which unite to form duct 22 conveying the fluid to coils 12.

As the heat-exchange fluid within the coils loses its heat to the Dry Ice and its temperature is lowered, it flows from the coils 12 through an outlet pipe 9 and fitting 11 into the heat-absorbing coils 6 and through the sinuous passages 7 and 8 thereof. The fluid then flows from the outlet 40 through the return line 39 to the balancing tank or reservoir 36. The balancing tank 36 shown as supported on brackets 37 may have a relief valve 38 and is a closed surge chamber to which the return pipe 39 conducts the heat-exchange fluid back from the outlet 40 of the coils 6, thus completing the closed circuit including the pump 29 through which the heat-exchange fluid is circulated, the heat-absorbing coils 6, and the heat-releasing coils 12.

It is of course obvious that the closed circulatory system may eliminate the tank 36. In this event the ducts 33 and 34 unite and carry the flow directly from the pipe 39.

In accordance with the present invention, means are provided which do not require the addition of any heat or other energy to the system but rather utilizes the gas sublimated from the Dry Ice for motivating or driving the pump which circulates the heat-exchange fluid. The pump shown herein as illustrating the invention is a positive double-acting displacement pump. In this way a self-contained unit is provided which operates as long as any refrigerant is available, which is efficient in that no external heat is added to the system, and which is economical since it makes a double use of the refrigerant. Furthermore, since the rate of circulation of the heat-exchange fluid through the coil 6 or series of coils

is a factor which is largely controlling of the temperature maintained within the refrigerated space, means are provided for regulating the operation of the circulating pump so that a substantially constant temperature can be maintained.

For this reason a pipe 41 is connected to the tank 13 adjacent the top thereof in a good location to receive sublimated gas from the Dry Ice, and pipe 41 is connected to a controlling valve 42 regulated by a thermostat 43 responsive to the temperature of the space being cooled, preferably, although the valve 42 can be manually controlled or can be made otherwise responsive. The gas which flows through the valve 42 is preferably of a pressure not to exceed 15 lbs. per square inch, since the relief valve 19 is ordinarily set to maintain substantially such pressure within the tank 13. Gas which passes through the valve 42 flows through an inlet pipe 44 into a passage 46 in the control body 47 of the motor pump unit 29. This passage 46 opens through a port 48 in a hardened sleeve 49 forming a shuttle valve cylinder. This cylinder is closed at opposite ends by screw plugs 51, and within the enclosure so formed a shuttle valve 52 operates. The valve, when in the position shown in Fig. 2, permits communication between the port 48 and a port 53 through a groove 54 in the shuttle valve, so that the incoming gas passing through the port 53 enters a channel 56 and flows through a duct 57 into a chamber 58.

The chamber 58 is a pump chamber of variable volume defined by a closure cap 59 screwed onto the body 47 and containing a flexible bellows 61 one end of which is held stationarily against the head of the cap 59 by a washer 62 and a nut 63 and the other end of which is clamped between plates 64 and 65 held by a nut 66 on a guide rod 67. The interior 68 of the bellows 61 communicates with the fitting 27 through a passageway 69, so that as the piston 64 reciprocates, the chambers 58 and 68 complementarily vary in size. Excess pressure in the motor chamber 58, which causes it to expand, correspondingly contracts the pump chamber 68, causing it to expel whatever liquid is therein. Hence, entry of gas from the duct 57 into the chamber 58 drives the piston 64 to the left, as seen in Fig. 2, and expels whatever heat-absorbing fluid is within the chamber 68 into the fitting 27. When the piston 64 is substantially in full-stroke position, the guide rod 67, which slides loosely within a bore in the body 47, acts to prevent further ingress of gas and to release the previously used gas.

This is accomplished by a projection 70 on the rod 67 which encounters a projection 71 on a needle valve body 72 ordinarily held in seated position by a leaf spring 73. The needle valve body fits loosely within its bore, so that when it is unseated against the urging of the spring 73, gas which is within the chamber 58 can flow around the body 72 and past the needle valve seat 74 into a passageway 76 opening into one end of a pilot valve cylinder 77 which is formed within the body 47 and is closed by a screw plug 78. Within the pilot valve cylinder is a pilot valve 79, urged toward one extreme position by a coil spring 81.

Gas under pressure from the chamber 58, which flows through the passage 76 when the needle valve 74 is unseated, forces the pilot valve 79 to the right, as seen in Fig. 2, closing communication between the cylinder 77 and the cylinder 49 through a passage 82 which theretofore has been

in communication with the atmosphere through a passage 83 extending from the cylinder 77 to the outside of the body 47. Further movement of the pilot valve 79 to the right uncovers a passageway 84, establishing communication between the chamber 58 and the cylinder 77, so that such communication is maintained through the port 84 even though the needle valve 74 may again seat when the piston 64 starts on a return stroke. The movement of the pilot valve 79 to the right is sufficient so that the chamber 58 communicates through the passage 84, through the cylinder 77 and through the passage 82, with the end of the hardened sleeve 49.

Gas under pressure is thereby delivered to the chamber 100 formed by the stop 101 located on the end surface of shuttle valve 52, thus exerting pressure to move the said valve to the right, as seen in Figure 2.

Since at this time the corresponding chamber 86 at the other end of the shuttle valve is subject to atmospheric pressure only, the pressure within the chamber 58, being then imposed upon the shuttle valve 52, translates it from its left-hand position as seen in Fig. 2 into its extreme right-hand position in such figure. When this occurs, the groove 54 no longer affords communication between the port 48 and the port 53, but rather a land 87 blocks communication between such ports, and also a groove 88 establishes communication between ports 89 and 91, respectively, in the sleeve 49, so that an exhaust passage 92 is then placed in communication with the interior of the chamber 58. Such being the case, the pressure within the chamber is reduced to atmospheric, but the shuttle 52, having been already translated, remains in its newly translated position.

As the pressure within the chamber 58 drops toward atmospheric, the spring 91 becomes effective to restore the pilot valve 79 to its position as shown in Fig. 2, ready for a subsequent cycle. The shifting of the shuttle valve 52 has opened up communication between the pressure passage 48 and a corresponding chamber on the opposite side of the mechanism. Hence, the cycle starts on the right-hand side of the mechanism to contract the chamber corresponding to the chamber 68 and to expel the fluid therein.

During this time the chamber 68 is re-expanded by its own resilience, augmented by a spring 96, to inspire additional heat-absorbing fluid and to decrease the size of the chamber 58. Movement toward the right in Fig. 2 of the rod 67 releases the needle valve body 72 so that, under the urging of the spring 73, the needle valve 74 again seats, ready for a subsequent cycle. The cycle of operation continues until the rod 67 is substantially to its extreme right-hand position in Fig. 2 and until the opposite side of the pump mechanism has gone through a comparable cycle, tripping itself at the end of a stroke to shift the shuttle 52 again into the left-hand position as shown in Fig. 2, whereupon the pumping cycle repeats.

A manually operable needle 97 is provided for starting the mechanism from rest under certain circumstances, by admitting pressure fluid into a passage 98, corresponding to the passage 83, and into a passage 99 corresponding to the passage 82, so that the shuttle valve 52 can be moved into one extreme position by pressure in the event it should be stuck or lodged in an intermediate position due to long disuse. The needle 97 is operated only for starting the mechanism into operation and is

promptly shut as soon as the device has been started.

An alternative piping arrangement, providing for utilization of the pumping chambers in series, is shown in Fig. 3. The duct 101 extends from the balance tank 36 through a check valve 102 to one chamber. A shunt pipe 103 leads from the duct 101 through a check valve 104 to the other chamber. A conduit 106, having a check valve 107 therein, leads to the coil 12. With this arrangement, fluid from the reservoir 36 is passed through the two pump chambers successively and is then passed into the line 22.

The structure made in accordance with my invention is particularly effective as it has no rotating parts subject to leakage and since it operates slowly and smoothly in accordance with the pressure of the entering gas at a rate sufficient to pump the heat-exchange fluid throughout the heat-absorbing coil 6 so that heat is absorbed at the desired rate to maintain a constant temperature. Pressures as low as from 3 to 8 lbs. per square inch have been found satisfactory as only a comparatively small volume of liquid is moved at any time. Gas which is discharged through the outlet 92 is released either into the compartment or into the atmosphere at a remote point. The pump mechanism operates upon the energy included in the Dry Ice, without necessitating the addition of any heat energy to the system, is substantially leak-proof, and is self-contained and readily replaceable in the event of difficulty. As a whole, the mechanism operates to maintain a desired temperature by circulating a heat-absorbing fluid which is deprived of its heat by the same refrigerant which furnishes the motive power for circulating it.

We claim:

1. A refrigeration mechanism comprising a closed heat-exchange circuit including heat absorbing coils, a heat releasing coil and a pump for circulating a heat exchanging fluid through said circuit, and a closed container for a sublimating refrigerant in thermal relationship with said heat releasing coil, said pump being operated solely with sublimated gas from said refrigerant.

2. A refrigeration system comprising a closed heat-exchange circuit including heat absorbing coils, a heat releasing coil and a positive double-acting displacement pump for circulating heat-exchange fluid through said circuit, and a closed container for a sublimating refrigerant in thermal relationship with said heat releasing coil, said pump being operated solely by sublimated gas from said refrigerant.

3. A refrigeration system comprising a closed heat-exchange circuit including heat absorbing coils, a heat releasing coil, a secondary fluid refrigerant and a positive double-acting displacement pump for circulating said secondary fluid refrigerant through said circuit, and a sealed container for a primary sublimating refrigerant in thermal relationship with said heat releasing coil and said secondary fluid refrigerant, said pump being operated solely by sublimated gas from said primary refrigerant.

4. A refrigeration mechanism comprising a closed container for a primary refrigerant which passes directly from solid phase into gaseous phase, a gas-driven pump unit for circulating a secondary fluid refrigerant in thermal relationship with said primary refrigerant in said container in a refrigerating circuit, a refrigerating circuit for said secondary fluid refrigerant sepa-

rating the secondary refrigerant from the primary refrigerant and its sublimate and means for operating said pump with sublimated gas from said container.

5. A controlled refrigeration mechanism requiring no outside source of power for complete functioning comprising a closed container for a primary refrigerant which passes directly from the solid phase into gaseous phase, a gas-driven pump unit for positive circulation of a secondary fluid refrigerant into thermal relationship with said primary refrigerant in a refrigeration circuit, a refrigeration circuit for said secondary refrigerant in thermal relation both with the space to be refrigerated and said primary refrigerant but separating the secondary refrigerant from direct contact with the primary refrigerant and its sublimate, means for operating said pump with sublimated gas from said container and a thermally responsive means for controlling the operation of said pump.

6. The method of refrigeration which comprises maintaining a desired temperature by circulating a heat absorbing fluid in a closed circuit in which said fluid is relieved of its heat by but always separated from the same refrigerant which furnishes the operating pressure for circulating said fluid.

7. The method of refrigeration which comprises maintaining a desired temperature by circulating a secondary fluid refrigerant in a circuit in which the said fluid is relieved of its heat by a sublimating primary refrigerant which also furnishes the operating pressure for circulating the secondary fluid refrigerant, keeping said secondary fluid refrigerant from contact with said primary refrigerant and its sublimate, and interrupting the circulation on attaining the desired temperature.

8. A refrigeration system including in combination, a closed container for a sublimating primary refrigerant, a heat releasing surface adjacent said primary refrigerant, a pump operated by gas sublimated by said primary refrigerant, a heat absorbing surface, means for connecting said heat releasing surface, said heat absorbing surface, and said pump in a sealed fluid circuit, and a secondary fluid refrigerant in said sealed fluid circuit free from any contact with the primary refrigerant or its gas.

9. A refrigeration mechanism comprising a closed container for a sublimating refrigerant, a heat absorbing coil, a pump having a piston, a heat releasing coil in said container, means for connecting both of said coils and one side of the piston of said pump in a fluid circuit, and means for conducting gas sublimed from a sublimating refrigerant within said container to the other side of the piston of said pump for forcing fluid to flow through said circuit.

10. In refrigerating apparatus, the combination with a container having arranged therein means for holding a primary gas forming refrigerant, of a secondary heat exchange system associated with said container: said system comprising a coil section arranged in heat exchange relation with said holding means, a second coil section for absorbing heat from the space to be cooled, a pair of parallel pipes connected to said sections and each having arranged therein a pair of check valves, a pumping device interposed between said parallel pipes and including a pair of expansion chamber elements cooperating with said check valves to promote a circulation of

secondary heat exchange fluid through said system and a thermostatically controlled conduit connecting said pumping device to the vapor space of said container; said pumping device comprising a control-body and a pair of cap members secured thereto and cooperating therewith to form a pair of chambers extending in opposite directions from the control-body and each enclosing one of said expansion chamber elements; each of said expansion chamber elements comprising a bellows secured at one end to the associated cap member and having its opposite end closed by a plate movable towards and away from said control-body, a spring arranged within said bellows and resiliently urging the plate towards said body, a piston rod projecting from said plate towards said control-body and means connecting the interior of said bellows with one of said parallel pipes at a point between the check valves therein; said control-body having a first pair, a second pair and a third pair of bores, the bores of each pair being in axial alignment and separated from each other and terminating within the interior of the control-body; each bore of the first pair slidably receiving one end of one of said piston rods; each bore of the second pair having loosely arranged therein a valve having a stem projecting therefrom, a spring for holding said valve yieldingly to its seat and means on the valve stem for cooperating with the adjacent piston rod for moving said valve from its seat; each bore of the third pair having a plunger slidably arranged therein and a spring interposed between the plunger and closed end of the bore; means arranged within said valve body and forming a shuttle valve cylinder and having a shuttle valve slidable therein; a set of passages within the control body connecting each end of the shuttle valve cylinder through one bore of the third pair with the interior of one of the cap members, and connecting the adjacent bore of the second pair with the adjacent bore of the third mentioned pair, the bores and passages being arranged to cause vapor evolved from the primary refrigerant to flow from a cap member through the associated bore of the second pair, after the valve therein is retracted from its seat, and into the adjacent bore of the third pair and depress the plunger therein against the resistance of the associated spring and then permit vapor to flow from the interior of such cap member into the adjacent end of the said shuttle valve cylinder and shift the shuttle valve therein; a bore extending through said valve body and connecting said thermostatically controlled conduit with said shuttle valve cylinder; and an additional set of passages cooperating with the shuttle valve cylinder and the shuttle valve for conducting refrigerant vapor from said shuttle valve cylinder into one cap member to depress the bellows therein and for simultaneously exhausting the space within the other cap member to the atmosphere.

11. In a refrigerating system, in combination, a closed container for the reception of a refrigerant of the type which evaporates from a solid to a gaseous state, a compartment to be cooled, a closed conduit circuit extending into said container and into said compartment for circulating a liquid in successive heat exchanging relation with the solid refrigerant in said container and with the compartment to be cooled, a mechanical pump in said closed conduit circuit for positively circulating the liquid therein, driv-

ing means operated by the pressure of the gas evolved by the evaporation of said refrigerant in said container for driving said pump without contact between the gas and the liquid, and means controlled by the temperature in the compartment to be cooled for governing the supply of gas from said container to said driving means. 5

12. In a refrigerating system a closed container for the reception of solid CO₂, a chamber to be cooled, a closed conduit circuit for circulating a liquid refrigerant in successive heat exchanging relation with the CO₂ in said container but without contact between the CO₂ or its sublimated 10

gas and with the chamber to be cooled, means in said closed conduit circuit for positive circulation of said liquid therein, said means being driven by pressure developed through sublimation of said CO₂ and conduit means for conveying gas pressure from said closed container to said positive circulating means.

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