

Aug. 23, 1949.

R. K. DEUTSCH ET AL

2,479,821

PROCESS AND APPARATUS FOR REFRIGERATION

Filed March 30, 1946

2 Sheets-Sheet 1

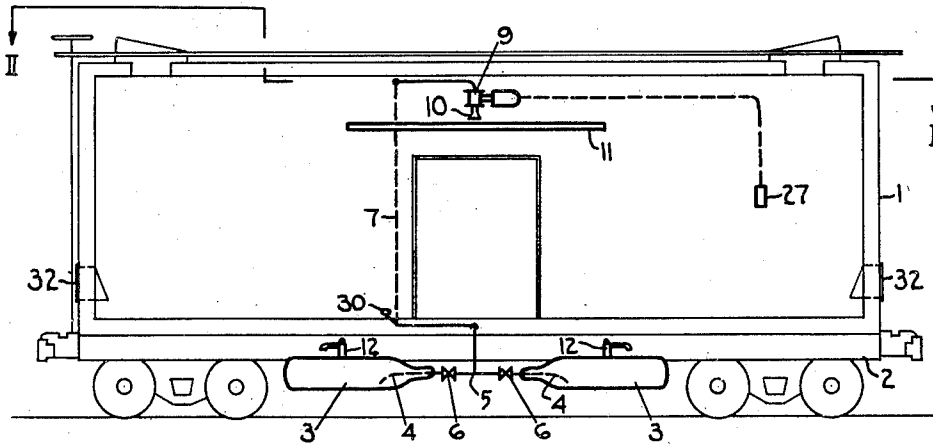


Fig. I

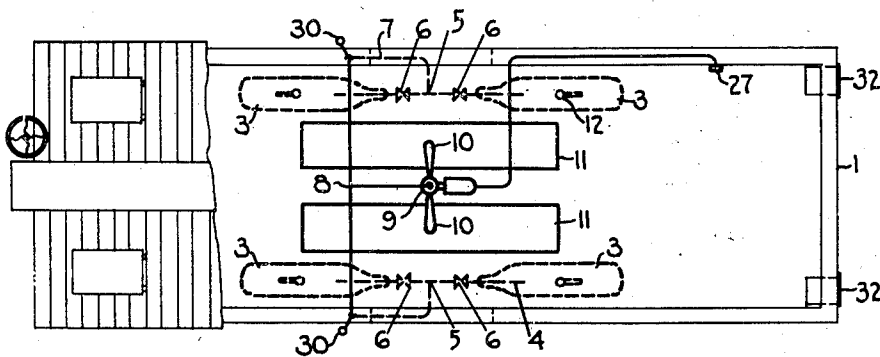


Fig. II

Inventors: Robert K. Deutsch
Frithjof A. Larson
Vernon E. Middlebrook

By their Attorney: *H. Birch*

Aug. 23, 1949.

R. K. DEUTSCH ET AL

2,479,821

PROCESS AND APPARATUS FOR REFRIGERATION

Filed March 30, 1946

2 Sheets-Sheet 2

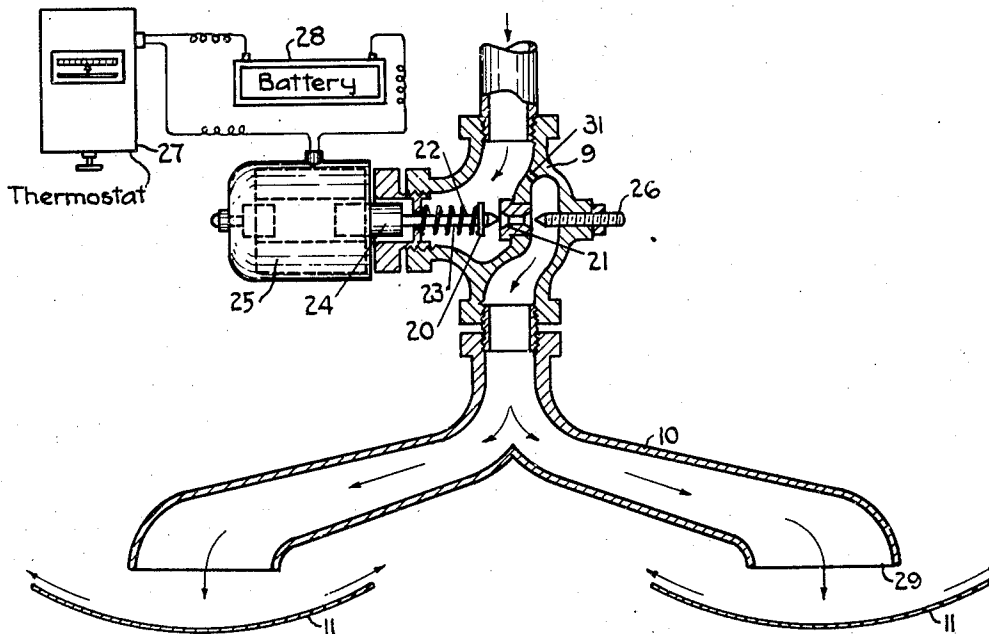


Fig. III

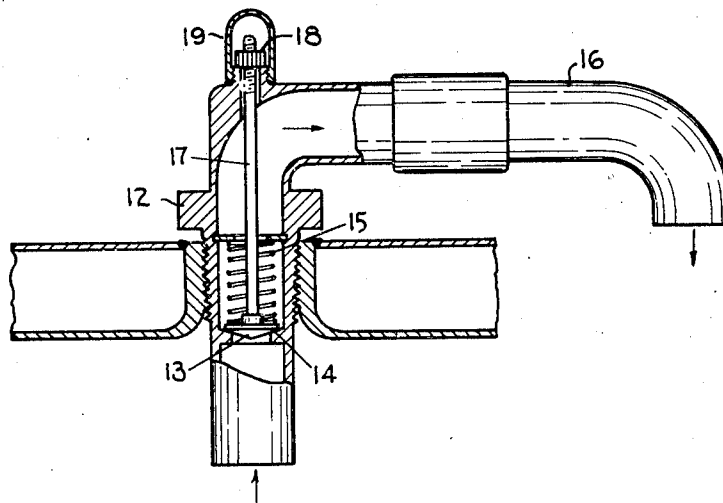


Fig. IV

Inventors: Robert K. Deutsch
Frithjof A. Larson
Vernon E. Middlebrook

By their Attorney: *H. Bitch*

UNITED STATES PATENT OFFICE

2,479,821

PROCESS AND APPARATUS FOR
REFRIGERATION

Robert K. Deutsch, Chicago, Ill., Frithjof A. Larson, Bronxville, N. Y., and Vernon E. Middlebrook, Tulsa, Okla., assignors to Shell Development Company, San Francisco, Calif., a corporation of Delaware

Application March 30, 1946, Serial No. 658,492

9 Claims. (Cl. 62—2)

1

This invention relates to the cooling or refrigeration of food stuffs and is particularly concerned with the safe and economical preservation of food stuffs during transportation from place to place, for example by various transport means such as railroad cars, motor trucks and cargo vessels.

The invention is primarily concerned with keeping fresh food stuffs at a sufficiently low temperature during transportation so that deterioration of the food stuffs is prevented.

As is well known, it is an usual procedure to transport fresh food stuffs both from production area to distribution areas and from primary distribution areas to secondary distribution areas or to consumers in refrigerated compartments. In the case of railroad shipment, specially built refrigerator cars are used for this purpose. These usually comprise a well insulated, closed compartment similar in appearance to the usual box car, but having ice bunkers generally at each end for carrying of about five tons of ice and salt. The ice and salt being in close proximity to the contents of the storage section of the refrigeration car serve to keep the contents within the desired temperature range, principally by air convection.

The ice bunkers are provided with hatches in the roof of the refrigerator cars so that the ice may be replenished when necessary in order that the food stuffs being transported do not spoil due to the ice having melted.

Similarly refrigerated motor trucks are used to transport small quantities of food stuffs from place to place by highways. While the use of ice as a refrigerant in the manner above outlined has the advantage of simplicity, yet it has many disadvantages such as requiring frequent reicing during long journeys (or when stoppages in traffic occur), the carrying of a large dead load with its attendant loss in usable space for pay load. In recent years the use of mechanical refrigerating units of the compression or absorption type has become almost universal on cargo vessels where one central plant can effectively cool the entire refrigerated cargo space. However, the application of such mechanical refrigeration systems to smaller transportation units, such as refrigerator cars and refrigerator motor trucks has not been adapted to any great extent. This situation has in part been due to the fact that such mechanical refrigeration systems require the supervision of an engineer or skilled mechanic to ensure the proper and continual

2

working, and in part due to the high cost of such equipment.

It is the object of our invention to provide a new and useful process for the refrigeration of food stuffs.

It is another object of our invention to provide a simple and efficient apparatus for the refrigeration of compartments on mobile units such as railroad cars, motor vehicles and airplanes.

It is a further object of our invention to provide a process and apparatus using liquid air as an expendable refrigerant.

By the term "liquid air" we include all liquefied mixtures of oxygen and nitrogen. In other words, we contemplate by the term "liquid air" mixtures consisting of oxygen and nitrogen in the proportions occurring in nature as well as "liquid air" produced as a by-product of industrial processes wherein the proportions of oxygen and nitrogen may vary considerably from the proportions occurring in nature. This "liquid air" may in fact be substantially pure oxygen or substantially pure nitrogen.

Another object of our invention is to provide a process and apparatus whereby the food stuffs being transported are supplied with a continuous stream of cooled air to affect favorably the freshness of the food stuffs.

The further objects of our invention will be apparent from the following detailed description of specific embodiments of our invention, and by referring to the accompanying drawings.

Figure I is a longitudinal section of a refrigerator car showing our refrigeration system.

Figure II is a sectional plan view of the refrigerator car of Figure I taken along the line II—II.

Figure III is an enlarged sectional view of the control valve and distributor shown in Figures I and II.

Figure IV is an enlarged sectional view of a cylinder relief valve shown in Figures I and II.

Referring to Figures I and II, numeral 1 represents the outside sheathing of a railroad refrigerator car.

Located under the floor of the car along each side of the main girder 2 are four double walled liquid air cylinders 3 preferably of the dewar or vacuum flask type. These cylinders are provided with baffles to prevent surging of the contents and are also provided with eduction tubes 4.

The two cylinders on the same side of the girder 3 are connected together by a manifold 5 and are each provided with a shut off valve 6.

The manifolds 5 are each connected to riser pipes 7 which are vertically mounted inside the

3

insulation of the car and are joined to each other in the roof of the car at a T fitting 8.

The third arm of the T fitting is connected to a solenoid type control valve 9. The details of this valve 9 and its associated parts may be seen in Figure III to which further reference will be made later herein. On the outlet side of the control valve 9 a distribution manifold 10 is attached. Diffusion pans 11 are positioned under the open discharge ends of the manifold.

The cylinders 3 of liquid air are each provided with a relief valve 12. The detail of these relief valves can be seen by referring to Figure IV. The relief valve comprises a valve member 13 provided with a seat 14. The valve member 13 is normally kept in closed position on the seat 14 by means of a spring 15. Upon sufficient pressure being exerted against the valve member 13 it will rise from its seat 14 and permit the escape of gas through an open ended pipe 16. The valve member 13 is provided with an elongated stem 17 which extends through the wall of the pipe 16.

The upper end of the valve stem 17 is threaded and provided with a knurled nut 18 so that the tension of the valve spring may be overcome and the valve member lifted when refilling the liquid air cylinder.

A dust cap 19 covers the exterior end of the valve stem and the adjusting nut 18.

The details of construction of the control valve 9 and associated mechanism can be readily seen by referring to Figure III.

The control valve 9 comprises a pintle valve member 20 cooperating with an annular seat 21. A spring 22 surrounding a valve stem 23 connected to the valve member 20 is employed to keep the valve member normally against the seat 21. The upper end of the valve stem 23 is attached to a metallic armature 24. This armature 24 is free to move within a coil (or solenoid) 25 of insulated wire.

A regulating needle 26 is threaded into the wall of the valve body and may be adjusted so as to partially obstruct the free flow through the seating member 21 when valve member 20 is raised from its seat. A small orifice or "pressure bleed" 31 is provided in the wall of the valve 9.

Electrical leads from the solenoid 25 are attached to an adjustable thermostat unit 27 and to an electric battery 28. The discharge side of the valve 9 is connected to the distribution manifold 10 which increases in diameter towards its discharge ends 29. The discharge manifold is positioned over the diffusion pans 11 and is supported by suitable hangers from the roof of the car.

The operation of the system is as follows:

Liquid air is charged into the cylinders 3 from an external source through fill pipes 30 attached to the risers 7. During the filling operation it is necessary to vent air displaced by the incoming liquid. This can be done by raising the relief valves 13 from their seats 14 by means of the adjusting nuts 18.

Upon filling being completed the relief valves are closed.

Due to the evaporation of some of the liquid air internal pressure will be built up inside the cylinders.

Under this pressure some liquid air will be forced through the eduction tubes into the manifold system and through risers 7 to the top of the car. Provided the control valve 9 is open liquid air will pass through the valve and through the distribution manifold 10. During its passage

4

therethrough some of the liquid air will be changed to the vapor state. The mixed vaporized liquid air and unvaporized liquid air will be eventually discharged to the diffusion pans 11 where evaporation of the rest of the liquid air will take place and in so doing will take up heat from the surrounding atmosphere.

The cold vaporized air will flow from the diffusion pans 11 downward through the interior of the refrigerator car due to its greater density and in so doing will effectively reduce the temperature of the contents of the car.

The thermostatic control unit 10 should be set to the temperature required for the contents of the car and will upon being lowered to that desired, act to shut off the flow of current in the solenoid 25. As a consequence the spring 22 will cause the valve to close and cut off the flow of liquid air to the distribution manifold 10. Upon the temperature in the refrigeration compartment rising above that desired the thermostat will close an electric circuit so that current flows through the solenoid 25 of the valve 9 and will cause the plunger to be drawn into the middle of the solenoid, thus opening the valve and permitting additional refrigerant to flow into the compartment and thereby withdrawing heat from the contents again lowering the temperature to the desired figure.

The orifice 31 in the valve 9 permits the continuous passage of a small amount of liquid air into the distribution manifold 10. This flow of liquid air prevents the back flow of humidified car atmosphere into the manifold during periods when the valve member 20 is on its seat 21. Back flow of humidified car atmosphere would result in water ice forming on the inside of the manifold which would impair the normal operation of the system.

As will be apparent this cycle will be repeated again and again. The frequency, will, of course, depend upon various factors such as the sensitivity of the thermostat, and the efficiency of the insulation of the refrigerator car.

The system will operate with only a few pounds pressure existing on the surface of the liquid air in the cylinders. As it is not practical to obtain perfect insulation, some heat will be transmitted to the liquid air in the cylinders 3 from the atmosphere. The heat absorbed will cause ebullition of liquid air in the cylinders and the eventual creation of a high internal pressure in the cylinders (provided no means of releasing this pressure is provided).

In the drawings we have shown a spring loaded pressure release valve 12 for this purpose. The operation of this valve is arranged so that upon the pressure on the surface of the liquid air in the cylinders exceeding a predetermined value, for example, 10 lbs. per square inch, the valve member 13 will rise from its seat 14 and vent the excess gas through pipe 16.

In order to avoid the formation of ice on the valve mechanism and to prevent the loss of refrigeration the exterior of each relief valve is preferably covered with a heavy insulation coating of asbestos, magnesia or other well known insulating material.

Owing to the introduction of liquid air and vaporized liquid air into the interior of the refrigerator car, it will be apparent that a super-atmospheric pressure would eventually build up inside the car, providing there were no provision for the relief thereof.

In order to relieve this pressure louvre type

vents 32 in the end walls of the refrigerator car or in the sides can be provided. Where our system is installed in an existing refrigerator car originally designed for the use of ice, ventilation can also be effected by partially opening one or more of the hatches normally fitted in the roof of such cars. Other conventional ventilator means can of course be provided.

It will be appreciated that we may make specific changes in the apparatus shown. For example, we may use a source of electric current other than a storage battery and we may in some cases use a control valve operated by means other than an electric current such as compressed air.

It should also be appreciated that we contemplate the possibility of using liquid air cylinders of the single wall type heavily insulated with asbestos, glass wool or other suitable thermal insulating substance.

We contemplate that the invention can be applied to other mobile equipment such as motor trucks and airplanes. The system disclosed can likewise be used for stationary refrigeration service such as in household refrigerators, cold storage warehouses, deep freeze lockers and the like and may also be used in air conditioning systems.

We further contemplate that where the ripening of produce has to be heavily retarded that liquid air of substantially pure nitrogen can be used to advantage in the refrigeration system for this purpose and that vice versa substantially pure oxygen can be used to hasten the ripening of the produce.

We claim as our invention:

1. A process for refrigeration using liquid air comprising maintaining a superatmospheric pressure on the surface of liquid air in an insulated storage vessel, admitting liquid air in controlled amounts from said storage vessel onto an unconfined diffusion receptacle within the interior and near the top of a refrigerator compartment, and vaporizing the admitted liquid freely from said receptacle.

2. A process for refrigeration using liquid air comprising maintaining a controlled superatmospheric pressure on the surface of liquid air in an insulated container, flowing liquid air in controlled amounts from said container onto an unconfined diffusion receptacle within a refrigeration compartment through a tubular passageway which is in free communication with the interior of said compartment, controlling the amount of liquid air so admitted by means of the temperature existing in said refrigerator compartment vaporizing the admitted liquid air freely from said receptacle, and continuously flowing a small amount of liquid air through said passageway irrespective of said temperature to prevent the back flow of air from said compartment into said passageway.

3. Apparatus for refrigeration using liquid air comprising a refrigerator compartment, a closed insulated container for liquid air, a pressure relief valve attached to said container, a control valve, eduction piping extending from the bottom of said insulated container to one side of said control valve, an open diffusion pan within said refrigerator compartment, conduit means for conducting liquid air from said control valve onto said pan, and a thermostatic device in said compartment connected to said control valve so as to open and close said control valve in accord-

ance with the temperature existing in the refrigerator compartment.

4. The apparatus according to claim 3 wherein the conduit means is a tubular pipe having its discharge end in spaced relation above said pan and directed downwardly toward the pan, and having a cross-sectional area increasing progressively from said control valve to the said discharge end.

5. Apparatus for refrigeration using liquid air comprising a refrigerator compartment, a closed insulated container for liquid air, a control valve, piping extending from the bottom of said insulated container to one side of said control valve, a conduit from the other side of said control valve to the interior of said refrigerator compartment, a thermostat in said compartment connected to said control valve whereby said control valve is operated according to the temperature condition in said compartment and a bleed passageway connected in parallel with said control valve for flowing a small amount of liquid air through said conduit on the other side of said control valve irrespective of the temperature in said compartment.

6. Apparatus for refrigeration using liquid air comprising a refrigerator compartment, a closed insulated container for liquid air, a pressure relief valve attached to said container, a control valve, eduction piping extending from the bottom of said insulated container to one side of said control valve, a distribution conduit from the other side of said control valve to the interior of said refrigerator compartment, open diffusion pans under the discharge ends of said distribution conduit and spaced therefrom, the discharge ends of said distribution conduit being disposed to discharge liquid air from said conduit onto said pans and a thermostatic device in said compartment connected to said control valve so as to open and close said control valve in accordance with the temperature existing in the refrigerator compartment.

7. The apparatus according to claim 6 wherein the pans are located near the top of said refrigerator compartment.

8. The apparatus according to claim 6 wherein there is provided a bleed passageway connected in parallel with said control valve for flowing a small quantity of liquid air through said distribution conduit irrespective of the temperature of said compartment.

9. The apparatus according to claim 6 wherein there is provided a bleed passageway connected in parallel with said control valve for flowing a small quantity of liquid air through said tubular pipe irrespective of the temperature of said compartment.

ROBERT K. DEUTSCH.
FRITHJOF A. LARSON.
VERNON E. MIDDLEBROOK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
686,531	Ostergran	Nov. 12, 1901
927,595	Place	July 13, 1909
966,076	Babrick	Aug. 2, 1910
2,089,428	Ross et al.	Aug. 10, 1937
2,247,850	Rayburn	July 1, 1941
2,309,938	Diserens et al.	Feb. 2, 1943