June 12, 1945. F. R. BICHOWSKY 2,378,177

MEANS FOR REFRIGERATING

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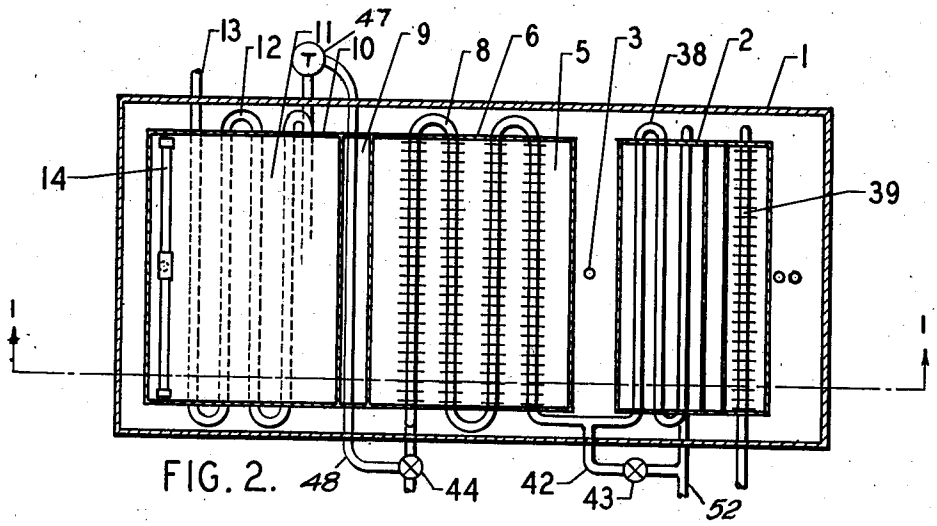



FIG. 2.

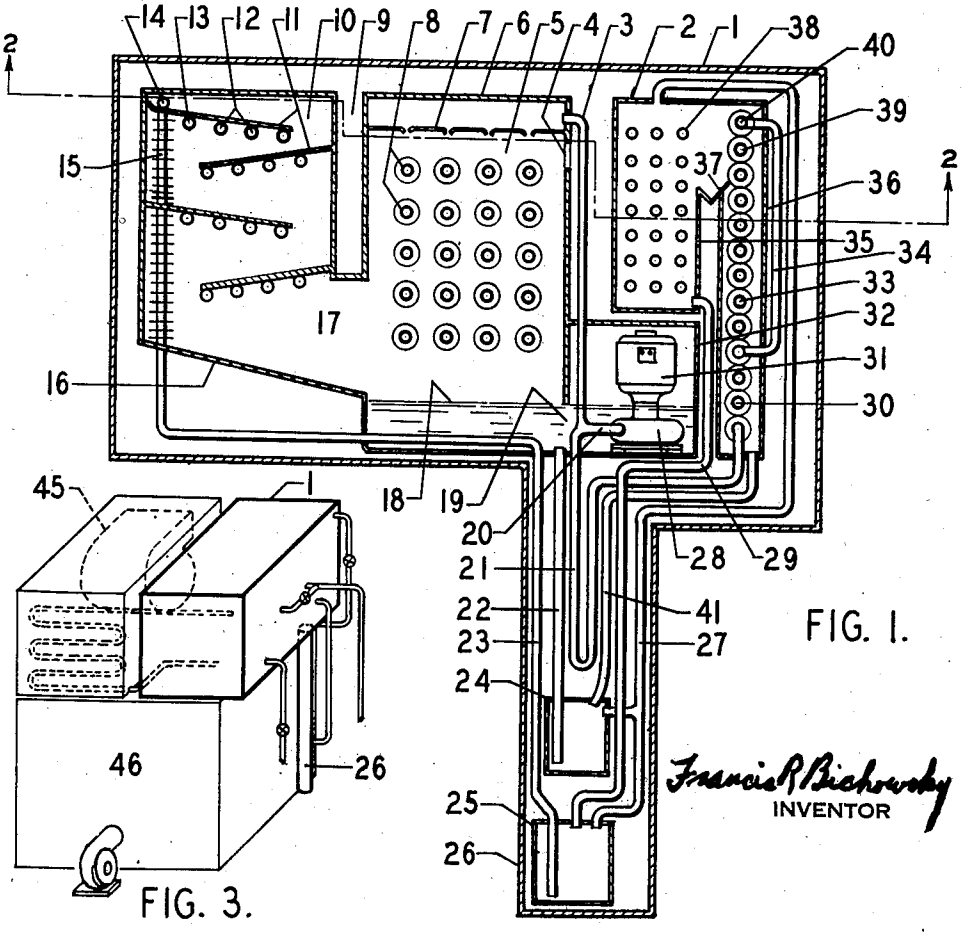



FIG. 1.

FIG. 3.

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## MEANS FOR REFRIGERATING

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11 Claims. (Cl. 62—5)

This invention relates to improved methods of refrigerating and apparatus therefor. More specifically the invention is concerned with improved methods of refrigerating in apparatus of the vacuum absorption type. Refrigerants commonly employed are water, methyl alcohol, or the like and frequently used absorbents are solutions of lithium chloride, lithium bromide, zinc chloride, and similar salts.

It is among the objects of the present invention to provide vacuum absorption apparatus including an evaporator in which high refrigerating efficiencies are obtained. Another object of the invention is to provide novel means for partially cooling refrigerant before passing it into the evaporator. A further object of the invention is to provide means for exhausting inert gases from the evaporator and absorber after the unit has been sealed. A primary object of the invention is to provide vacuum absorption refrigeration apparatus in a single container.

To the accomplishment of the foregoing and related ends, the invention, then consists of the methods and means hereinafter fully described and particularly pointed out in the claims, the annexed drawing and the following description setting forth in detail certain methods and means for carrying out the invention, such disclosed methods and means illustrating, however, but several of various ways in which the principle of the invention may be used.

In said annexed drawing: Figure 1 is a side elevation of a vacuum absorption refrigerator illustrating the principle of the present invention. Figure 2 is a plan view of the same apparatus taken on the line 2—2. Figure 3 is an isometric view of a vacuum absorption refrigerator illustrating the principle of the present invention mounted on a furnace for air conditioning.

In Figure 1, an hermetically sealed vessel 1 is provided in the form of a box. This vessel contains a high pressure chamber 2, a low pressure chamber 6 and has a leg 26 appended to it. The two chambers are separated from the vessel 1 by a space 9, said space communicating with the low pressure chamber 6 by an opening 4 in the wall of said chamber.

The high pressure chamber 2 is divided into two parts, namely, a condenser 35 and a regenerator 36. The condenser includes coils 38 through which a cooling agent may be run. The regenerator 36 includes finned coils 33 and a liquid distributor 40 so arranged that the liquid from the distributor will flow over the surface of the finned coils 33. The finned coils 33 contain a heating medium such as steam, said heating medium entering the regenerator by the pipe 39 and leaving the regenerator by the pipe 33.

The low pressure chamber 6 is divided into two parts, namely, the evaporator 10 and the absorber 5. The evaporator includes trays 11 which are sloped slightly downward toward the center of the evaporator and placed in staggered formation; alternate trays being placed on opposing sides of the evaporator. A liquid primary refrigerant distributor 14 is placed in the top of the evaporator and a sloping plate 16 in the bottom drains into the absorber sump 18. Pipes 12 are attached to the bottom of the trays 11 so that materials circulating in said pipes are in heat exchange relation with said trays.

The absorber 5 includes finned coils 8 and a liquid absorbent distributor 7, said liquid absorbent distributor being positioned in the top of the absorber. In the bottom of the absorber a sump 18 is formed and communicating therewith is a chamber 32 containing a centrifugal pump 28 driven by a motor 31.

In the preferred embodiment of this invention the primary refrigerant enters the evaporator section 10 by means of the distributor 14. The refrigerant flows over the trays 11, the major portion of it being vaporized in the vacuum therein and the balance passing into the sump 18. The pipes 12 attached to the trays 11 contain a secondary refrigerant, e. g., dichlordifluormethane, whereby the secondary refrigerant is cooled by the refrigeration produced by the evaporation of primary refrigerant passing over said trays which form heat exchange means for cooling the secondary refrigerant. The so-cooled secondary refrigerant is then used in any desired manner to refrigerate, for example, it might be circulated in an air-cooling chamber. The vapor of the primary refrigerant is passed from the evaporator into the absorber through the opening 17; the vapor there circulates among the pipes 8 and is taken up by the liquid absorbent entering the absorber by means of the distributor 7.

The absorbent after taking up the water vapor collects in the sump 18. This sump communicates with the pump chamber 32 by means of an opening 19. Absorbent may thus flow from the sump to the bottom of the pump chamber and thereby enter the pump 28 by an opening, not shown, and leave through the pipe 20. The major portion of the diluted absorbent coming out of the pump 28 is returned by the pipe 3 to the distributor 7 in the top of the absorber 5 and is redistributed over the finned coils 8. The re-

mainder of the absorbent leaving the pump 28 through the pipe 20 flows through the pipe 21 contained in the leg 26 from whence it passes through a heat interchanger 30 and is pre-heated by the hot, concentrated absorbent leaving the regenerator coils 33. After leaving the interchanger 30, the dilute absorbent flows through the pipe 34 and into the distributor 40 at the top of the regenerator. The diluted absorbent is distributed over the heated coil 39, 33, the refrigerant being vaporized and the absorbent thereby regenerated; the vaporized refrigerant passes from the regenerator into the condenser 35. The cooling coils 38 in the condenser cool the vapor so that it is condensed. Because of the relatively high temperature of the liquids in the chamber 2, the pressure in this portion of the apparatus will be substantially higher than that in the chamber 6. Thus the condensate in the condenser section 35 passes into the pipe 29 and into the sump 25 contained in the leg 26. A pipe 27 connects the sumps 25 and 24 above the liquid level therein with the condenser chamber 35 so that pressure may be communicated from the condenser chamber to the sumps. Then, since the pressure in the sump 25 is higher than that in the chamber 6, the water flows by means of the partially-finned pipe 23 through the evaporator 10 to the distributor 14 therein to be passed again through the system.

The concentrated absorbent after passing over the regenerator coils 33, 39 passes over the hereinbefore-mentioned heat interchanger coils 30, thereby being partially cooled, and thence into the pipe 41 and down to the sump 24 from whence it is forced by the higher pressure therein to the absorber sump 18 by means of the pipe 22. From there it is passed into the absorber 5 by means of the pump 28 and other apparatus hereinbefore described.

Since considerable heat is generated in the absorber by the absorption of water vapor in the absorbent, the coils 8 which are utilized to spread the absorbent also contain a liquid cooling agent to absorb and carry this heat away.

It has been found that there is a tendency for warm water entering an evacuated space to flash into spray. There is a tendency for this spray to be carried along by the water vapor produced and thus have its refrigerating effect lost. In order to prevent this flashing, the tube 15 for conveying primary refrigerant to the distributor 14 in the evaporator 10 passes through the evaporator and is in thermal contact with the interior thereof so that the liquid flowing through the tube 15 is pre-cooled before entering the distributor 14. To further this effect, the liquid entering the evaporator 10 is passed through progressively wider passages, the ones at the top being narrow relative to the lower ones. Thus, the vapor is restricted in its flow through the evaporator and the pressure at the distributor 14 is greater than that at any other point in the evaporator and flashing is limited to a minimum.

Since the temperatures obtained with pure water are limited by the freezing point thereof (32° F.), if lower temperatures should be desired while using water as the primary refrigerant, a trough 37 may be provided in the regenerator 36 so that a small proportion of the absorbent therein flows into the condenser section 35, joins the condensed water and thus gives a primary refrigerant solution flowing back to the evaporator 10 with a freezing point lower than that of water.

It has been found that complete exhaustion of the unit of all inert gas is not commercially feasible. Therefore, the vapor flowing from the evaporator 10 to the absorber 5 carries with it any inert gas which obtains in the evaporator. This gas forms a blanket in the top of the absorber, decreases the rate of absorption of water vapor therein, and the capacity of the entire unit unless the inert gas is removed by some means. Therefore, the preferred embodiment illustrated herein is provided with an opening 4 in the absorber through which the inert gas is forced into the space 9.

In Figure 2 the flow of secondary refrigerant and cooling water is more particularly shown. The secondary refrigerant is recirculated in the coil 13. Cooling water passes through the coils 8 and then through the coils 38 and hence either to waste or to the hot water supply of the house by means of the pipe 52. A by-pass 42 with valve 43 is provided to send a portion of the cooling water around the condenser when desired. A valve 44 is provided to control the flow of cooling water to the absorber.

It has been found that the amount of heat removed by the cooling water leaving the condenser is proportional to the heat removed by the cooling water from the absorber and that, therefore, by setting the amount of water by-passed around the condenser so that the pressure difference between the absorber and condenser is at a predetermined value, that pressure difference will maintain itself regardless of the load, if the inlet water temperature is approximately constant. A pressurestat or thermostat 47 may be provided to control by means of the valve 44 and the connecting means 48 the flow of cooling water through the absorber coils 8 (as shown in applicant's copending application Serial No. 286,989, filed July 28, 1939, which has now matured into U. S. Patent No. 2,298,924).

Figure 3 shows the apparatus mounted on top of an ordinary hot water or steam furnace 46. An air conditioning unit 45 is also mounted on top of the furnace.

While the mode of operation of the specific apparatus illustrated has been described, my method broadly comprises recirculating a secondary refrigerant in heat exchange relation with an evaporating primary refrigerant; passing said evaporating primary refrigerant from heat exchange relation with said secondary refrigerant into an absorbing medium; passing the so-formed mixture of primary refrigerant and absorbing medium into a pump and returning the major portion of said mixture to the absorption zone for re-use as absorbing medium, passing the minor portion of said mixture to a heating zone, passing the vapor thereby obtained into a condensing zone and returning the so-formed condensate to the zone wherein primary refrigerant is evaporated, said condensate being in heat exchange relation with primary refrigerant evaporating in said zone before being passed therein; and passing that portion of the mixture not vaporized in the heating zone back to the absorption zone for re-use as absorbing medium.

Other modes of utilising the refrigeration obtained can be used besides the secondary refrigerant circuit without exceeding the scope of the present invention.

Other modes of applying the principle of this invention may be employed instead of those explained, change being made as regards the methods and means herein disclosed, provided those

stated by any of the following claims or their equivalent is employed.

What is claimed is:

1. Vacuum absorption refrigeration apparatus comprising a container within a surrounding airtight wall, said container being divided into two chambers, one of said chambers including an evaporator and an absorber, and one of said chambers including a regenerator and a condenser; means providing communication between the absorber-evaporator chamber interior and the space existing between the wall and the container.

2. Vacuum absorption refrigeration apparatus including a regenerator, a condenser, an absorber, and an evaporator, means for passing liquid from said regenerator including a sump located below said regenerator, means for equalizing pressure between said sump and said condenser, and a pipe connecting said sump below the liquid level in said sump with said absorber.

3. Vacuum absorption refrigeration apparatus including a regenerator, a condenser, an absorber, and an evaporator, means for passing liquid from said regenerator including a sump located below said regenerator and in open communication therewith but at substantially the same pressure as exists in the condenser, and a pipe connecting said sump below the liquid level therein with said absorber; a pipe between the condenser and the sump, said pipe being so positioned in both connections that the openings into the condenser and the sump are above liquid level in each.

4. Vacuum absorption refrigeration apparatus including a condenser and an evaporator, means for conveying liquid from said condenser to said evaporator including a sump located below said evaporator, means for equalizing the pressure in said sump with that in said condenser, and communicating means between said sump and said condenser.

5. Vacuum absorption refrigeration apparatus including an evaporator, an absorber, a regenerator and a condenser, means for cooling said condenser and absorber whereby the condenser and absorber are cooled by a single liquid passed in series, and means whereby a portion of the cooling liquid passed from the absorber is bypassed around the condenser.

6. Vacuum absorption refrigerating apparatus including an evaporator, an absorber, a regenerator and a condenser means for utilizing the refrigeration produced in said apparatus to cool a secondary refrigerant, means responsive to the temperature of said secondary refrigerant to control a flow of cooling agent to the absorber and condenser.

7. Vacuum absorption refrigeration apparatus comprising a container divided into two chambers, one of said chambers including an evaporator and an absorber, and one of said chambers including a regenerator and a condenser, said evaporator including a passage through which primary refrigerant may pass, said passage being narrower at the point at which primary refrigerant enters than the point at which primary refrigerant leaves said passage.

8. Vacuum absorption refrigeration apparatus comprising a container divided into two chambers, one of said chambers including an evaporator and an absorber, and one of said chambers including a regenerator and a condenser, and means for conveying primary refrigerant into the evaporator including a tube in thermal contact with the interior of said evaporator.

9. Vacuum absorption refrigeration apparatus comprising a container divided into two chambers, one of said chambers including an evaporator and an absorber, and one of said chambers including a regenerator and a condenser, said evaporator including a passage through which primary refrigerant may pass, said passage being narrower at the point at which primary refrigerant enters than the point at which primary refrigerant leaves said passage, heat exchange means in said evaporator for cooling a secondary refrigerant, means responsive to the temperature of said secondary refrigerant to control the flow of cooling agent to the said condenser and absorber, and means for conveying primary refrigerant into the evaporator including a tube in thermal contact with the interior of said evaporator.

10. Vacuum absorption refrigeration apparatus comprising an absorber and an evaporator, said evaporator comprising a chamber and a series of downwardly sloping staggered trays positioned therein to define a passageway for primary refrigerant, said passageway starting between the topmost tray and the top wall of said chamber and being progressively larger to its point of discharge short of the bottom of said chamber, means for introducing primary refrigerant adjacent the small end of said passageway and means for transferring vaporized primary refrigerant from said chamber below said passageway to the absorber.

11. Vacuum absorption refrigeration apparatus comprising a container divided into two chambers, one of said chambers forming an evaporator and an absorber and the other of said chambers forming a regenerator and a condenser, means for circulating a primary refrigerant between said two chambers, means for circulating a secondary refrigerant in a circuit partly inside and partly outside of said container, and means responsive to the temperature of said secondary refrigerant controlling a flow of cooling agent to the absorber and condenser.

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