Sept. 20, 1932. E. ALTENKIRCH 1,878,803

CONTINUOUS ABSORPTION REFRIGERATING SYSTEM

Filed May 21, 1931 3 Sheets-Sheet 1

Fig. 1.

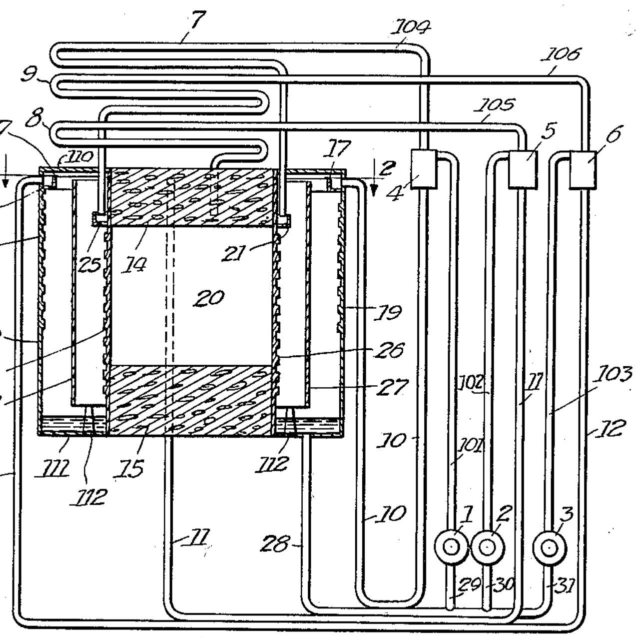


Fig. 2.

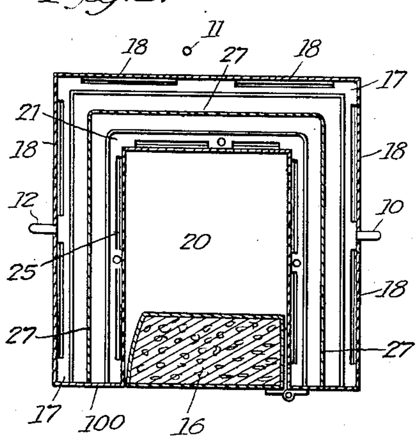
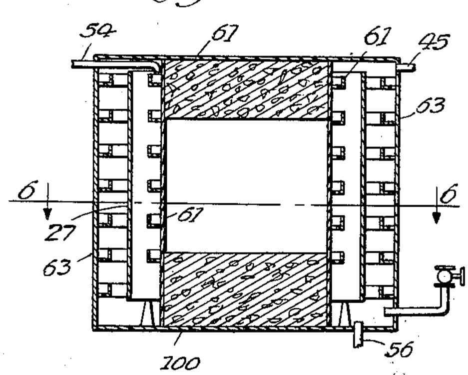


Fig. 5.



Witness:
R.B. Davison.

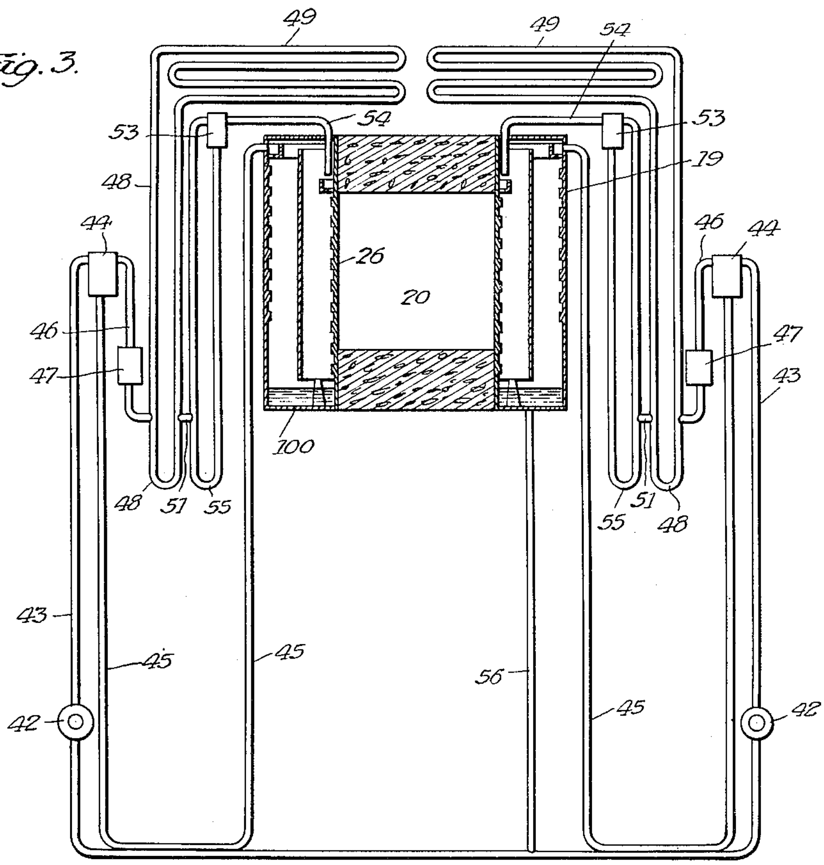
Inventor:
Edmund Altenkirch.
By: Harry S. Demarest
Atty.

Sept. 20, 1932. E. ALTENKIRCH 1,878,803

CONTINUOUS ABSORPTION REFRIGERATING SYSTEM

Filed May 21, 1931 3 Sheets-Sheet 2

Fig. 3.



Witness:
R.B. Davison

Inventor:
Edmund Altenkirch.
By: Harry S. Demarest
Atty.

Sept. 20, 1932. E. ALTENKIRCH 1,878,803

CONTINUOUS ABSORPTION REFRIGERATING SYSTEM

Filed May 21, 1931 3 Sheets-Sheet 3

Fig. 4.

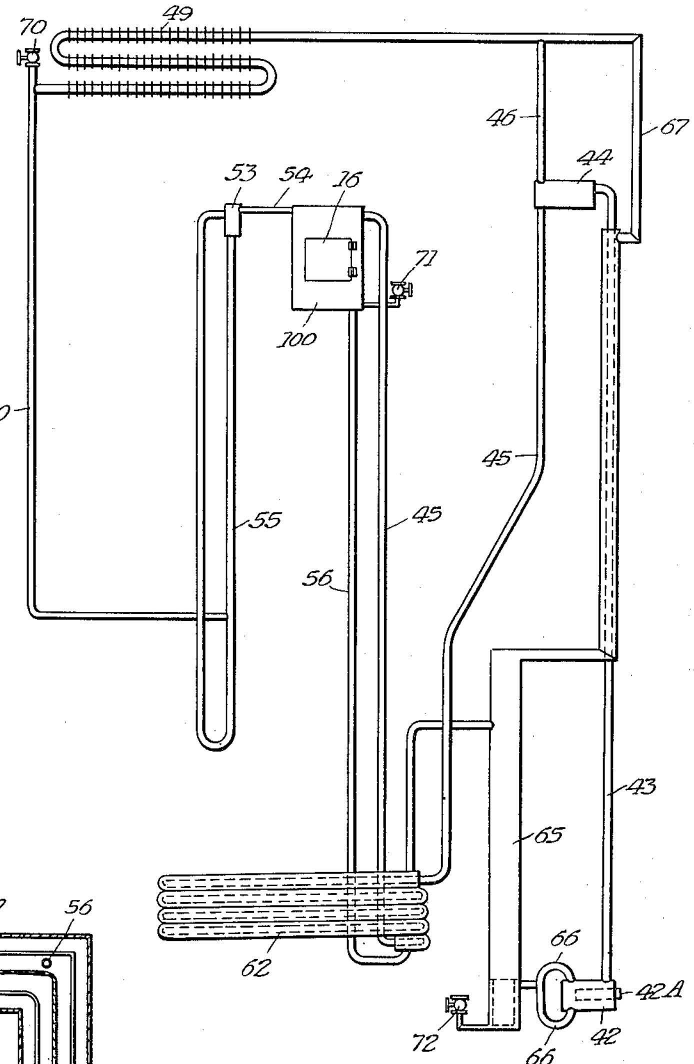
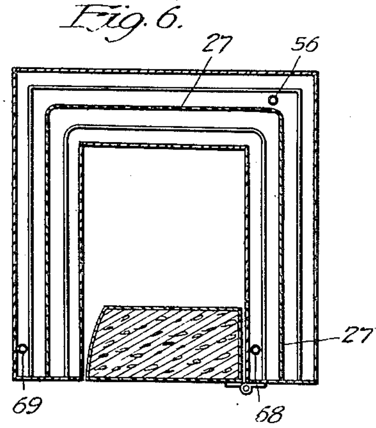


Fig. 6.



Witness:
R.B. Davison

Inventor:
Edmund Altenkirch.
By: Harry S. Demarest.
Atty.

Patented Sept. 20, 1932 1,878,803

UNITED STATES PATENT OFFICE

EDMUND ALTENKIRCH, OF NEUENHAGEN, NEAR BERLIN, GERMANY, ASSIGNOR TO SIEMENS-SCHUCKERTWERKE AKTIENGESELLSCHAFT, OF BERLIN-SIEMENSSTADT, GERMANY, A CORPORATION OF GERMANY

CONTINUOUS ABSORPTION REFRIGERATING SYSTEM

Application filed May 21, 1931, Serial No. 538,905, and in Germany May 27, 1930.

This invention relates to continuous absorption refrigerating systems and more particularly to systems of the type in which an inert gas is employed as an auxiliary agent.

In systems employing an inert gas, the refrigerant evaporates into the inert gas in the evaporator. The mixture is then usually conveyed to the absorber where a weak absorption solution absorbs the refrigerant out of the inert gas, the latter then returning to the evaporator. As is well known the inert gas may circulate between the evaporator and the absorber due to a difference in specific gravity maintained between parts of the gas circuit. In the case where the refrigerant vapor has a different density than the inert gas this difference may result from evaporation of refrigerant into the gas in the evaporator and the absorption of the refrigerant out of the gas in the absorber. The difference in temperature which prevails in these two vessels may also cause circulation.

The present invention has for an object the improvement of the operation of such a system by bringing about a more uniform rate of flow of the inert gas.

Another object is to provide for the circulation of an inert gas along two surfaces in a common chamber, one surface acting as an evaporator and the other as the absorber.

Another object is to provide a new evaporator and absorber construction having a large evaporation and absorption area and at the same time providing means for effectively isolating the evaporator from the exterior of the unit to permit it to cool a cabinet while using a minimum of insulation. To accomplish this the absorber may practically entirely surround the evaporator so as to insulate the same from the atmosphere.

A further object is to provide a novel arrangement of evaporator and absorber adapted to permit the system to be air cooled.

Other objects and advantages will be apparent from the following description taken in connection with the accompanying drawings in which,

Fig. 1 is a diagrammatic illustration of an absorption refrigerating system showing how the invention may be applied to a system in which the difference in refrigerant pressure between the evaporator and the condenser is maintained solely by means of an inert gas.

Fig. 2 is a cross sectional view of the evaporator-absorber vessel of Figure 1, this view being taken on the line 2—2 of Fig. 1.

Fig. 3 is a diagrammatic illustration of another type of absorption refrigerating system in which the invention may be incorporated, this figure showing a system in which the difference in refrigerant pressure between the evaporator and the condenser is maintained partly by an inert gas and partly by liquid columns.

Fig. 4 is a view in elevation of an actual refrigerating system constructed in accordance with the principles of the diagrammatic showing in Figure 3.

Fig. 5 is a vertical cross sectional view thru the evaporator-absorber vessel of Figure 4 and

Fig. 6 is a horizontal cross sectional view of the evaporator-absorber of Fig. 4, the view being taken on the lines 6—6 of Fig. 5.

Referring first to Figures 1 and 2 an arrangement is shown in which a common evaporator-absorber vessel designated 100 is incorporated into a system having three boilers or generators designated 1, 2 and 3, three gas separating chambers 4, 5 and 6 and three condensers 7, 8 and 9. Each of the boilers together with its gas separating chamber and condenser may cooperate with the evaporator-absorber vessel 100 to cause the production of refrigeration. As to features other than the evaporator-absorber, the arrangement is similar to the arrangement shown in Altenkirch's Patent No. 1,700,276, granted January 29, 1929 for "Absorption machines". As shown in that patent the purpose of the boilers 1, 2 and 3 is to expel gaseous refrigerant from strong absorption liquid. As the refrigerant is expelled it passes upwardly thru the conduits 101, 102 and 103 to the gas separating chambers 4, 5 and 6 and in so doing carries the weakened absorption solution to these gas separating chambers. From the separating chambers the vapor of the refrigerant passes to the condensers 7, 8 and 9 thru the conduits 104, 105 and 106 and as the vapors condense, the condensed refrigerant flows to the evaporator.

The weakened absorption liquid lifted from the boilers to the gas separating chambers, passes thru the U-pipes 10, 11 and 12 and into the top of the evaporator-absorber vessel 100. As shown in Figure 2 the pipes 10, 11 and 12 may enter the vessel 100 on three different sides thereof so that weak absorption solution is distributed throughout the absorber.

Strong absorption solution is drained out of the bottom of the evaporator-absorber vessel 100 by the conduits 28 which after passing in heat exchange relation with the conduits 10, 11 and 12 passes to a point beneath the boilers 1, 2 and 3 from which the absorption liquid is distributed to the boilers 1, 2 and 3 thru the conduits 29, 30 and 31.

Referring now to the vessel 100, which is shown in vertical cross section in Figure 1 and in horizontal cross section in Figure 2, it will be seen that the construction is such that this vessel surrounds an inner space 20 on three sides, the vessel itself being of a sort of channel shape, and forming with the door 16 and the upper and lower insulating slabs 14 and 15 a complete refrigerating cabinet. With these parts the vessel forms a rectangular solid so that it has a neat appearance.

The vessel 100 is hollow and is closed at the top and the bottom by U-shaped plates 110 and 111. If the system is designed to operate at a low total pressure the entire vessel may be made of sheet material. The walls may be welded or otherwise secured to each other as will be apparent to those skilled in the art. By changing the design somewhat and adding suitable trusswork to give strength the vessel may be adapted for use in systems operating at higher pressures.

The inner surface of the outer wall of the vessel 100 functions as the absorber while the surface inside of the vessel 100 next to the space 20 operates as the evaporator to cool the space 20. The absorption liquids entering thru the conduits 10, 11 and 12 empty into a distributing channel 17 which extends around the periphery of the absorber portion of the vessel. The channel 17 is provided with elongated holes or slots 18 at suitable places to provide for the dripping of the absorption liquid down on to distributing projections 19 which may be formed by serrating or knurling the absorber surface.

In a similar way liquid refrigerant which has condensed in the condensers 7, 8 and 9 is distributed onto the evaporator projections 26 by the channel 21 provided with slots 25.

Between these two roughened surfaces 19 and 26 which as stated above function as the absorber and the evaporator respectively a partition 27 is provided. As shown in Figure 2 this partition may be disposed about equidistantly between the two. It follows the contour of these surfaces, that is it extends from the front of the vessel rearwardly to a point near the back then across and again forward to the front of the vessel. As shown in Figure 1, the partition does not extend clear to the top of the vessel 100 nor to the bottom but is supported by the legs 112. This permits the passage of gas underneath the partition and also across the top. A slightly larger space should be left at the bottom so as to permit the accumulation of absorption liquid in the vessel without interfering with the gas circulation.

It will be seen that with this arrangement the condensed refrigerant entering the vessel 100 from the condensers may evaporate into the inert gas contained in the vessel and in so doing withdraw heat from the chamber 20 to be cooled. Let us suppose that the apparatus is designed to use ammonia water and air as the refrigerant, absorption liquid and inert gas respectively. The ammonia vapor has a lower specific gravity than that of a mixture of ammonia vapor and air. As ammonia evaporates into the air along the evaporator surface 26, the mixture will rise in consequence of the lowering of the specific gravity and pass over the partition 27 to the absorber surface 19. Here the ammonia vapor will be absorbed from the gas mixture by the absorption solution. As the ammonia is absorbed at this point, the density of the mixture of gases increases so that the gas passes downwardly and under the partition 27 back to the evaporator surface 26. It then repeats the cycle.

The partition 27 should preferably consist of heat insulating material so as to prevent the passage of heat from the absorber to the evaporator portion of the vessel. To this end the partition may be made of a hollow body which is either filled with air or better still is nearly a vacuum. Metal may be used as a material for this partition, as for example aluminum so as to enable it to be provided with a heat reflecting surface. Various other ways for preventing heat flow through the partition 27 will readily suggest themselves to those skilled in the art.

In case hydrogen is used as an inert gas in the system, the direction of circulation between the evaporator and the absorption surfaces will be opposite to that indicated above. With hydrogen the circulation will be influenced not only by the changes in specific gravity due to the addition and removal of refrigerant from the neutral gas but also by the cooling on the evaporator side and the heating on the absorber side of the partition.

It will be seen that with this arrangement a very large absorption surface is provided and that the outside area provides a large heat dissipating surface for giving up heat to the atmosphere. The arrangement thus presents an excellent means for air-cooling the absorber. If desired this outer surface may be provided with additional heat radiating fins.

It will also be seen that the arrangement provides an excellent means for insulating the inner chamber 20 since it is unnecessary to provide insulation on the vertical walls except at the door 16.

In describing the operation of the above system it was stated that ammonia, water and air might be used as the working substances. Where the apparatus is of the condenser type, the use of these substances would present a serious problem in that a relatively high pressure would be necessary and a very strong absorption evaporator vessel would be required because of the unusual shape. If, however, instead of the condensers, resorbers are employed, as disclosed in the patent to Altenkirch No. 1,767,639, patented June 24, 1930 the apparatus may operate at a much lower pressure. Thus the invention is not limited to the particular system shown. The arrangement diagrammatically illustrated in Figures 1 and 2 is also suitable for use with other refrigerants and working substances. For example, if the apparatus is made of suitable acid resisting material, such as glass, as disclosed in Altenkirch Patent No. 1,728,742, sulphuric acid and water may be used as the absorption liquid and refrigerant respectively. A mixture of sodium hydroxide and potassium hydroxide and water may also be used, the water then acting as the refrigerant and the machine operating at a pressure at or below atmospheric.

Figure 3 illustrates the principles of another type of machine and Figures 4 to 6 an actual working model adapted to use sodium hydroxide and potassium hydroxide, water and air as the working substances. In the apparatus illustrated in these figures the difference in pressure between the evaporator and the condenser is maintained partly by the presence of air in the evaporator-absorber vessel and partly due to the presence of liquid columns.

Referring first to Figure 3 it will be seen that a multiple unit somewhat similar to that of Figures 1 and 2 is provided except that here only two boilers, two gas separating chambers and two condensers are provided. The evaporator-absorber vessel 100 may be similar in all respects to that described in connection with Figures 1 and 2.

Except for the evaporator-absorber vessel the parts are duplicates and are similarly designated.

For supplying refrigerant to the vessel 100 and for removing it therefrom the system may consist of a boiler 42 connected by a gas lift pump 43 to the gas separating chamber 44 and a condenser 49. Refrigerant vapor passes from the gas separating chamber 44 thru the conduit 46, and equalizing vessel 47, to the U-tube 48 connected to the condenser. Condensation from the condenser flows downwardly thru the right hand legs of the U-pipe 48 and from there through a connecting pipe 51 to a second U-pipe 55. The upper ends of the U-pipe 55 are connected to separator vessel 53 which in turn feeds liquid refrigerant to the evaporator surface 26 thru the conduit 54. A liquid conduit 56 conveys the strong absorption solution back to the boiler 42.

The formation of a liquid column in the left hand leg of the U-pipe 55 permits the evaporator-absorber to operate at a lower total pressure than that prevailing in the condenser 49. Liquid also forms in the right hand leg of the U-pipe 48 but upon heat being supplied to boiler 42 the pressure in the condenser 49 rises above that in the evaporator-absorber and thus causes the level of the liquid in the right hand leg of the U-pipe 48 to move downwardly and the liquid level in the U-pipe 55 to rise. The differential between the heights in these two conduits is determined by the difference in total pressure between the condenser and the evaporator-absorber. An inert or neutral gas is employed to maintain a further difference in partial pressure of the refrigerant between the evaporator-absorber and the condenser. Since the gas separating chamber 44 is at about the same total pressure as the condenser 49 a difference in liquid levels will exist in the conduit 45 which conveys weak absorption liquid from the gas separating chamber to the absorber portion of the evaporator-absorber vessel 100. The pipe 45 may be in heat exchange relation with the conduit which conveys strong absorption liquid to the boiler. The operation of this system is the same as that described in connection with Figure 1 except for the formation of the liquid columns referred to and the difference in total pressure between the parts.

In Figures 1 and 3 the evaporator surface 26 is shown at a slightly lower level than the absorber surface 19. This is desirable in case the vapor of the refrigerants used is lighter than the inert gas. In case hydrogen or other very light neutral gas is employed the evaporator should be at the higher level.

Figures 4, 5 and 6 illustrate an actual working apparatus constructed in accordance with the principles of the invention illustrated in Figure 3.

As shown, only one boiler condenser system is employed but it is obvious that two or more may be used as indicated in Figure 3. The system of Figures 4, 5 and 6 is particularly designed for the use of a mixture of sodium hydroxide, potassium hydroxide and water with air as inert gas. The figure is drawn to scale from an actual working apparatus in which the heights were so designed as to maintain the proper differences in pressure due to liquid columns. The heights are suitable for a mixture consisting of 25 parts sodium hydroxide, 25 parts potassium hydroxide and 50 parts of water. The system may be operated, with the evaporator and absorber at an absolute pressure equal to a head of from six to ten centimeters of water while the gas separating chamber and the condenser are at a pressure of from 30 to 40 centimeters of water.

The essential parts of Figure 4 are the boiler 42 adapted to be heated by a cartridge heater 42*a*, a gas lift pump 43 connecting the boiler to the gas separating chamber 44, a condenser 49 and the evaporator-absorber vessel 100. Refrigerant gas, in this case water vapor or steam, passes thru the conduit 43, gas separating chamber 44, conduit 46 to the condenser 49 where it condenses and flows downwardly thru the conduit 60 which in this case corresponds to the right hand leg of the pipe 48 of Figure 3 into a U-conduit 55 connected to a chamber 53. From there, a conduit 54 conveys the liquid refrigerant to a series of baffles 61 on the evaporator side of the evaporator-absorber vessel 100 as shown more particularly in Figure 5. The baffles of the evaporator are provided with staggered holes so as to permit the liquid refrigerant to trickle downwardly thereover.

The absorption liquid flows from the boiler 42 upwardly thru the conduit 43, gas separating chamber 44, then downwardly thru the conduit 45, heat exchanger 62 and into the top of the absorber thru the conduit 45. It then trickles downwardly over a series of baffles 63 located on the absorber side of the partition 27 as illustrated in Figure 5. As explained previously, in connection with the other figures, the refrigerant is conveyed from the evaporator surface to the absorber surface by the neutral gas so that it returns with the absorption liquid to the boiler through the conduit 56. In so doing it passes thru the heat exchanger 62 and into the top of a reservoir 65. This vessel has its lower end connected to a double branch pipe 66 for conveying liquid to the boiler. The pipe 66 prevents the formation of surges from adversely affecting the circulation. The upper end of the reservoir is connected by the conduit 67 to the conduit 46 above the gas separating chamber, a portion of the conduit 67 being in heat exchange relation with the gas lift pump 43.

As shown in Figure 6 the baffles or trays in the vessel 100 which contain the liquid refrigerant and the absorption liquid extend all the way around the periphery of the evaporator and absorber proper. Openings are provided in these trays as indicated at 68 and 69 in Figure 6 for permitting liquid to drain from one tray to another, these openings being alternately staggered as indicated in Figure 5.

Due to the fact that the arrangement of Figure 4 is dependent upon the maintenance of a total pressure which is relatively low (being less than atmospheric in the evaporator and absorber) it is necessary to remove gases from the apparatus when it is initially started. Also in some cases, gases are generated during operation and it is then necessary to remove them. To this end valve 70 is provided in the conduit 60. Valves 71 and 72 are also provided at convenient places as for example on the evaporator-absorber vessel and at the lower end of the reservoir 65 for the purpose of charging the apparatus and to permit removal of fluid therefrom to properly trim it.

While only one actual construction model has been described herein it is obvious that the invention is suitable for use in a wide variety of systems and that it is not limited to the constructional details illustrated in Figures 4 to 6 or to the arrangement diagrammatically illustrated in Figures 1 to 3. Certain features are suitable for use in apparatus in which no inert gas is employed.

Various changes may be made without departing from the spirit of the invention or the scope of the annexed claims.

I claim:—

1. A refrigerator structure including a combined evaporator and absorber consisting of a single vessel shaped to form the sides and back of a refrigerator cabinet.

2. A refrigerator structure including a combined evaporator and absorber consisting of a single vessel shaped to form the sides and back of a refrigerator cabinet the inner side of said vessel functioning as the evaporator and constituting the inner wall of the cabinet.

3. A refrigerator structure including a combined evaporator and absorber consisting of a single vessel shaped to form the sides and back of a refrigerator cabinet, the outer wall of said vessel functioning as the absorber whereby a large heat dissipating surface is provided to enable the vessel to be air cooled.

4. A refrigerator structure including a combined evaporator and absorber consisting of a single vessel shaped to form the sides and back of a refrigerator cabinet, the inner surface of said vessel functioning as the evaporator and the outer surface functioning as an air cooled absorber.

5. A refrigerator cabinet structure having a vessel mounted in the wall thereof, the surface of the vessel on the inside of the wall functioning as the evaporator of a refrigerating system and the surface of the

vessel on the outside of the wall functioning as an air-cooled absorber of the refrigerating system.

6. The combination of an absorption refrigerating system and a refrigerator cabinet for storing food to be cooled by said system wherein part of the structure of said cabinet is made of a vessel, a portion of said vessel being disposed on the inside of the cabinet and functioning as an evaporator and a portion of said vessel being disposed on the outside of said cabinet and functioning as an air-cooled absorber.

Signed at Berlin-Siemensstadt, Germany, this 5th day of May A. D., 1931.

EDMUND ALTENKIRCH.