Aug. 27, 1929. R. W. DAVENPORT 1,726,344

REFRIGERATING APPARATUS

Filed April 29, 1926 2 Sheets-Sheet 1

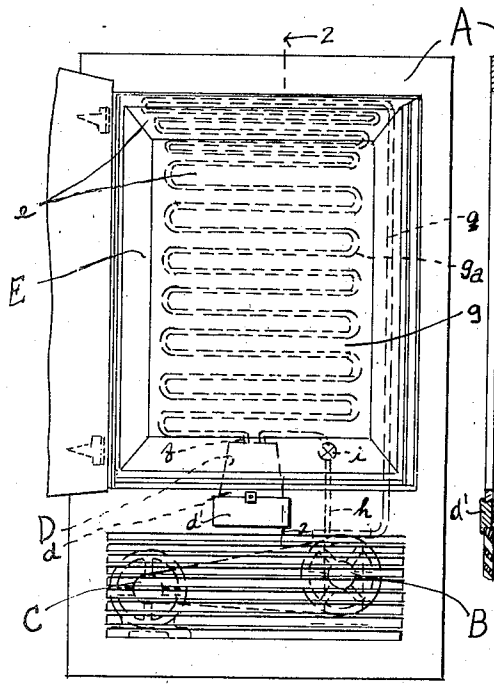

Fig. 1

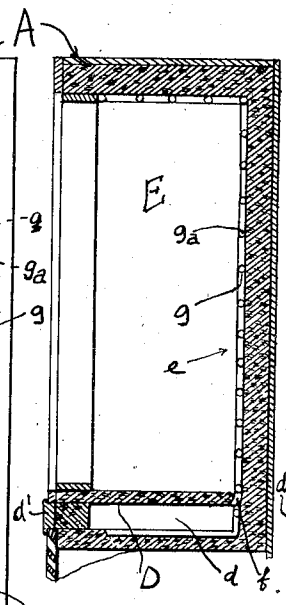

Fig. 2

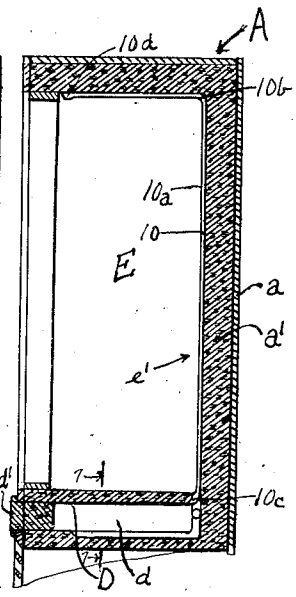

Fig. 3

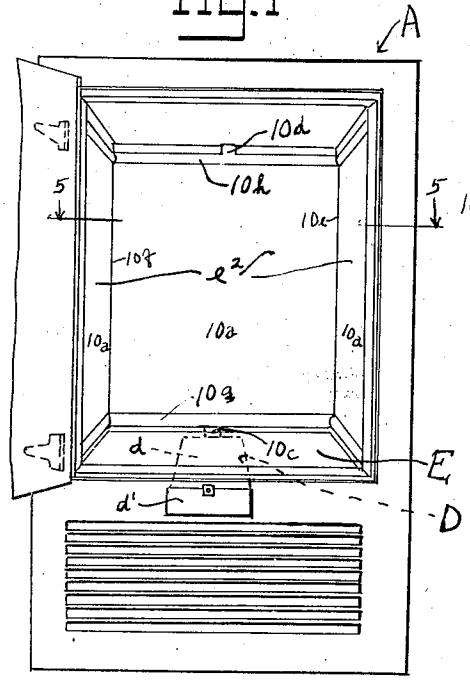

Fig. 4

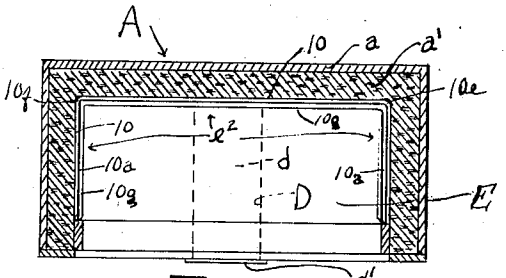

Fig. 5

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REFRIGERATING APPARATUS

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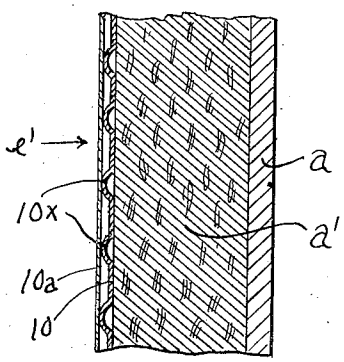

Fig. 6

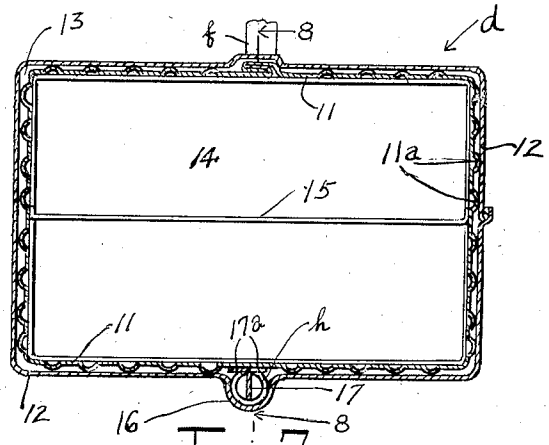

Fig. 7

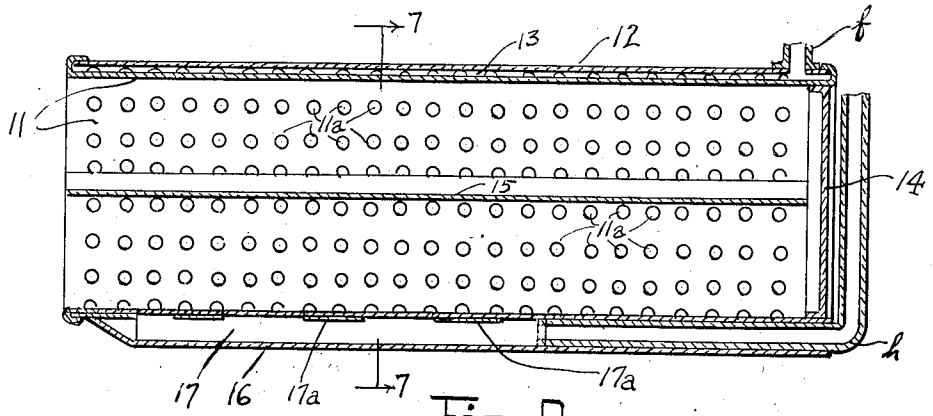

Fig. 8

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Patented Aug. 27, 1929. 1,726,344

UNITED STATES PATENT OFFICE.

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REFRIGERATING APPARATUS.

Application filed April 29, 1926. Serial No. 105,372.

This invention relates to apparatus for producing thermodynamic effects and in particular to apparatus for use in connection with refrigerating and freezing cabinets and compartments. While it possesses many features of general application it has a special field in mechanical refrigerating outfits for household use where features of compactness, simplicity, efficiency and economy are particularly desired.

In refrigerating systems elements functioning to absorb heat from the medium in contact with one surface through the evaporation of a suitable medium in contact with the opposite surface are old and commonly used in forms adapted for various specific applications. When the contact medium from which heat is absorbed is the atmosphere, it is common practice to extend the contact area by various expedients such as fins, corrugations, tubes, coils, etc. as it is well known that a given quantity of heat can be absorbed from air with less temperature differences between the air and the element when the contact area is large than when it is relatively small. Commonly used structures generally afford relatively great air contact surface packed into relatively small cubical volume. For instance, the elements used in domestic refrigeration are in the form of coils and headers, or cubical tanks occupying and filling the space which, before the advent of such improvements, was filled with ice.

The elements just described are always operated at temperatures colder than melting ice and act to induce a rather rapid circulation of a relatively small proportion of the air content of the entire refrigerator, so that the current of air leaves the element at temperatures far below the average temperature of the refrigerator. Therefore, there is always a great difference between the temperature of the element and that of the articles in the refrigerator. With the conventional arrangement of the refrigerating element in a corner of the refrigerator, often isolated by partitions, radiation from warmer objects to such an element is of course quite negligible, since few or none of them can "see" it.

It is an object of the present invention to provide a refrigerating element adapted to cause a rather slow circulation of a relatively large proportion of the air content of the compartment or refrigerator to be cooled and so formed and disposed as to be "seen" by all or most of the objects in the refrigerator so as to take some of their heat by radiation in addition to the convective transfer by way of the circulated air. Another object is to provide a refrigerator having the maximum food storage capacity with the least possible volume lost in the refrigerating element used therewith. Another object is to establish and maintain a more even and more uniform temperature throughout the food storage space. Another object is to provide a freezing element having improved heat absorbing effects upon objects placed within it. A still further object is to attain the above objects with forms of apparatus which are cheaply manufactured and of simplified construction.

It is well known in other arts that the temperatures within a nearly total enclosure tend to reach perfect equality, and such nearly total enclosure is sometimes called a "black body" because it radiates through a small opening in its wall the maximum amount of heat, as does a surface covered with lamp black. My invention further aims to secure in heat absorbing devices, results similar to the effects noted in "black body" structures.

In carrying out my invention I provide both a large surface contact area and a nearly total enclosure by the novel combination with a refrigerating or a freezing compartment of an element forming the lining thereof or a portion of said lining.

In order to illustrate the invention and the manner of its application and use, concrete embodiments thereof are shown in the accompanying drawings in which:

Fig. 1 is a front elevational view of a mechanical refrigerator.

Fig. 2 is a partial, vertical, transverse, sectional view substantially on the line 2—2 of Fig. 1.

Fig. 3 is a view similar to Fig. 2 showing a different form of refrigerating element.

Fig. 4 is a view similar to Fig. 1 showing still another form of refrigerating element.

Fig. 5 is a horizontal sectional view substantially on the line 5—5 of Fig. 4.

Fig. 6 is an enlarged sectional view of a portion of the rear wall of the embodiment shown in Fig. 3.

Fig. 7 is a transverse sectional view through the freezing compartment indicated in Figs. 1 to 4 inclusive, substantially on the line 7—7 of Fig. 8.

Fig. 8 is a longitudinal, vertical, sectional view on the line 8—8 of Fig. 7.

Fig. 1 illustrates the invention as embodied in a mechanical refrigerating outfit for household use comprising a refrigerator A having its lower part provided with a chamber in which are disposed the mechanical parts of the refrigerating apparatus which may include a pump or compressor B and a prime mover for driving the compressor, such as an electric motor C. Above the apparatus chamber are disposed the compartments from which heat is to be extracted. In the present instance two compartments are shown, namely, a freezing compartment D in which liquids are intended to be frozen and a food storage compartment E. The freezing compartment D contains a freezing element *d* and the food storage compartment E a refrigerating element *e*. These elements serve as containers or evaporators for the refrigerant fluid and are connected in series by a suitable duct *f*. The vaporized refrigerant is drawn from the top of element *e* through connection *g* which leads to the inlet of pump B and the discharge of the pump passes through pipe *h* into a condenser (not shown) and thence into element *d*, a suitable throttling or expansion device *i* being interposed to control the rate of feed of the condensed refrigerant.

The invention relates especially to the form, extent, disposition and arrangement of the refrigerating elements utilized to extract heat from the freezing compartment D and the food storage compartment E. In order to attain the desired simplicity and compactness as well as to secure the greatest conservation of space for useful refrigerating purposes the refrigerating elements are preferably constructed so as to enable them to form at least a portion of the lining of the compartments in which they are disposed. The element for the food storage compartment will first be considered since it may conform to or differ from the preferred structure of the freezing element without departing from the objects of the invention. The element may be constructed in a variety of ways and utilized to line any desired part of its compartment. Typical forms and arrangements only are herein shown and described. The type of refrigerating element *e* disclosed in Figs. 1 and 2 is arranged to form the lining for the back and top of the food storage compartment E and comprises a long metal pipe or tube 9 coiled or disposed in substantially horizontal parallel stretches and secured to a metal plate or sheet 9^a with which the coil has good thermal contact so that plate 9^a forming the lining of the back and top of the compartment acts as an efficient heat absorber.

Fig. 3, discloses a slightly different form of refrigerating element *e'* which, however, lines the same parts of the food storage chamber as does the element disclosed in Figs. 1 and 2, namely, the back and top thereof. This evaporator comprises two metal plates 10 and 10^a disposed in face engagement and united in a fluid-tight manner at their peripheries to form therebetween a chamber of restricted volume for the vaporizing refrigerant. Element *e'* is constructed of the proper size and with a right angle bend at 10^b so as to closely fit the rear and top walls of chamber E and form a part of the lining of the compartment. Element *e'* has an inlet connection 10^c at its base leading from freezing element *d* and at its top an outlet 10^d for connection with the compressor.

Figs. 4 and 5 disclose still another arrangement of a refrigerating element in the food storage space E. This element e^2 is similar in structure to that disclosed in Fig. 3 being formed of two sheet metal plates 10 and 10^a disposed in face engagement and peripherally united. This element, however, has two right angular bends at 10^e and 10^f, respectively, and is formed of such proportions as to fit and to line three sides of compartment E, namely, the back and the two sides. The chamber for refrigerant provided by refrigerating element e^2 is enlarged somewhat adjacent the top and bottom of the element in any suitable manner as by outwardly bulging either or both of the plates 10 and 10^a in a substantially horizontal line as indicated at 10^g and 10^h (Fig. 4) and the inlet 10^c and the outlet 10^d make connection with these enlargements respectively as indicated.

Fig. 6 disclosing an enlarged sectional view through a wall of the refrigerator illustrates the disposition of the refrigerating element and the negligible amount of space occupied by the same. The refrigerator wall comprises the outer casing *a* which may be wood, metal, or other suitable material, and a layer of the heat insulating material *a'* forming a relative thick wall within casing *a*. Immediately adjacent the insulating wall *a* is disposed the refrigerating element, either *e*, *e'* or e^2. Fig. 6 happens to illustrate the form of element shown in Figs. 3–5. To maintain the plates 10 and 10^a forming the refrigerating element *e'* or e^2, slightly apart, so as to form a chamber of small but fixed volume for the refrigerant fluid, suitable means are provided. Such means preferably take the form of interior projections upon one or both of the plates. In the present instance, the rear plate 10 has been dented at intervals to form projections 10^f to engage the inner face of plate 10^a. While plate 10^a, which forms a part of the lining of compart-

ment E, may be wavy or corrugated to present a great air contact area instead of plain and smooth as shown it should be in such form as to be easily kept in a clean and sanitary condition.

From the above it will be apparent that even if the refrigerating element used to line the chamber from which heat is to be extracted is made of a thick heavy material so as to withstand successfully high pressures or the impact of heavy objects which might be stored in the chamber, the necessary contact area for heat removal to maintain ordinary refrigerating temperatures can be secured with an extended refrigerating element occupying not more than ten per cent of the cubical volume of the compartment. When conditions safely permit the use of thin walled sheet metal refrigerating elements of the type disclosed in Figs. 3 to 6 as in installations operating in accordance with the process disclosed in my copending application, Serial No. 15,172, filed March 12, 1925, the space occupied by the element is reduced to approximately $\frac{1}{32}$ of the volume of the compartment, a quite insignificant amount in view of the extension of the element.

By using the refrigerating element to line the storage compartment, after the manner disclosed in Figs. 1–5, an important advantage additional to that of the increased space available for useful purposes is secured. This advantage lies in the fact that almost every object placed in the compartment can "see" at least a portion of the element so that heat is withdrawn from the objects by radiation as well as by convection.

Figs. 7 and 8 illustrate a preferred embodiment of the invention particularly adapted for freezing compartments although equally available for compartments intended to operate at a higher temperature, if desired. This element provides an almost total enclosure in which heat is extracted from at least four walls thereof, namely, top, bottom and sides. The structure of the walls conforms substantially to that of the type of element disclosed in Figs. 3–5. The element *d* consists of a double walled enclosure having a lining formed by a metal plate 11 with an outer plate 12 enclosing the same. One of the plates, preferably the inner one 11, is provided with projections 11^a which may be formed by indenting the same as previously described in relation to Fig. 6, so as to slightly space the plates and form therebetween a restricted chamber 13 for the refrigerant fluid. The rear end of the enclosure may be made also with a double wall but as a manufacturing expedient it is closed by a single plate 14. The front end is open for the insertion of receptacles or trays (not shown) containing the liquid to be frozen. The space within the element *d* may be divided by one or more partitions 15 and access is had to the open front end of the element by a suitable closure or door *d'* in the refrigerator cabinet (Figs. 1–4). The inlet pipe *h* for the refrigerating fluid may be disposed adjacent the back of the element as indicated in Figs. 2, 3 and 8 to conduct the fluid into a trough 16 secured to outer plate 12 (Fig. 7), and dispose axially beneath the center of the element. A division plate 17 within trough 16 is secured to inner plate 11 by oppositely bent portions 17^a so as to provide spaced openings at the top of the trough to distribute the entering refrigerant fluid to both sides of the element *d*. The outlet connection *f* leads from the top of element *d* as indicated. By constructing the freezing element *d* as a substantially total enclosure with thin slightly spaced walls the maximum of useful storage space is secured and "black body" conditions are closely approximated.

While preferred forms of the invention have been herein shown and described the invention is not limited to the specific details thereof but covers all changes, modifications and adaptations within the scope of the appended claims.

I claim as my invention:

1. In a mechanically operated refrigerating outfit, a refrigerator having a compartment for containing perishable articles, an extended evaporator member lining at least a part of said compartment for containing a volatile liquid, and means for withdrawing the vapor of the liquid and cause said member to extract heat from said compartment.

2. The combination with a compartment insulated against heat, of a container for volatile liquid built into and forming a part of the lining of said compartment, and means for inducing evaporation of the liquid in said container to extract heat from said compartment.

3. The combination with a compartment insulated against heat, of a metallic lining for said compartment, said lining forming one wall of an extended element for containing evaporating liquid, and means for withdrawing the vapor of said liquid thereby to extract heat from said compartment.

4. The combination with a compartment for perishable articles having insulating material forming the inner portion of the wall of the compartment, of an evaporating element immediately adjacent said insulation and forming a lining for said compartment, and means for inducing evaporation of a liquid contained in said element.

5. The combination with a compartment from which heat is to be extracted, of an evaporator element presenting a large surface area with but small cubical content disposed within said compartment so as to line

a portion of the same and to extract heat therefrom both by radiation and convection, and means for inducing evaporation of a liquid contained in said element.

6. The combination with a compartment having its walls formed of heat insulating material, of a thin evaporator element disposed within said compartment adjacent said heat insulating material to form a lining for at least one wall of the compartment, and means for connecting said element to compressing and condensing members to form a closed cycle refrigerating system of the compressor-condenser-evaporator type.

7. The combination with a compartment having its walls formed of heat insulating material, of an evaporator element lining at least a part of the walls of said compartment and taking up not more than ten per cent of the content space of said compartment, and refrigerating apparatus connected to said element to form a closed cycle system.

8. In a refrigerating system, the combination with a heat-insulating wall of a heat-conducting plate adjacent said wall, means for maintaining a body of volatile liquid in a thin sheet or film between said wall and said plate, and means for removing vapor from said liquid.

9. A mechanical refrigerator comprising a motor-driven compressor, a condenser, and a hollow lining for said refrigerator, and means for feeding liquid from said condenser into said lining to be evaporated by said compressor, said lining being in direct contact with the interior of said refrigerator.

10. In a closed cycle refrigerating system, a freezing compartment and a refrigerating compartment, and interconnected refrigerating elements arranged to contain vaporizing refrigerant and to extract heat from said compartments, one of said elements forming at least a part of the lining of its compartment.

11. In a closed cycle system, a freezing compartment and a refrigerating compartment, refrigerating elements in said compartments arranged to line the same, said elements being interconnected and each arranged to contain vaporizing refrigerant.

12. In a closed cycle system having a plurality of compartments from which heat is to be extracted, an evaporator element in each compartment forming at least a part of the lining of the compartment, and means connecting said elements in series, and pressure reducing means connected to the last elements in the series.

13. A heat absorbing member for refrigerating systems comprising an extended evaporator element arranged to fit within a compartment from which heat is to be extracted and to line a portion of the interior thereof, said element being constructed and arranged to dispose the liquid refrigerant in a thin film or sheet so as to occupy a minimum amount of space within the compartment.

14. A heat absorbing member for refrigerating systems comprising an extended evaporator element formed with a substantially plane face arranged to be disposed within a compartment from which heat is to be extracted so that said face forms the lining of at least a part of the compartment, said element being so thin as to provide merely a film of evaporating liquid in contact with said face.

15. A refrigerating element comprising a pair of metallic sheets joined to each other adjacent their peripheries, one of said plates being indented to provide contact projections for the other plate so as to maintain said plates slightly spaced throughout their full area and provide a chamber therebetween of small volume.

16. A freezing element comprising a metallic container of such proportions as to form a practically total enclosure of the "black body" type, means for maintaining a thin film of liquid in contact with the exterior of said container, and means for inducing vaporization of the liquid.

17. A freezing element comprising a container formed with hollow walls for containing a vaporizing refrigerant, said container having an outlet at the top, and inlet means at the bottom of said element arranged to effect distribution of entering fluid.

18. A freezing element comprising a container formed with hollow walls for containing a vaporizing refrigerant, said container having an outlet at the top, and means disposed longitudinally of said element at the bottom thereof for distributing entering fluid.

19. A freezing element comprising a container formed with hollow walls for containing a vaporizing refrigerant, said container having an outlet at the top, and means forming a trough in the bottom of said element for effecting longitudinal and lateral distribution of entering fluid.

20. A freezing element comprising a container formed with hollow walls for containing a vaporizing refrigerant, said container having an outlet at the top, and inlet means forming a trough disposed longitudinally and centrally beneath said element for distributing entering fluid.

21. A freezing element comprising a container formed with hollow walls for containing a vaporizing refrigerant, said container having an outlet at the top, inlet means forming a trough disposed longitudinally and centrally beneath said element, and a partition within said trough for effecting equal lateral distribution of the entering fluid.

Signed by me at Detroit, Wayne County, Michigan, this 26th day of April, 1926.

RANSOM W. DAVENPORT.