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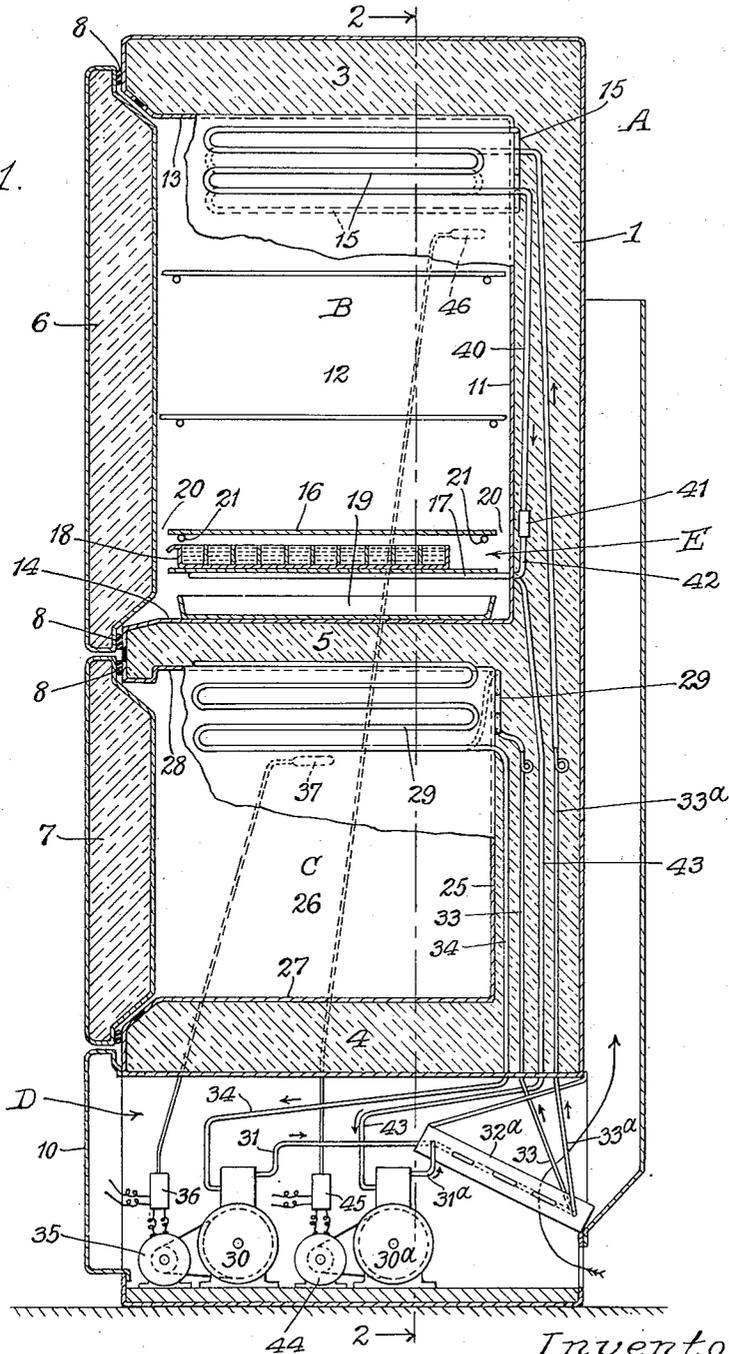
W. D. JORDAN ET AL
TWO-TEMPERATURE REFRIGERATOR, INCLUDING
A HUMIDITY CONTROL SYSTEM

2,493,488

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3 Sheets-Sheet 1

Fig. 1.



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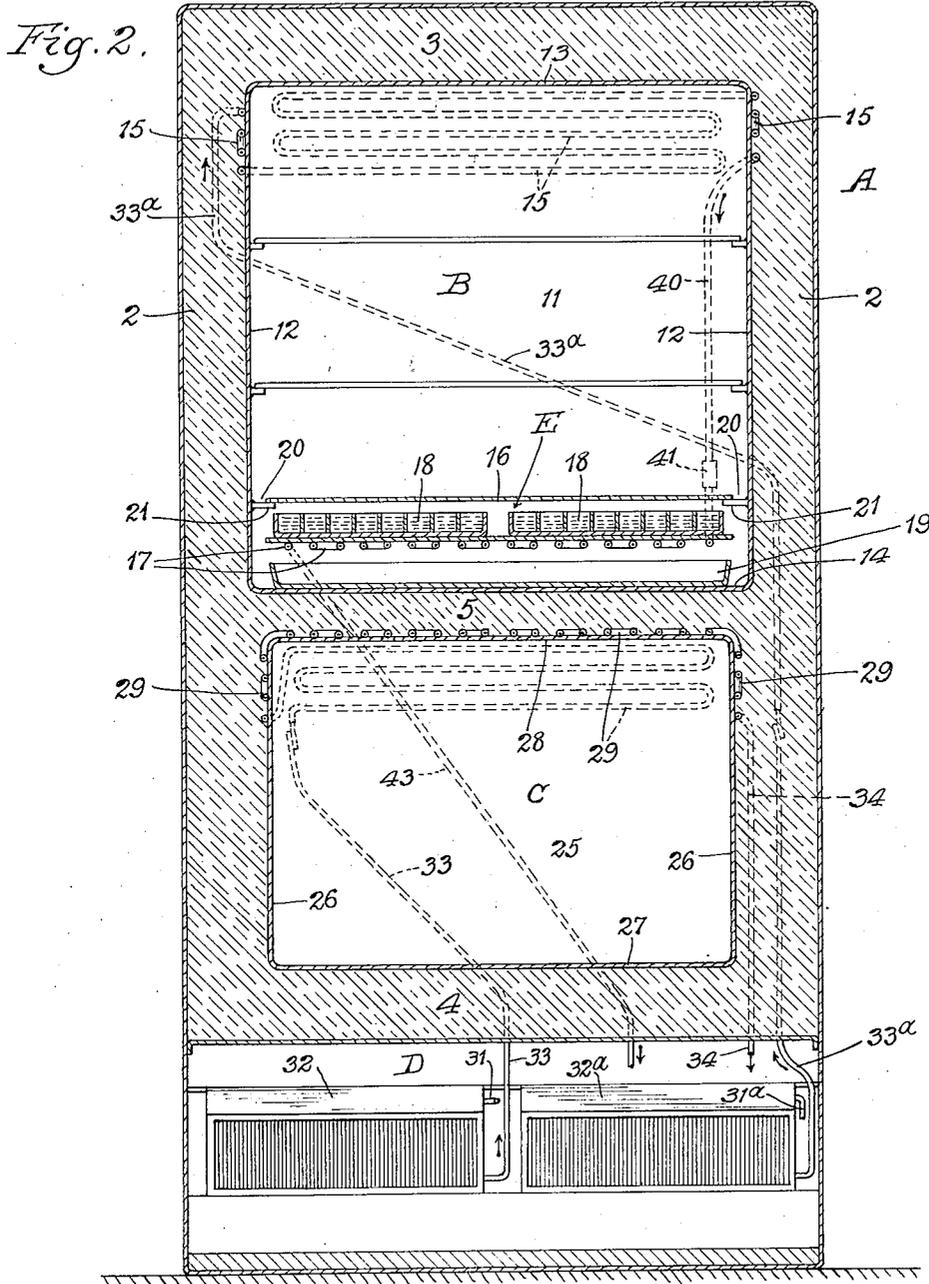
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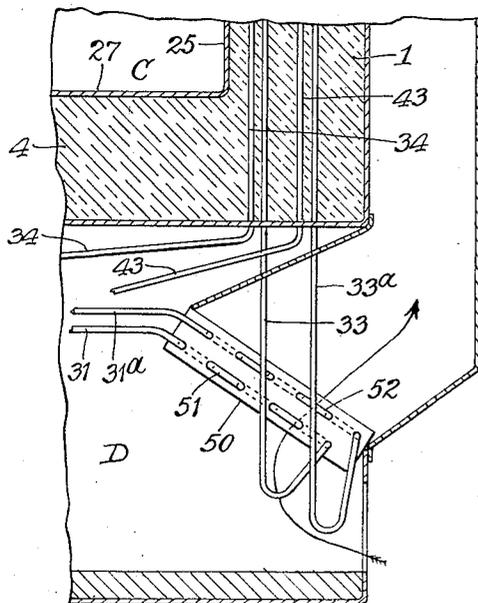
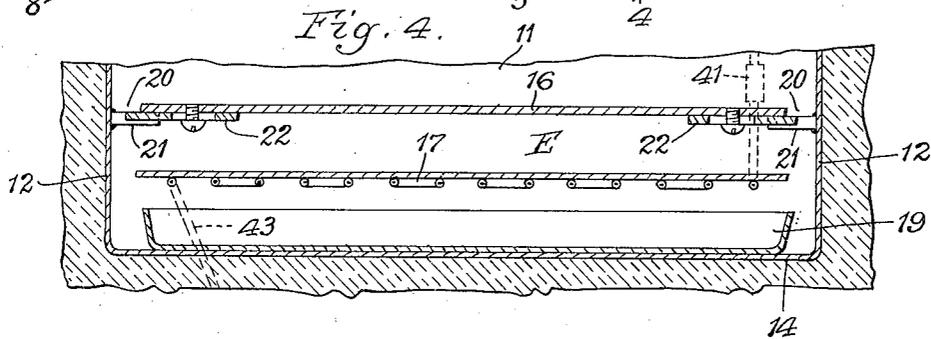
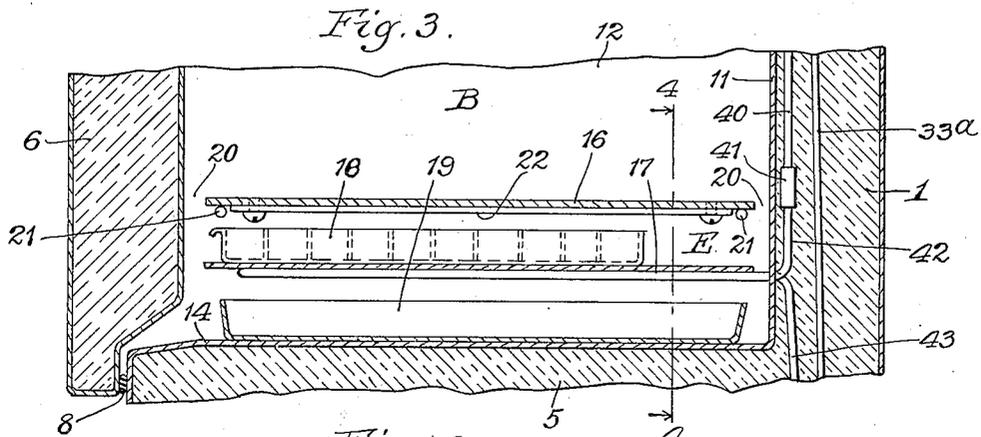
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UNITED STATES PATENT OFFICE

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TWO TEMPERATURE REFRIGERATOR, INCLUDING A HUMIDITY CONTROL SYSTEM

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Application March 21, 1945, Serial No. 583,924

8 Claims. (Cl. 62—116)

1

This invention relates to an improvement in refrigerators and is adapted for use in domestic refrigerators.

One purpose is to provide an improved two temperature refrigerator.

Another purpose is to provide a two temperature refrigerator having separate refrigerating means for a relatively high temperature and a low temperature storage space, the storage spaces being separate, and insulated.

Another purpose is to provide improved means for controlling the relative humidity of air in a refrigerator storage cabinet.

Another purpose is to provide improved means for freezing ice cubes and for at the same time controlling the relative humidity of a refrigerator storage cabinet.

Another purpose is to provide a refrigerator cabinet having means for freezing ice cubes in a relatively high temperature storage space without unduly dehydrating the foods in such storage space.

Another purpose is to provide a means of and method for employing ice cube freezing means to control the relative humidity of a refrigerator storage space in which food is stored at temperatures above freezing.

Another purpose is to provide means for preventing excess humidity in a refrigeration storage cabinet in which the food is stored at temperatures above freezing.

Other purposes will appear from time to time in the course of the specification and claims.

The invention is illustrated more or less diagrammatically in the accompanying drawings wherein:

Figure 1 is a vertical section of a two temperature refrigerator;

Figure 2 is a section at the line 2—2 of Figure 1;

Figure 3 is a sectional view showing a modification of Figure 1;

Figure 4 is a section at the line 4—4 of Figure 3; and

Figure 5 is a sectional view showing a further modification.

Like parts are indicated by like symbols throughout the specification and drawings.

Referring to the drawings, A generally indicates a food storage cabinet including an insulated back wall 1, insulated side walls 2, an insulated top wall 3, an insulated bottom wall 4, and an insulated intermediate partition 5. The above mentioned walls and partitions define two storage compartments which are separated from and insulated from each other. 6 is an insulated door

2

for the upper compartment and 7 an insulated door for the lower compartment. Thus the two storage compartments are insulated from each other and from the outside air. Any suitable gasketing or sealing means 8 may be employed, it being understood that the details of the walls, doors and sealing means do not of themselves form part of the present invention. Any suitable means may be employed for limiting to a minimum heat transfer between the inside of the compartments and the outside air, and between the two compartments.

For convenience, the upper compartment is indicated as B and the lower compartment as C. Located below the lower compartment C is an uninsulated space D for the condensing unit.

The upper storage compartment B is preferably held at a relatively high temperature, as from 35 to 45 degrees Fahrenheit. The interior of the compartment C may be maintained at a temperature substantially below freezing, as from 0 to 10 degrees in order to adapt it for quick freezing and for cold storage of frozen goods.

In the form of Figures 1 and following a dual refrigerating system is employed having two separate refrigerant condensing units, with evaporators in circuit with each unit, there being thus a complete and independent refrigerating system for each of the above mentioned storage compartments.

Referring to the details of the compartments, it is advantageous to employ a liner or sleeve of sheet metal for each compartment, with evaporator coils on the exterior of each such sleeve, in heat transfer relationship therewith. In connection with the upper compartment B is indicated a sleeve including a vertical rear wall 11, side wall 12, a top wall 13 and a bottom wall 14. 15 indicates an evaporator coil which may extend about three sides of the liner or sleeve thus formed, namely about the rear wall 11 and each of the side walls 12. The length of the coil and the area of walls with which it is in contact may be varied to cause the refrigerant to be evaporated at the desired temperature, preferably somewhat above freezing, to prevent frost and to minimize dew formation on the walls, and to insure a sufficiently high relative humidity to prevent dehumidification of stored food. The storage space of the compartment B is bounded at the bottom by an insulating food storage shelf 16 which is shown as supported several inches above the bottom wall 14, of the upper sleeve. It is convenient to identify the space below the insulating food shelf as the ice cube forming and storage com-

3

partment E. In the compartment E is illustrated a shelf including an evaporator coil 17, this coil or evaporator being in series with the evaporator 15. A restrictor 41 is interposed in the line 40 between evaporator 15 and evaporator 17, to reduce refrigerant pressure on evaporator 17, which is thus made effective to freeze the contents of any suitable ice cube tray or trays 18. Positioned below the evaporator 17 is any suitable defrosting pan 19. Any suitable gap or gaps 20 may be employed between the insulating shelf 16 and the side walls and door of the compartment B. This air gap provides a connecting vapor path or paths between the compartment E and the compartment B, to permit excess water vapor to be withdrawn from the air in compartment B. The storage shelf 16 may be permanently fixed in relation to the upper sleeve, with suitable gaps or apertures provided, or it may be removably mounted on any suitable supports such as the spacing and supporting pins 21. In the forms of Figures 3 and 4 are illustrated details of adjusting shutters which may be employed to vary the gap between the compartments B and E. We illustrate for example adjustable shutters 22 which may be mounted on the bottom of the shelf 16 and may be moved toward and away from the side walls of the upper shelf in order to vary and control the air gap. It will be understood however that any other suitable means may be employed for maintaining the desired control. Or, it may be advantageous to omit any such variable control means and to design the gap from shelf to wall to produce the desired average condition.

In compartment C is a liner sleeve including the back wall 25, side walls 26, bottom wall 27 and top wall 28. As in the case of the upper sleeve, any suitable evaporator coil 29 may extend about the sleeve, being preferably exterior thereto but in heat transfer relationship therewith. The length and shape of the coil may be varied to suit desired conditions but it may advantageously extend about the walls 25, 26 and 28, being preferably omitted from the bottom wall 27.

With reference to the refrigerant condensing unit, any suitable means may be used. The particular mechanisms herein illustrated, however, are of the mechanical type. With reference to their details, two compressors are employed, 30 for the lower sleeve and 30a for the upper sleeve. The refrigerant is delivered under pressure along the ducts 31 and 31a respectively, to any suitable condensers 32, 32a. From the condensers 32 and 32a liquid refrigerant flows to evaporators 15 and 29 through pressure lines 33, 33a in the form of small bore tubing or restrictor tubes. Any other suitable means may be employed for feeding refrigerant. The lower sleeve, is thus cooled to a temperature from zero to plus 15 degrees Fahrenheit, and the evaporated refrigerant returns by the suction line 34 to the compressor 30. 35 indicates any suitable motor for the compressor 30, which may be controlled by any suitable thermostatically operable switch 36, which may for example include the bulb 37 in the compartment C.

Tracing the circuit for the upper sleeve, the liquid refrigerant is delivered through the restrictor tube 33a to the evaporator 15, cooling that sleeve to a temperature between 35 and 45 degrees. Preferably the refrigerant is evaporated at such a pressure and corresponding temperature in evaporator 15, that the surface of the upper sleeve is kept at or above freezing, thus preventing the formation of frost and minimiz-

4

ing deposit of dew on the walls. Refrigerant from the evaporator 15 flows through the return passage 40 to any suitable restriction 41, which causes a further pressure drop and consequent temperature drop in the refrigerant which thereafter flows through the passage 42 to the evaporator 17 and there evaporates at a temperature low enough to cause the freezing of ice cubes or other material in the compartment E. The evaporated refrigerant then returns along the return duct 43 to the compressor 30a. 44 indicates a motor for the compressor 30a, this motor being controlled by any suitable means such as for example the thermally operable switch 45 associated with the bulb 46 located at any suitable point in the upper compartment.

With reference to Figure 1 it will be understood that the motors 35 and 44 may be employed to drive fans which circulate air through the individual condensers 32 and 32a, or a chimney at the rear of the enclosing structure may be used to create an air current through the condenser. In the form of Figure 5 a double circuit condenser 50 is illustrated which includes separate condenser coils 51 and 52, one being in circuit with the compressor 30 and the other with the compressor 30a, but both coils associated with a single fin structure.

Whereas we have shown the ice freezing shelf 17 at the bottom of the upper compartment B, it will be understood that under some circumstances it may be placed at the top or the side of the compartment, with any suitable enclosure means limiting interchange of air between compartments B and E through convection currents, but making possible the free movement of water vapor between the compartments.

It will be realized that, whereas, a practical and operative device is described and illustrated, nevertheless many changes may be made in the size, shape, number and disposition of parts without departing from the spirit of the invention. Therefore the description and drawings are to be taken as in a broad sense illustrative or diagrammatic rather than as limited to the precise showing.

The use and operation of the invention are as follows:

The domestic refrigerator of the usual type has an evaporator serving both to cool the food storage space and to freeze ice. To freeze ice the evaporator must operate at a refrigerant temperature so low as to produce excessively dry air. The relative humidity of the air to which food is exposed may run from 20 to 40% which dehydrates meats, fruits and vegetables.

To avoid that dehydration it is the practice with some to cool the space by means of a refrigerated liner surface, the cool area being sufficiently great so that the sleeve temperature need be only a few degrees below the wanted space temperature, with a minimum of around 32 degrees. This cold wall will assume a higher temperature during off-cycles of the condensing unit due to heat leakage through insulation to the liner wall. It may rise to 40 degrees or above. By this means much less moisture is condensed from the air and the relative humidity is therefore high.

Moisture entering with new air admitted when the door is opened will condense as dew largely on the coldest surfaces—the liner wall during the on-cycles—and will partly or wholly evaporate during off-cycles when the wall is warm. The extent of the evaporation will be limited by

the time between on-cycles and the relative vapor pressures between water on the cold wall and water in the air.

Should the cold wall rise to 40 degrees the vapor pressures will come to balance at 100% humidity, providing sufficient time elapses for evaporation between on-cycles. Actually the cold wall may exceed 40 degrees.

With air at such high humidity there is certain to be condensation of moisture on shelves and stored food at times when the temperature of the wet wall is above that of the shelves and stored food. This creates an unsanitary condition and causes deterioration of meats and other foods. Another fault is that in humid weather sufficient moisture may enter with incoming air to cause water to condense on and run down the side walls and pool on the liner floor. This also is unsanitary.

In our refrigerator we use the cold wall means for space cooling, with the refrigerant coil external to but in thermal contact with the sleeve. To correct the faulty conditions mentioned we use the colder surface of the ice freezing evaporator to condense such water vapor as would cause a humidity above, say 85%.

We place the refrigerated ice cube freezing shelf near the floor of the liner and locate a storage shelf of low heat conductivity immediately above it. This storage shelf is dimensioned to give an open space on all sides to permit water vapor to pass from the upper storage chamber to the cold shelf space.

We place the shelf at the bottom of the liner to prevent air interchange between the two spaces by convection, the colder air surrounding the ice freezing shelf being colder and therefore denser. Water vapor, however, is free to pass downward under a head set up by the differential in vapor pressures above and below, and this vapor flow is controlled in amount by the size of the openings provided between the lower food shelf and surrounding walls, as well as by the refrigerant temperature maintained in the ice freezing coil.

The ice freezing coil temperature, selected for purposes both of controlling humidity and of freezing ice at the required rate, is obtained by interposing a fixed restrictor between the space cooling coil and the ice freezing coil, resulting in a temperature of sleeve surface at or slightly above 32 degrees and in the ice coil of from 10 to 15 degrees. These vary during the cycle and with the conditions of loading.

By this construction we find it readily possible to hold the relative humidity at from 60 to 85% under widely varying ambient air conditions. At such humidities the liner wall may at times be moist when door openings are frequent in humid weather but at no time does it run down the wall or deposit on shelves or food.

Food is not dehydrated and open storage of food is made possible, avoiding the loss of space occasioned by the use of covered containers.

It is not essential that the ice freezing shelf be located at the bottom of the food storage chamber. An insulating housing around an ice freezing shelf or shelves at top or side, so arranged as to prevent interchange of air by convection currents but permitting vapor movement, will give the same control of humidity.

The refrigerator described may be made alone or we may combine it with a second food compartment, all within one insulated housing, refrigerated with a second expansion coil and condensing unit, holding a temperature below freez-

ing for storage of frozen foods. In this case the two refrigerating systems are wholly separate and independent in operation.

Or we may use a single condenser structure having a single fin assembly but two separate refrigerant tube circuits, both in thermal contact with the same fins, this 2-circuit condenser serving two otherwise independent refrigerating means.

We may also utilize a single condensing unit to refrigerate both sleeves in accordance with the system described in our co-pending application Serial No. 583,925, filed March 21, 1945, now Patent No. 2,462,240, granted Feb. 22, 1949, on a two temperature refrigerator system, in which case the warmer sleeve is controlled as to humidity exactly as described above.

Certain variations may be made in the design described above, as the use of a variable restrictor instead of the fixed restrictor between the space cooling and the ice freezing evaporators. Or the opening between the lower food shelf and the outer walls may be varied in area by means such as dampers to permit the user to obtain variations in humidity. We may also place the ice freezing shelf at the side or top of the food storage compartment, with an enclosure limiting or preventing cold air leaving the ice freezing compartment but maintaining the free movement of water vapor. Such variations are within the scope of this patent application.

We claim:

1. In a domestic refrigerator having two storage chambers thermally insulated from each other and from the outside, a single work chamber, two independent refrigerant condensing units in said work chamber, common means for maintaining a cooling circulation of air past both said condensing units, an evaporator effective in each storage chamber, two independent refrigerant circuits each including one of said evaporators and one of said condensing units, and an ice freezing evaporator, in one of said storage compartments, in series with one of said first mentioned evaporators.

2. In a refrigerator including a cabinet having two storage chambers thermally insulated from each other and from the outside, a single work chamber, two independent refrigerant condensing units in said work chamber, common means for maintaining a cooling circulation of air past both said condensing units, an evaporator effective in each storage chamber, two independent refrigerant circuits each including one of said evaporators and one of said condensing units, and an ice freezing evaporator, in one of said storage compartments, in series with the evaporator of the same storage compartment.

3. In a refrigerator including a cabinet having two storage chambers thermally insulated from each other and from the outside, a single work chamber, two independent refrigerant condensing units in said work chamber, common means for maintaining a cooling circulation of air past both said condensing units, an evaporator effective in each storage chamber, two independent refrigerant circuits each including one of said evaporators and one of said condensing units, an ice freezing evaporator near the bottom of one of said storage chambers, in series with the evaporator of that chamber, and insulating partition means, in said storage chamber, above said ice freezing evaporator, adapted to define an ice compartment and a food storage compartment within that chamber, there being communication be-

7

tween the two compartments thus formed, adapted to provide water vapor transfer without air transfer between the compartments.

4. In a refrigerator having two storage chambers thermally insulated from each other and from the outside, a single work chamber, two independent refrigerant condensing units in said work chamber, common means for maintaining a cooling circulation of air past both said condensing units, an evaporator effective in each storage chamber, two independent refrigerant circuits each including one of said evaporators and one of said condensing units, an ice freezing evaporator near the bottom of one of said storage chambers, in series with one of said first mentioned evaporators, insulating partition means, in said storage chamber, above said ice freezing evaporator, adapted to define an ice compartment and a food storage compartment within that chamber, there being communication means between the two compartments thus formed, adapted to permit water vapor transfer without air transfer between the compartments, and means for varying the effective vapor transfer capacity of said communication means.

5. In a domestic refrigerator system, a food storage compartment, a refrigerant condensing unit, an evaporator adapted to cool the upper inside surface of said compartment, an ice cube shelf within the compartment, an evaporator for said shelf, in series with and following said first mentioned evaporator, a restrictor between said evaporators, adapted to reduce the pressure and temperature of the ice cube evaporator below the pressure and temperature of the first mentioned evaporator, and an insulating partition defining an ice cube shelf zone within the compartment but adapted to permit communication between that zone and the compartment, and means for controlling said communication.

6. In a domestic refrigerator system, a food storage compartment, an evaporator adapted to cool the upper inside surface of said compartment, an ice cube shelf located near the bottom of the compartment, an evaporator for said shelf, in series with and following said first mentioned evaporator, a restrictor between said evaporators, adapted to reduce the pressure and temperature of the ice cube evaporator below the pressure and temperature of the first mentioned evaporator, means for delivering liquid refrigerant to the first evaporator and for withdrawing the evaporated refrigerant from the ice cube evaporator, and a partition located above the ice cube shelf and extending toward but spaced from the walls of the

8

compartment, said partition having one or more gaps adapted to permit water vapor flow from the space above to the space below said partition.

7. In a domestic refrigerator system, a food storage compartment, an evaporator adapted to cool the upper inside surface of said compartment, an ice cube shelf located near the bottom of the compartment, an evaporator for said shelf, in series with and following said first mentioned evaporator, a restrictor between said evaporators, adapted to reduce the pressure and temperature of the ice cube evaporator below the pressure and temperature of the first mentioned evaporator, means for delivering liquid refrigerant to the first evaporator and for withdrawing evaporated refrigerant from the ice cube evaporator, a partition located above the ice cube shelf and extending toward but spaced from the walls of the compartment, said partition having one or more gaps adapted to permit water vapor flow from the space above to the space below said partition, and means for varying the effective cross sectional area of said gaps.

8. In a domestic refrigerator system, a food storage compartment having a liner of heat conductive material, an evaporator constructed and arranged to cool the upper walls of said liner, a shelf adapted to receive ice cube trays, located adjacent the bottom of said compartment, an evaporator arranged to cool said shelf, means for circulating a volatile refrigerant through said evaporators, a restriction between said evaporators, said circulating means being adapted to supply liquid refrigerant to the first mentioned evaporator and to withdraw gaseous refrigerant from the second evaporator, and an insulating partition located above said ice cube shelf, and extending between but spaced from the walls of said compartment.

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