Dec. 11, 1945. D. F. NEWMAN 2,390,808

REFRIGERATOR

Filed July 21, 1943

Fig. 1.

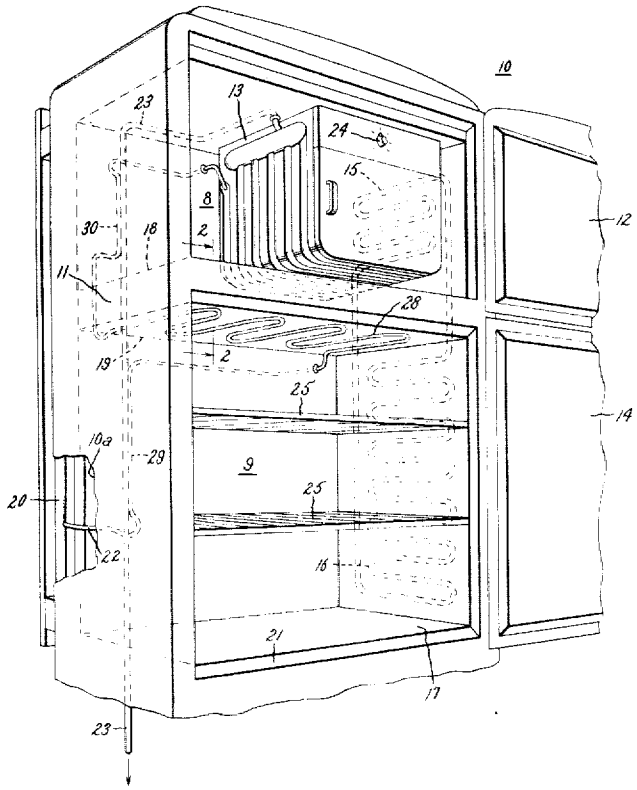


Fig. 2.

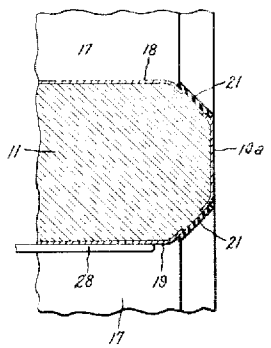
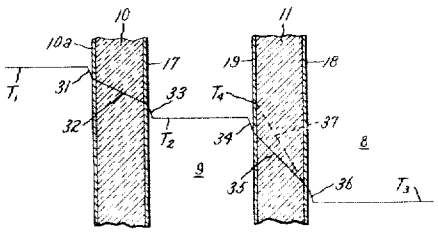


Fig. 3.



Inventor:
Delbert F. Newman,
by Harry E. Dunham
His Attorney.

Patented Dec. 11, 1945 2,390,808

UNITED STATES PATENT OFFICE

2,390,808

REFRIGERATOR

Delbert F. Newman, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application July 21, 1943, Serial No. 495,639

6 Claims. (Cl. 62—116)

My present invention relates to refrigerators including cabinets having a plurality of temperature zones and more particularly to arrangements for minimizing undesired condensation of moisture within the higher temperature zones.

This is a continuation-in-part of my copending application, Serial No. 422,894, filed December 13, 1941, and assigned to the same assignee as the present application.

Refrigerators have heretofore been proposed and constructed which comprise cabinets in which the available storage space is divided into different temperature zones. For example, a freezing compartment and a food storage compartment may be arranged adjacent each other in the cabinet and quite frequently the freezing compartment is arranged directly above the higher temperature food compartment. The food compartment is usually designed to be operated at a relatively high temperature such as 45° F., for example, for the general storage of foods at relatively high humidity. The separation of the freezing zone and the food storage zone may be accomplished by providing an insulating partition completely or substantially eliminating direct communication between the two compartments and refrigerating apparatus is provided for suitably cooling the compartments to their required temperatures. The warmer food storage compartment is operated above the freezing point of water and at a relatively high humidity. Under certain conditions of operation the inherent cooling of the partition due to the operation of the freezing compartment cooler will be sufficient to cause a condensation of moisture on the wall of the food compartment adjacent the freezing compartment. This condensation is objectionable since it becomes necessary to provide some arrangement for conducting away and removing the condensate. Condensation is particularly objectionable when it occurs on the top wall of the food storage compartment from which it may drip onto the articles stored in the compartment. Accordingly, it is an object of my invention to provide a refrigerator having compartments maintained at different temperatures and comprising an improved arrangement for minimizing the transfer of heat from the air in the higher temperature compartment directly through the partition between the compartments to the cooling element in the lower temperature compartment.

Further objects and advantages of my invention will become apparent as the following description proceeds, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

For a better understanding of my invention, reference may be had to the accompanying drawing in which Fig. 1 is a perspective view of a portion of a refrigerator cabinet of the domestic type embodying my invention, Fig. 2 is an enlarged sectional view of a portion of the cabinet of Fig. 1 on the line 2—2 thereof, and Fig. 3 is a graph of the temperature gradients prevailing in portions of the refrigerator of Fig. 1.

Briefly, the refrigerator illustrated in the drawing comprises a thermally insulated cabinet divided into two compartments by a thermally insulated partition. The upper compartment is cooled by a freezing unit and the lower compartment by a refrigerating system of the secondary type having its condensing portion arranged in heat exchange relationship with the freezing unit. The arrangement of the compartments is such that there is a tendency for the partition to be substantially cooled by the operation of the freezing unit so that the temperature of the wall of the partition adjacent the lower compartment may be so low that condensation of moisture results. In order to prevent the condensation of moisture, the side of the partition adjacent the lower compartment is supplied with heat generated in the refrigerating machine during the operation thereof so that the temperature of that side is maintained in the neighborhood of the temperature of the air in the lower compartment. This minimizes the transmission of heat from the lower compartment through the partition.

Referring now to the drawing, the refrigerator shown in Fig. 1 comprises a cabinet 10 having thermally insulated walls divided by a partition into an upper compartment 8 and a lower compartment 9 by a thermally insulated partition 11. The upper compartment 8 is a freezing or cold compartment closed by a door 12 and provided with a primary refrigerant evaporator or cooling unit 13. The lower compartment is provided with a thermally insulated door 14 and is cooled by a secondary type refrigerating system comprising a closed refrigerant circulating conduit formed to provide a condensing portion 15 in heat exchange relation with the evaporator 13 and a refrigerant vaporizing portion 16 in heat exchange relation with the lower food compartment. The secondary system is a form of heat transfer device frequently employed, the closed conduit being partially filled with a vaporizable liquid; the liquid is vaporized by the absorption of heat in the evaporating portion 16 and is condensed in the

portion 15, the liquid returning to the portion 16 by gravity. The walls of the cabinet 10 comprise an outer sheet metal casing 10a and a sheet metal inner liner 17 spaced therefrom, the space being filled with thermal insulation. The top and bottom walls of the partition 11 indicated, respectively, at 18 and 19 are also constructed of sheet metal, and the spaces between the edges of the metal sheets 17, 18 and 19 and the outer casing 10a are closed by breaker strips 21 of suitable non-hygroscopic material of low thermal conductivity. The evaporating portion 16 of the secondary system is secured in direct heat exchange relation with the liner 17 along one side wall of the lower compartment. Liquid refrigerant is supplied to the evaporator 13 from an air cooled condensing and liquefying unit 20 mounted on the back of the cabinet 10, the liquid being conducted to the evaporator through a liquid line or capillary tube 22. A refrigerant compressing and circulating unit (not shown) is connected in the usual manner to withdraw refrigerant from the evaporator 13 through a suction line 23 and to supply hot compressed refrigerant to the condenser 20.

During the normal operation of the refrigerating machine the doors 12 and 14 are closed and the evaporator 13 cools the upper compartment to a suitable freezing temperature while the lower compartment is cooled by the secondary system 15, 16 to a temperature above freezing but sufficiently low to provide adequate preservation of food-stuffs. This arrangement makes it possible to maintain relatively high humidity in the lower compartment 9 and renders it unnecessary to provide separate closed containers for maintaining the high humidity required for certain foods. Any suitable control systems arranged to operate in accordance with good refrigeration practice to maintain the desired temperatures in the upper and lower compartments may be employed. The control devices themselves form no part of the present invention and have, therefore, not been illustrated; a temperature adjusting knob 24 is shown on the upper panel of the evaporator 13.

During the operation of the refrigerator heat tends to flow from the higher temperature compartment 9 through the partition 11 to the lower temperature compartment 8 and thereby tends to reduce the temperature of the sheet metal wall 19 of the partition to a value lower than the temperature of the air in the compartment 9; as a result moisture may condense from the air in the compartment and collect on the wall 19 from which it may drip onto articles placed on shelves 25 in the compartment.

In order to prevent the condensation of moisture on the partition 11, an arrangement is provided for supplying heat to the plate 19 to raise its temperature to the temperature of the air in the compartment 9 or higher thereby preventing the transfer of heat from the air in the compartment through the partition 11. As shown in Fig. 1 a capillary tube 22 is provided with a sinuous or zigzag portion 28 extending across the lower side of the wall 19 in good heat exchange relation therewith. Compressed refrigerant leaving the compressing unit is hot and is cooled sufficiently to be condensed in the condenser 20, however, the liquid refrigerant passing through the capillary tube 22 still contains a substantial quantity of heat and the portion 28 of a capillary tube utilizes this heat for raising the temperature of the plate 19 of the partition 11. The partition 11 is provided with sufficient thermal insulation to retard the cooling of the plate 19 during the "off" period of the refrigeration cycle when additional liquid refrigerant is not being supplied to the tube 22. It will readily be understood by those skilled in the art that the amount of insulation in the partition 11 may be determined with a view to preventing an undue fall in temperature of the plate 19 during the "off" period. Portions of the capillary tube 22 may be arranged in heat exchange relation with the suction line 23 in a manner well known in the art to increase the efficiency of the refrigerating machine. For example, a portion 29 of the capillary tube between the condenser 20 and the portion 28 may be connected in heat exchange relation with the suction line 23, and a portion 30 between the portion 28 and the evaporator 13 may also be connected in heat exchange relation with the suction line. It will be understood that the heat exchange portions 29 and 30 are used only when there is more heating capacity in the liquid refrigerant in the tube 22 than is required for heating the wall 19 of the partition.

The graph in Fig. 3 illustrates the temperature gradients prevailing between the air outside the refrigerator cabinet and the air in the compartment 9 and the air in the compartment 8. In this figure the wall 10 may be considered as the left side wall of the compartment 9 as viewed in Fig. 1, the partition 11 being shown parallel to the side wall merely in order to indicate the temperature gradient as a continuous downwardly extending line. In Fig. 3 the horizontal line T_1 represents the ambient temperature outside the cabinet, the horizontal line T_2 the temperature within the compartment 9, and the horizontal line T_3 the temperature in the compartment 8. In passing from the ambient temperature T_1 to the wall 10a there is a drop in temperature indicated at 31 through a stagnant layer or skin of air immediately adjacent the surface of the wall. The temperature drop through the insulation is indicated at 32 and a drop 33 between the wall 17 and the temperature of the air in the compartment 9 occurs in the stagnant layer of air adjacent the liner 17. The width of the skin or stagnant layer of air has been exaggerated for purposes of illustration, it being known in the art that there is a measurable temperature drop between a wall and the air circulating over the wall. The drops in gradients at temperature T_2 to temperature T_3 shown at 34, 35 and 36, correspond to the drops 31, 32 and 33 in the wall of the cabinet 10. It is evident that the temperature at the surface of the wall 19 is lower than the temperature T_2 of the air in the compartment 9. This air is therefore cool and condensation may result when the relative humidity is sufficient high. By providing the liquid line 28 in heat exchange with the sheet metal wall 19, the temperature of the wall, for example, may be raised to a value at T_4 which is the same as the temperature of the wall 17 and it is thus obvious that no heat may be transferred from the air of the compartment 9 at the temperature T_2 to the wall 19 at the temperature T_4. The wall 19 may, of course, be heated to any suitable temperature at least as high as the temperature T_2 and preferably at least as high as T_4. It is clear that if the wall 19 is heated to the temperature T_2 or higher there can be no transfer of heat from the air to the wall and, consequently, heat cannot be removed from the air to produce condensation of moisture on the wall. By raising the temperature of the wall to a value higher than T_2 there is provided a margin of

safety such that a drop of the temperature T_4 during the "off" period of the refrigerating cycle will not lower the temperature of the wall below the temperature T_2, the lag in temperature reduction being due to the presence of the insulation in the wall 11. The temperature gradient from the heated wall 19 to the wall 18 is indicated by the dotted line 37. When a cool surface such as provided by the evaporator portion 16 of the secondary system exists in the compartment 9, the temperature of this surface substantially determines the dew point of the air in the compartment 9 and moisture will not normally collect on those surfaces which are at a higher temperature; however, when the door 14 is opened there is a rush of warm moist air into the compartment 9. Thus upon opening the door some condensation may occur on the partition 11 as well as on the cold side wall; however, the amount of moisture collected in this manner is not sufficient to cause dripping of the condensate, and after the door is closed any moisture condensed on the plate 11 evaporates and migrates to the colder surface.

While the secondary cooling system has been illustrated as arranged in heat exchange with one side wall of the compartment 9, it will be understood that this portion may be disposed wherever supplemental cooling is desired. For example, the cooling portion 16 may extend around all the side walls and the bottom wall of the compartment. The condensing portion 15 of the secondary system may be disposed in any suitable relationship with the evaporator 13 which provides sufficient cooling to maintain the secondary system in operation.

The particular arrangement of the capillary tube 28 on the sheet metal wall 19 is immaterial so long as an adequate distribution of the heat is obtained. For example, the tube may be secured to the plate by soldering or it may be formed as a suitable passage in the wall 19 as by constructing the wall 19 of complementary sheet metal portions having a zigzag path formed therethrough.

While I have described my invention in connection with a two-temperature household refrigerator in which the freezing compartment is arranged above the high humidity food storage compartment other applications will readily be apparent to those skilled in the art. I do not, therefore, desire my claims to be limited to the particular construction shown and described and I intend by the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A refrigerator comprising a cabinet having thermally insulated walls, a thermally insulated partition for dividing the interior of said cabinet to provide two compartments within said cabinet, refrigerating means arranged in said cabinet for cooling said compartments, said means being arranged to maintain one of said compartments at a lower temperature than the other of said compartments, said means tending to cool the surface of said partition within said other compartment to a temperature below the normal temperature of the air in said other compartment, and means disposed in heat exchange relation with said partition on its side adjacent said other compartment for maintaining the temperature of the surface of said partition within said other compartment at least as high as the temperature of the air within said other compartment whereby the transfer of heat from the air in said other compartment through said partition is minimized.

2. A refrigerator comprising a cabinet having thermally insulated walls and a thermally insulated partition dividing said cabinet into a freezing compartment in the upper portion thereof and a food storage compartment below the freezing compartment, means including a cooling element arranged in said freezing compartment for cooling both compartments of said cabinet and for maintaining said freezing compartment at a lower temperature than said food storage compartment, said means tending to cool the surface of said partition within said food compartment to a temperature below the normal temperature of the air in said food compartment, means for supplying liquid refrigerant to said cooling element, and means disposed in heat exchange relation with the side of said partition adjacent said food compartment and utilizing heat of the liquid refrigerant for maintaining the temperature of the surface of said partition within said food compartment sufficiently high to minimize the transfer of heat from said food compartment through said partition to said freezing compartment.

3. A refrigerator comprising a cabinet having thermally insulated walls and a thermally insulated partition dividing said cabinet into two compartments, means including a cooling element arranged in one of said compartments for cooling both said compartments and for maintaining said one compartment at a lower temperature than the other of said compartments, said means tending to cool the surface of said partition within said other compartment to a temperature below the normal temperature of the air in said other compartment, and means including a liquid line for supplying liquid refrigerant to said cooling element, at least a portion of said liquid line being disposed in heat exchange relation with the side of said partition adjacent said other compartment for supplying heat to said side to maintain the temperature of the surface of said partition within said other compartment sufficiently high throughout the normal range of operation of said refrigerator to minimize the transfer of heat from said other compartment through said partition to said one compartment.

4. A refrigerator comprising a cabinet having thermally insulated walls and a thermally insulated partition for providing two compartments within said cabinet, said partition comprising sheet metal walls spaced apart and provided with thermal insulation therebetween, means including a cooling element arranged in one of said compartments for cooling both said compartments and for maintaining said one compartment at a lower temperature than the other of said compartments, said means tending to cool the surface of said partition within said other compartment to a temperature below the normal temperature of the air in said other compartment, means including a capillary tube for supplying liquid refrigerant to said cooling element, at least a portion of said capillary tube being arranged in heat exchange relation with the one of said metal walls of said partition adjacent said other compartment for maintaining the temperature of the surface of said one wall within said other compartment sufficiently high throughout the normal range of operation of said refrigerator to minimize the transfer of heat from the air in said other compartment through said partition to said cooling element.

5. A refrigerator comprising a cabinet having thermally insulated walls and a thermally insu-

lated partition for providing two compartments within said cabinet, said partition comprising sheet metal walls spaced apart and provided with thermal insulation therebetween, means including a cooling element arranged in one of said compartments for cooling both said compartments and for maintaining said one compartment at a lower temperature than that of the other of said compartments, said means tending to cool the surface of said partition within said other compartment to a temperature below the normal temperature of the air in said other compartment, means including a capillary tube for supplying liquid refrigerant to said cooling element, a suction line for removing vaporized refrigerant from said cooling element, at least a portion of said capillary tube being arranged in heat exchange relation with the one of said metal walls of said partition adjacent said other compartment for maintaining the temperature of the surface of said one wall within said other compartment sufficiently high throughout the normal range of operation of said refrigerator to minimize the transfer of heat from the air in said other compartment through said partition to said cooling element, a portion of said suction line being arranged in heat exchange relationship with said capillary tube for limiting the amount of heat in the liquid refrigerant flowing to said portion of said tube in heat exchange with said wall of said partition.

6. A refrigerator comprising a cabinet having thermally insulated walls and a thermally insulated partition dividing said cabinet into two compartments, a primary evaporator arranged in one of said compartments for providing a freezing zone, a secondary cooling system having a condensing portion in heat exchange relation with said primary evaporator and an evaporating portion arranged for cooling the other of said compartments, said primary evaporator also tending to cool said other compartment by the transfer of heat through said partition from the air in said other compartment, means for supplying liquid refrigerant to said primary evaporator, and means arranged in heat exchange relation with the side of said partition adjacent said other compartment and utilizing the heat of the liquid refrigerant supplied to said primary evaporator for maintaining the temperature of the surface of said side within said other compartment sufficiently high throughout the normal range of operation of said refrigerator to minimize the transfer of heat from said other compartment through said partition to said primary evaporator whereby the lowest temperature in said other compartment is determined by said evaporating portion of said secondary system.

DELBERT F. NEWMAN.

Certificate of Correction

Patent No. 2,390,808. December 11, 1945.

DELBERT F. NEWMAN

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 58, for "sufficient" read *sufficiently*; page 3, first column, line 23, for "plate 11" read *plate 19*; page 4, first column, line 30, claim 5, after "said" insert *one*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of May, A. D. 1946.

[SEAL]

LESLIE FRAZER,
First Assistant Commissioner of Patents.

lated partition for providing two compartments within said cabinet, said partition comprising sheet metal walls spaced apart and provided with thermal insulation therebetween, means including a cooling element arranged in one of said compartments for cooling both said compartments and for maintaining said one compartment at a lower temperature than that of the other of said compartments, said means tending to cool the surface of said partition within said other compartment to a temperature below the normal temperature of the air in said other compartment, means including a capillary tube for supplying liquid refrigerant to said cooling element, a suction line for removing vaporized refrigerant from said cooling element, at least a portion of said capillary tube being arranged in heat exchange relation with the one of said metal walls of said partition adjacent said other compartment for maintaining the temperature of the surface of said one wall within said other compartment sufficiently high throughout the normal range of operation of said refrigerator to minimize the transfer of heat from the air in said other compartment through said partition to said cooling element, a portion of said suction line being arranged in heat exchange relationship with said capillary tube for limiting the amount of heat in the liquid refrigerant flowing to said portion of said tube in heat exchange with said wall of said partition.

6. A refrigerator comprising a cabinet having thermally insulated walls and a thermally insulated partition dividing said cabinet into two compartments, a primary evaporator arranged in one of said compartments for providing a freezing zone, a secondary cooling system having a condensing portion in heat exchange relation with said primary evaporator and an evaporating portion arranged for cooling the other of said compartments, said primary evaporator also tending to cool said other compartment by the transfer of heat through said partition from the air in said other compartment, means for supplying liquid refrigerant to said primary evaporator, and means arranged in heat exchange relation with the side of said partition adjacent said other compartment and utilizing the heat of the liquid refrigerant supplied to said primary evaporator for maintaining the temperature of the surface of said side within said other compartment sufficiently high throughout the normal range of operation of said refrigerator to minimize the transfer of heat from said other compartment through said partition to said primary evaporator whereby the lowest temperature in said other compartment is determined by said evaporating portion of said secondary system.

DELBERT F. NEWMAN.

Certificate of Correction

Patent No. 2,390,808. December 11, 1945.

DELBERT F. NEWMAN

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 58, for "sufficient" read *sufficiently*; page 3, first column, line 23, for "plate 11" read *plate 19*; page 4, first column, line 30, claim 5, after "said" insert *one*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of May, A. D. 1946.

[SEAL]

LESLIE FRAZER,
First Assistant Commissioner of Patents.