March 19, 1963 R. S. BUCHANAN ETAL 3,081,608

FROZEN FOOD COMPARTMENT FOR DOMESTIC REFRIGERATOR

Filed April 23, 1959 2 Sheets-Sheet 1

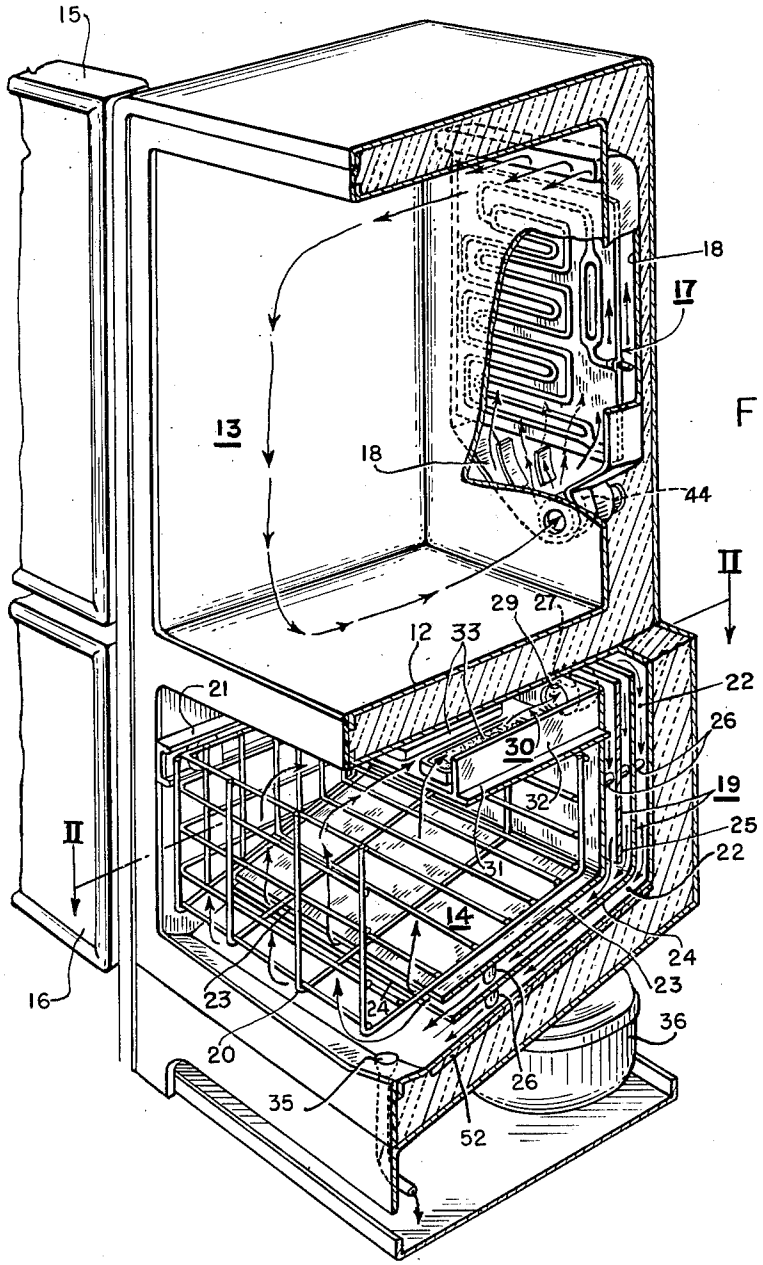

FIG. I.

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FIG. 2.

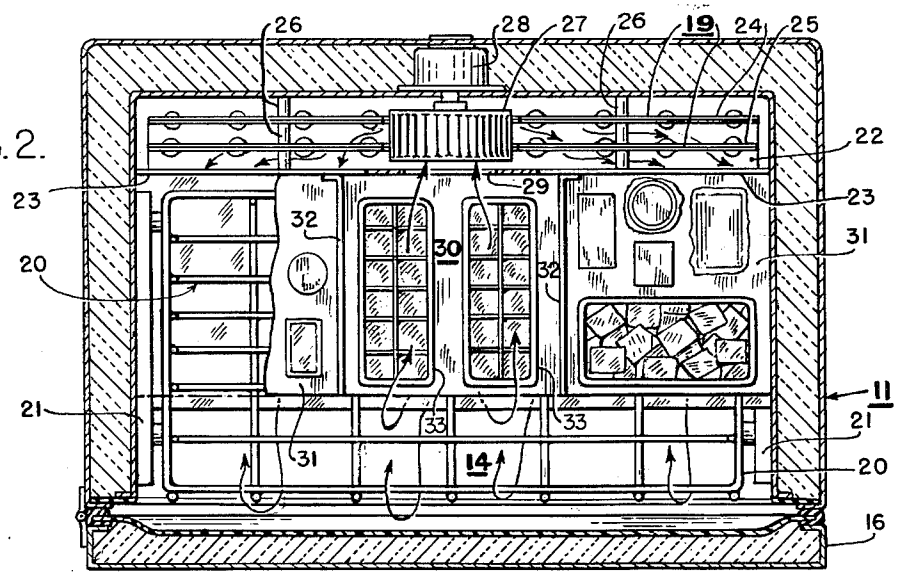
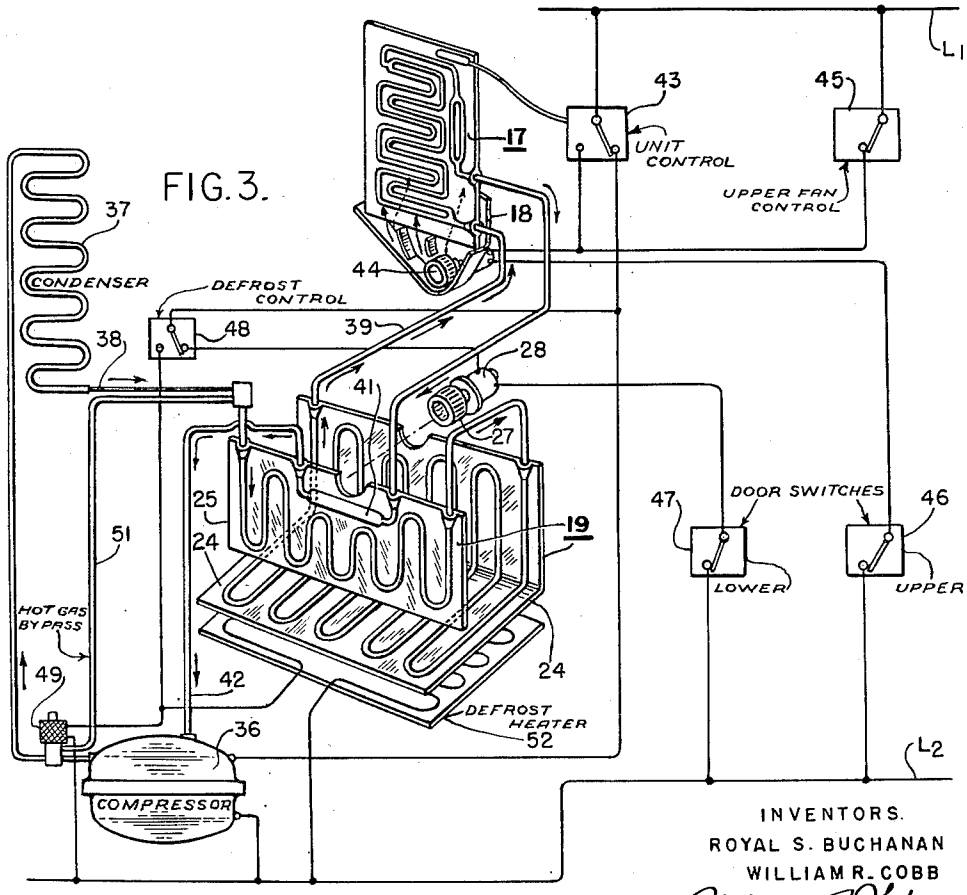


FIG. 3.



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FROZEN FOOD COMPARTMENT FOR DOMESTIC REFRIGERATOR

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This invention relates to refrigeration apparatus and more particularly to domestic refrigerators that are adapted to freeze food items and to store items in frozen condition without the accumulation of ice or frost on these items.

During recent years refrigerators have been marketed which embodied equipment for periodically raising the temperature of the cooling unit therein to melt away frost and ice that accumulated on the cooling unit. While, in many instances the defrosting systems used in these refrigerators functioned satisfactorily to remove frost from the surface of the cooling unit itself, the frozen food items and ice trays stored on or in the vicinity of the cooling unit frequently accumulated an undesirable quantity of frost and ice, the removal of which was rendered difficult by the fact that heat could not be applied to the items without melting or otherwise damaging them.

It has been proposed that the contents of a frozen food storage compartment be refrigerated entirely by forcibly circulating air through the compartment and over a cooling unit which is isolated from the compartment structure, so that conductive thermal exchange between the cooling unit and surrounding structure is minimized. In other words, the cooling unit is the sole structure that is subjected to direct, or primary, refrigeration and all other items and surfaces within the frozen food compartment are refrigerated solely by means of a rapidly moving air stream. This type of heat transfer between stored items and the cooling unit causes the migration of exposed moisture, whether liquid or solid, to the cooling unit and substantially eliminates the problem of frost accumulation on items or surfaces other than the cooling unit. The cooling unit can be defrosted relatively simply by the application of heat thereto by one means or another.

The disadvantage of forced air refrigeration is that there are no primary refrigerated surfaces on which ice trays, dessert dishes or other freezable items can be placed and rapidly chilled or frozen.

The present invention is particularly concerned with improving the chilling or freezing rate of items in a frozen food compartment in which heat is removed from the items solely by means of a refrigerated air stream. In accordance with the invention, freezable items such as those mentioned above, are subjected to a confined flow of refrigerated air which previously has been circulated over the other contents of the frozen food compartment; the other contents, presumably, being items which have been frozen and are merely being maintained at a suitably low temperature in insure their preservation. The principal advantage of this fast freezing arrangement, or system, is that the items previously stored in the frozen food compartment are virtually unaffected by use—even extended use—of the fast freezing region of the compartment to chill or freeze warm moist items. The arrangement is such that the temperature of the previously stored items is not raised, nor does the system redeposit moisture from the warm items onto the stored items.

In the preferred embodiment of this invention, hereinafter described in detail, the fast freezing region in the frozen food compartment is provided on a shelf which

is disposed so that the space immediately above the shelf is in close proximity to an inlet region of an air passage containing the cooling unit for the compartment. There is associated with this shelf sufficient baffle structure to confine the flow of air returning to the cooling unit to but a limited region of the shelf so that a large quantity of rapidly moving cold air is caused to pass over a limited number of items stored in this fast freezing region to effect rapid heat removal from these items.

The several objects, advantages and features of the invention will become apparent from the following detailed description of the invention wherein reference is made to the accompanying drawings, in which:

FIG. 1 is a sectional perspective view of a refrigerator cabinet embodying this invention;

FIG. 2 is a horizontal sectional view of the refrigerator taken as indicated with the line II—II in FIG. 1; and

FIG. 3 is a perspective view showing, somewhat schematically, the defrostable refrigeration system employed in the refrigerator.

The refrigerator illustrated in FIG. 1 comprises an insulated cabinet **11** having an insulated partition **12** therein dividing the interior of the cabinet into an upper, food storage compartment **13** and a lower, frozen food storage compartment **14**. The compartments **13** and **14** have access openings at the front thereof which are closed by hingedly mounted doors **15** and **16**, respectively.

Food storage compartment **13** is adapted for the preservation of food for a limited period of time and is maintained at a temperature of approximately 36° F. by circulating the air therein over a cooling unit, or evaporator, **17** disposed in a duct **18** in the rear wall of the compartment. The frozen food storage compartment **14** is capable of preserving foods for a considerably longer period of time and is maintained at a temperature of approximately 0° F. by forcibly circulating the air therein over another cooling unit, or evaporator, **19**. The two cooling units, **17** and **19**, have heat extracted therefrom and pumped outside the cabinet **11** by a suitable heat pumping system, such as a compression refrigeration system, which will be described hereinafter.

The present invention is particularly concerned with the frozen food compartment **14** and the manner in which the contents thereof are refrigerated. The majority of items, or packages of frozen food or other freezable items are stored in compartment **14** in a wire basket, or other foraminous container, **20** which may, if desired, be movably mounted in a glide structure **21** on the side walls of the compartment **14** to permit the basket to be moved part way out of the compartment for ease of loading and unloading.

The cooling unit **19** which chills the air circulating through the frozen food compartment **14** is preferably disposed within a duct, or passage, **22** formed in one or more walls of the compartment, so that the cooling unit is hidden from the view of the user of the refrigerator. This hidden location is considered to be advantageous because, with the cooling system here used, the cooling unit **19** is the only structure within compartment **14** on which ice and frost accumulates, and being hidden, gives the user the impression of a completely frostless refrigerator. As shown in FIGS. 1 and 2, the air cooling duct or passage **22** is formed between the rear and bottom walls of the frozen food storage compartment **14** and an L-shaped partition **23** spaced from these compartment walls and extending transversely of the compartment. The partition **23** may be made of light gauge metal, or of plastic, if desired, but need not possess heat insulating characteristics.

The cooling unit **19** is preferably formed to a generally L shape, so as to conform to the configuration of the duct **22** in which it is disposed and have all of its surfaces

in spaced relation to the compartment walls and the partition 23. As shown, cooling unit 19 comprises a main refrigerated plate 24 and an auxiliary plate 25. Both plates of the cooling unit 19 are supported in spaced relation to the partition 23 and the walls of the compartment 14 by means of heat insulating spacers 26, which also support the partition 23. The spacers 26 may be formed of any heat insulating material, such as polystyrene plastic, and are intended to prevent or at least minimize the conductive transfer of heat to the cooling unit 19 from surrounding cabinet structure.

Air is forcibly circulated through duct 22 in thermal transfer relationship with cooling unit 19 by means of a blower 27, which is preferably driven by an electric motor 28 (see FIG. 2). The blower draws compartment air into duct 22 through an inlet opening 29 provided in the partition 23 near the upper edge of the partition. The blower 27 is unshrouded and, consequently, discharges air outwardly in all radial directions therefrom to uniformly distribute the air and cause it to flow over all surfaces of the cooling unit 19. The lower, forward edge of partition 23 terminates rearwardly of the front of the frozen food compartment 14 to provide an outlet for air which has been chilled by passing over the cooling unit 19. Under the action of blower 27, this chilled air is forcibly circulated upwardly into heat transfer relationship with items stored in the container 20. The cooling unit 19 is preferably maintained at a temperature below the desired storage temperature of the items in container 20 to insure preservation of these items for an extended period of time.

In accordance with this invention, the frozen food compartment 14 is equipped with a fast chilling, or fast freezing, region 30 in which trays of water, desserts, or other items which are to be quickly chilled or frozen may be placed. This region is located on a stationary support, or shelf, 31 which extends across compartment 14 in a region above container 20 but spaced beneath the partition 12 forming the top wall of compartment 14. As can be seen in FIG. 1, the shelf 31 is positioned near the bottom edge of the inlet opening 29 for the cooling duct 22. This arrangement dictates that air returning to the duct 22, after having passed over the frozen items stored in container 20, flows over the upper surface of the shelf 31 and over and around any items stored thereon.

In the preferred embodiment of the invention illustrated in the drawings, the shelf 31 is equipped with partition means, such as the metal sheets 32, which confine air returning to the duct 22 to a limited area flow path over but a portion of the surface of the shelf 31. This results in a large quantity of high velocity air passing through the fast freezing region 30 between the sheets 32, so that freezable items stored in this region are effectively refrigerated and the time required to effect freezing reduced to a minimum. As shown, the fast freezing region 30 is made large enough in both height and width to accommodate a limited number of items, such as the two ice trays 33 shown therein. It is contemplated that the user of the refrigerator, upon perceiving that the items stored in the fast freezing region 30 have become frozen, will relocate these items to another region of the shelf 31 or into the container 20, to make the fast freezing region available for further items.

It will be noted that all items stored in the frozen food compartment 14 are refrigerated entirely by forcibly circulated, chilled air. The cooling unit 19 is the only structure which is subjected to primary refrigeration, i.e., has heat directly removed therefrom by the refrigeration system. The rapidly moving stream of cold air picks up moisture from the items stored in the compartment and deposits this moisture on the cooling unit. This is true even though the moisture may be in the form of frost or ice on previously frozen items that are placed in the compartment. All of the items stored in this frozen food compartment are, therefore, maintained in a frostless and iceless condition and do not become stuck together.

As will be explained hereinafter, the cooling unit 19 is periodically raised to a temperature above 32° F. and the frost and ice which accumulates thereon is melted free and flows out of the compartment through a drain 35 provided in the bottom wall of the compartment.

The problem of providing a fast freezing region in forced air frozen food compartments has been one which has limited the use of this compartment cooling system in spite of the advantages of the system. The present invention solves this problem in a unique manner and with improved results. The improved results are due principally to the order or sequence in which air is circulated within or through the frozen food compartment 14. As mentioned previously, air is chilled in the duct 22 through contact with the cooling unit 19, is discharged from the duct and first flows over the frozen items stored in container 20. The air being returned to the duct inlet 29 is confined to provide the fast freezing region 30. This is to be contrasted with prior attempts to provide a fast freezing region, in which chilled air issuing from the cooling unit has been directed onto ice trays, and the like, before being directed onto frozen items stored elsewhere in the compartment. The present invention eliminates two disadvantages of the prior arrangements. In the first place, there is no tendency to warm the already frozen items stored in compartment 14, because it is not until after the cooling air has passed over these items that it is directed over the warmer, unfrozen items in the fast freezing region 30. Secondly, the tendency to redeposit moisture which has been picked up by the air stream in passing over items to be frozen is discouraged because immediately after leaving, say a warm ice tray, the air contacts the cooling unit 19 and any moisture therein is immediately condensed and removed. This means that the other items stored in the frozen food compartment 14 will, at all times, be maintained free of frost, even through the fast freezing region 30 is used to chill a number of warm items in quick succession.

An illustrative refrigeration system and a control circuit therefor are depicted, somewhat schematically, in FIG. 3. This is the system by which heat is removed from the two compartments 13 and 14. While other types of systems may be employed in practicing the present invention, the system there illustrated is of the compression type in which the cooling units 17 and 19 function as evaporators for absorbing heat from compartments 13 and 14. This system also includes a compressor 36 which withdraws vaporous refrigerant from cooling units 17 and 19 and compresses the refrigerant vapor for delivery to a condenser 37, wherein heat is rejected and the refrigerant is condensed. Liquid refrigerant is delivered to cooling unit 19 by a capillary expansion tube 38 separating the high pressure side of the system from the low pressure side of the system.

Liquid refrigerant is directed first into auxiliary plate 25 of cooling unit 19, thereafter passes through main plate 24 of this cooling unit and is then delivered through an unrestricted conduit 39 to the food storage compartment cooling unit 17. Vaporous refrigerant is returned to the compressor 36 via a separator tank 41 located in auxiliary plate 25 of cooling unit 19 and a suction conduit 42. The refrigerant flow path is indicated by the solid line arrows in FIG. 3.

The compressor 36 is energized and deenergized to maintain the desired temperatures within the compartments 13 and 14 by a temperature sensitive unit control 43. The control 43 responds to the temperature of cooling unit 17 and is adapted to connect compressor 36 across electrical supply lines L1 and L2 when the temperature of cooling unit 17 rises to a value above the freezing point of water, of the order of 34 to 36° F. The compressor 36 is deenergized by control 43 when the temperature of cooling unit 17 falls to a predetermined low temperature,

of the order of 0° F. Since cooling unit **17** receives refrigerant after cooling unit **19**, the latter will be subjected to a greater degree of refrigeration and will be maintained at a considerably lower temperature than cooling unit **17**. Cooling unit **17** preferably has a low thermal mass so that it is capable of being warmed to above 32° F. within a short period of time by virtue of air from food storage compartment **13** being circulated thereover. Forcible circulation of this compartment air is effected by a motor-driven blower **44** which is energized from lines L1 and L2 by the unit control **43** or a temperature responsive control **45**. Unit control **43** is adapted to energize blower **44** whenever the compressor **36** is deenergized, so as to effect circulation of food compartment air over cooling unit **17** during periods when refrigeration is not being circulated to insure defrosting of cooling unit **17**. The other control **45** for the blower **44** responds to the temperature of the air in food compartment **13** and is adapted to energize the blower **44** when the temperature of this air rises above the desired storage temperature of 36° F. and to deenergize blower **44** when the temperature is reduced to this desired value. Unit control **43** and fan control **45** are adapted to effect energization of blower **44** independently of one another, but both are connected by suitable leads, as indicated in FIG. 3, through a switch **46** which is opened and closed, respectively, when the door **15** for compartment **13** is opened and closed. The function of switch **46** is to deenergize the blower **44** during periods when the food compartment door **15** is open to prevent refrigerated air from being blown out of the compartment **13** and replaced with warm outside air.

The blower **27**, which circulates air within the frozen food storage compartment **14**, operates only when the refrigerating system is operating to cool compartment **14** and the door **16** to this compartment is closed. The motor **28**, which drives blower **27**, is therefore wired, or connected, to supply lines L1 and L2 through a switch **47**, which opens and closes as door **16** is opened and closed, and through the unit control **43**, which is adapted to supply electricity simultaneously to refrigerant compressor **36** and motor **28**.

The refrigerating system also preferably incorporates apparatus for periodically raising the temperature of cooling unit **19** to above 32° F. to melt frost and ice from this cooling unit. Conversion of the system from refrigerating operation to defrosting operation and back to refrigerating operation is effected by a defrost control **48** which periodically closes an electrical circuit to a solenoid valve **49** controlling the flow of refrigerant through a bypass conduit **51** connecting the discharge side of the compressor **36** to cooling unit **19**. When energized, solenoid valve **49** permits warm gaseous refrigerant leaving the compressor **36** to bypass the condenser **37** and the capillary restrictor tube **38** and discharge directly into cooling unit **19**. The warm gas entering the cooling unit **19** raises the temperature of the cooling unit to above freezing within a few minutes and melts frost and ice which have accumulated on the cooling unit. Defrost water falling from cooling unit **19** flows along the bottom wall of the frozen food compartment to the drain **35**, and this region of the compartment is preferably heated during defrosting by an electric heater **52** (see FIG. 1) which prevents the defrost water from refreezing. The heater **52** is preferably electrically connected in parallel with the solenoid valve **49** as shown in FIG. 3 so that the heater and valve are simultaneously energized by the defrost control **48**.

The defrost control **48** also is preferably connected in the electrical supply conduit for blower motor **28** and deenergizes this motor to stop the circulation of air over cooling unit **19** during defrosting operation. With this control arrangement, the circulation of warm air over the items stored in compartment **14** is prevented.

The construction of defrost control **48** is not considered to be a part of this invention and is not described in detail because such controls are well known in the art. For example, the control described in U.S. Patent No. 2,595,967, G. S. McCloy, may be employed in a refrigerator embodying this invention.

With the refrigerating system described above, or similar systems functioning in a comparable manner, frost is periodically removed from the cooling unit **19** serving the frozen food compartment **14** without disturbing the contents of the compartment. Deenergization of the blower **27** which effects circulation of air within the compartment **14** insures that the items stored in compartment **14** will not be warmed by moving air during periods when the cooling unit **19** is being defrosted. As mentioned previously, the plates making up cooling unit **19** are supported in the duct **22** by insulated spacers **26**, which minimize conductive heat transfer between the cooling unit and surrounding structure, so that no heat is conducted to the items in compartment **14** during defrosting. Consequently, there is no tendency for the items to melt and become stuck together upon resumption of refrigerating operation.

The refrigerator user is thus provided with an appliance which is capable of storing items in a frostless condition for extended periods of time, is capable of rapidly chilling or freezing items that are placed therein and, moreover, requires no attention on the part of the user to effect removal of frost from the cooling unit therein.

While the invention has been shown and described with reference to but a single embodiment thereof, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. In a refrigerator, a cabinet having insulated walls defining a frozen food storage compartment, a generally L-shaped, non-insulated partition disposed in spaced relation to the bottom and rear walls of said compartment, a generally L-shaped cooling unit disposed in the space between said partition and said bottom and rear walls, means for extracting heat from said cooling unit to maintain the temperature thereof below the storage temperature of frozen food in said compartment, a foraminous container in said compartment, a horizontal shelf mounted in said compartment above said container, said shelf being spaced from the top wall of said compartment a distance sufficient to permit freezable items to be placed on said shelf, said partition having an opening in an upper portion thereof between said shelf and the top wall of said compartment, and fan means for forcibly circulating air in thermal exchange relationship with said cooling unit, then in thermal exchange relationship with frozen food in said container, then over the upper surface of said shelf, and thereafter through said opening.

2. In a refrigerator, a cabinet having insulated walls defining a frozen food storage compartment, a generally L-shaped non-insulated partition disposed in spaced relation to the bottom and rear walls of said compartment, a generally L-shaped cooling unit disposed in the space between said partition and said bottom and rear walls, means for extracting heat from said cooling unit to maintain the temperature thereof below the storage temperature of frozen food in said compartment, a foraminous container in said compartment, a horizontal shelf mounted in said compartment above said container, said shelf being spaced from the top wall of said compartment a distance sufficient to permit freezable items to be placed on said shelf, said partition having an opening in an upper portion thereof between said shelf and the top wall of said compartment, fan means for forcibly circulating air in thermal exchange relationship with said cooling unit, then in thermal exchange relationship with frozen food in said container, then over the upper surface of said shelf, and thereafter through said opening, and baffle means extending upwardly from said shelf to

said top wall for confining the flow of air over said shelf to a limited region of the shelf to provide a fast freezing region on said shelf.

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