United States Patent [19]

Laughlin et al.

[11] **3,745,786**

[45] **July 17, 1973**

[54] **REFRIGERATION APPARATUS**

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[73] Assignee: **Whirlpool Corporation,** Benton Harbor, Mich.

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[21] Appl. No.: **203,555**

[52] **U.S. Cl.** **62/419,** 62/414, 62/426

[51] **Int. Cl.** **F25d 17/06**

[58] **Field of Search** 62/426, 419, 414

[56] **References Cited**

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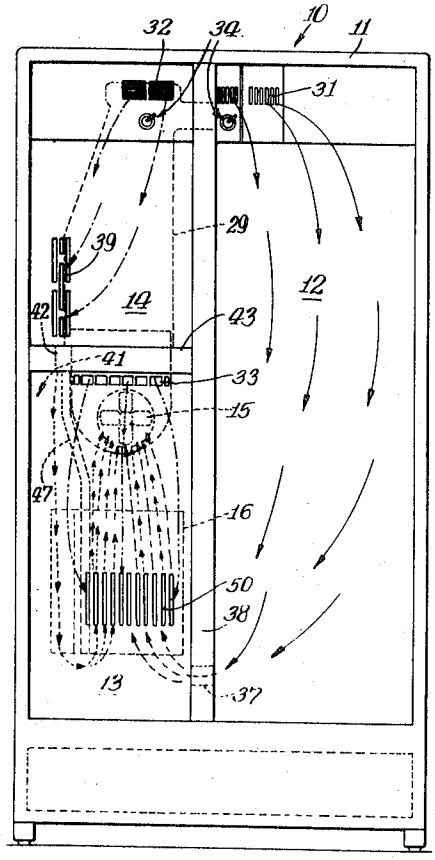
Primary Examiner—William J. Wye
Attorney—James S. Nettleton et al.

[57] **ABSTRACT**

A refrigeration apparatus having means defining a compartment which at least at times is refrigerated to a below-freezing temperature. Air is returned from this compartment to a fin-and-tube evaporator by firstly conducting the air over the tube end turns of the evaporator and then through the passages defined by the evaporator fins to be refrigerated by heat exchange relationship therewith. The compartment may comprise a convertible compartment which, at times, is maintained at an above-freezing temperature and at times is maintained at a below-freezing temperature. The apparatus may further include a refrigerator compartment and a freezer compartment with the air being returned to different portions of the evaporator from the different compartments for improved operation of the refrigeration apparatus.

10 Claims, 6 Drawing Figures



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SHEET 1 OF 2

Fig. 1.

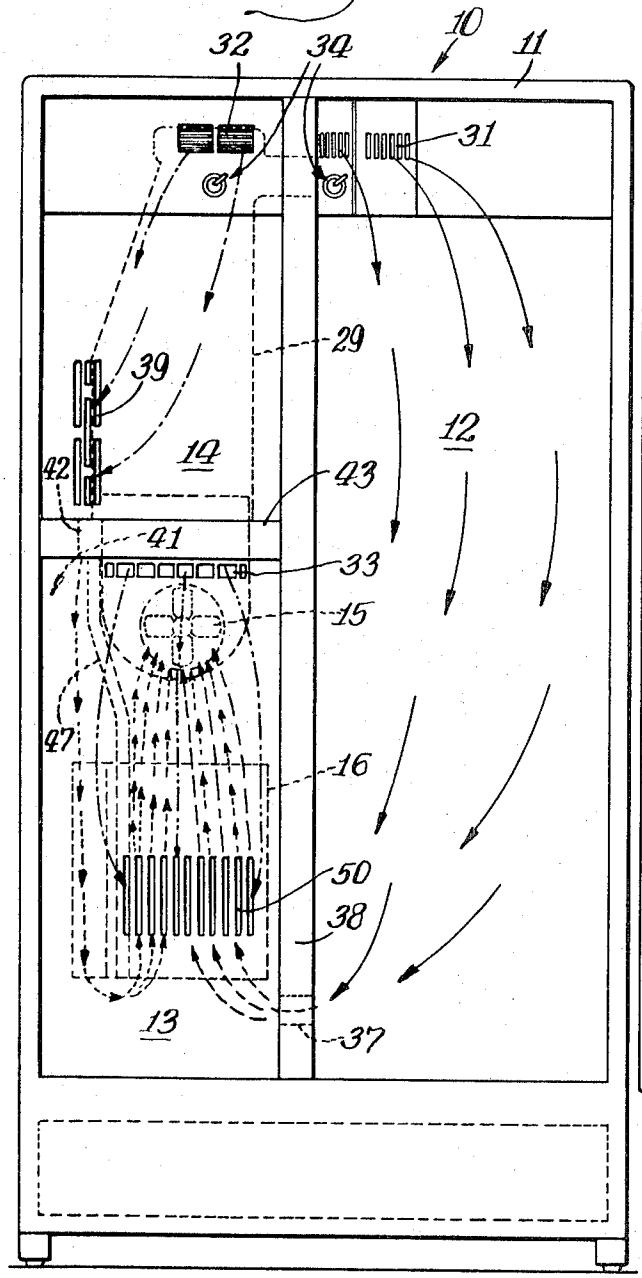
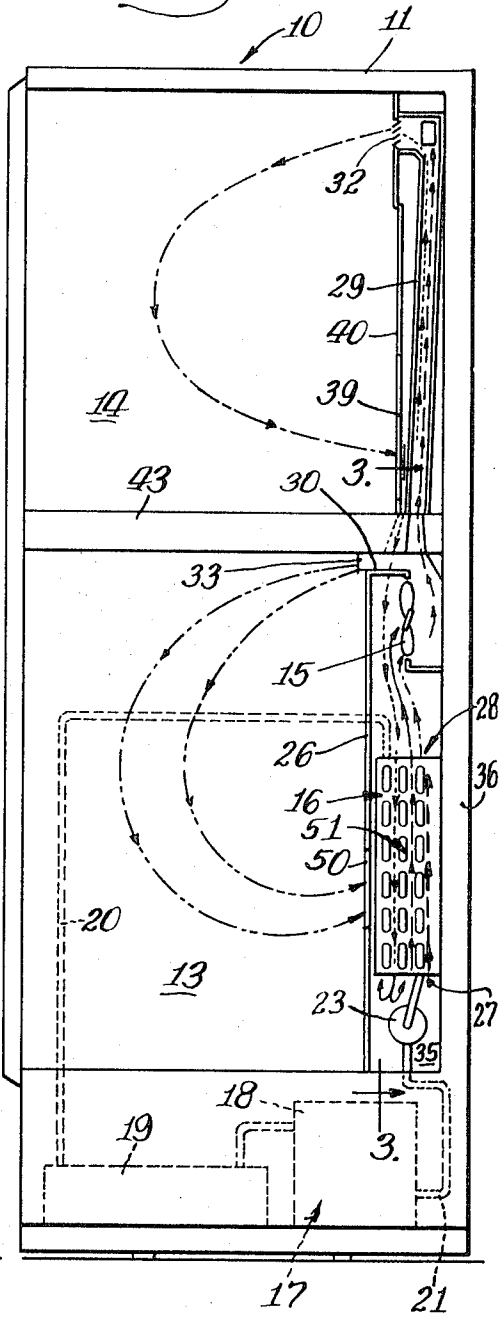


Fig. 2.



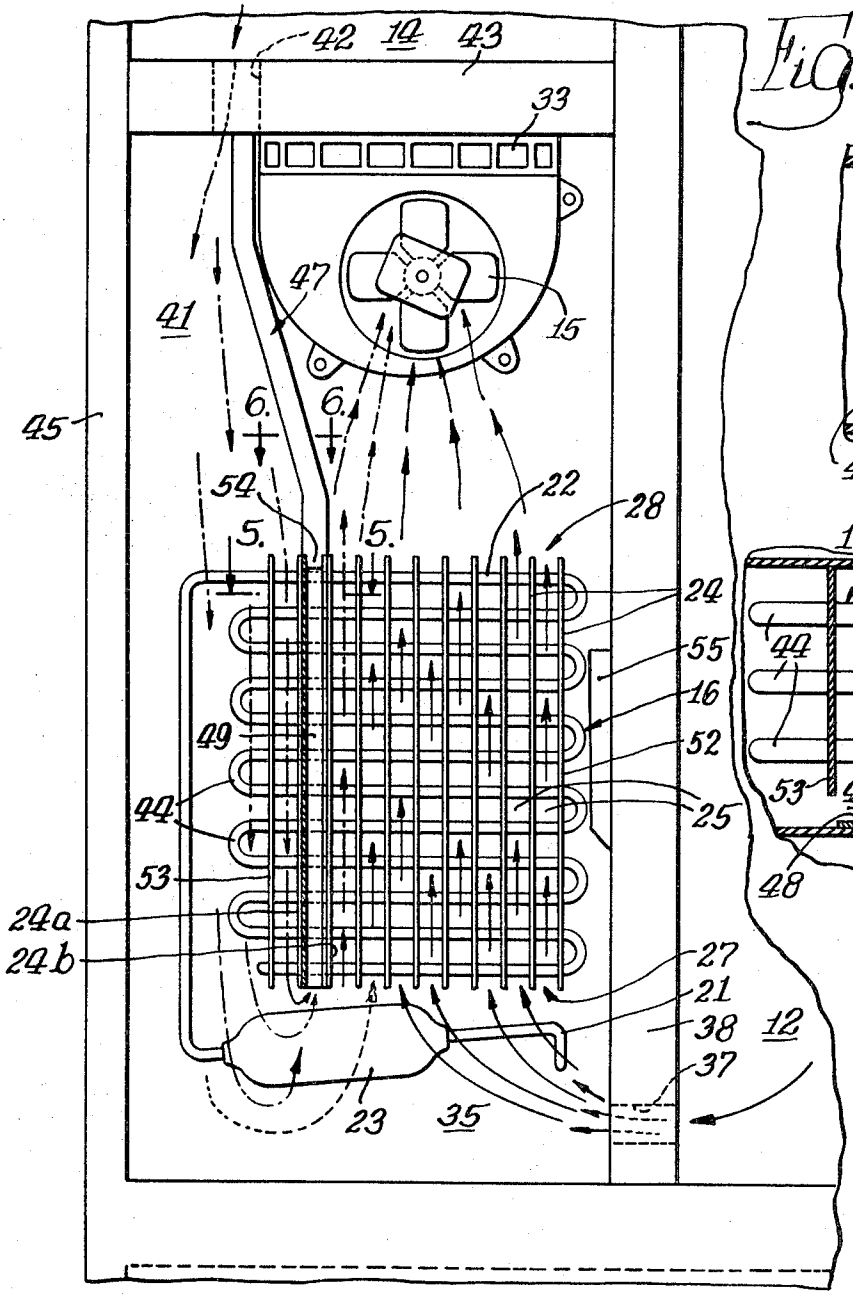


Fig. 3.

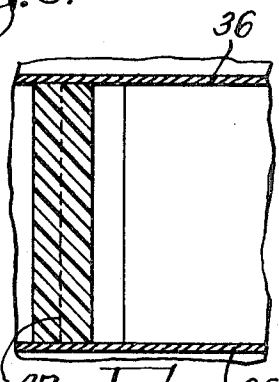


Fig. 6.

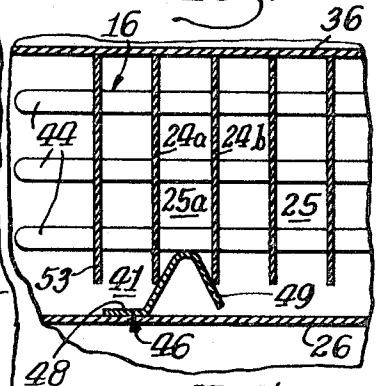


Fig. 5.

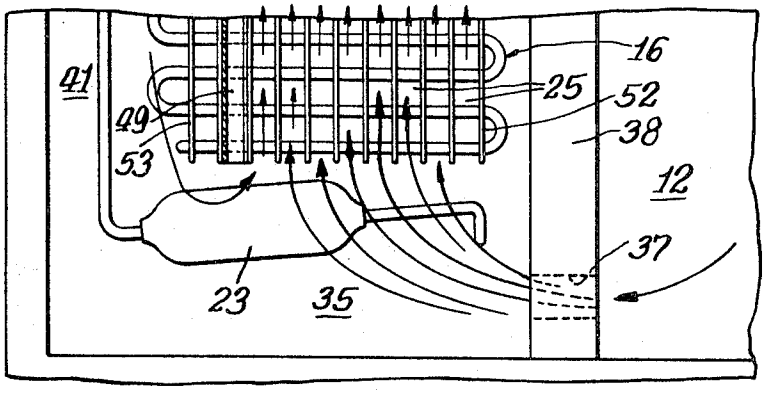


Fig. 4.

REFRIGERATION APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to refrigeration apparatus and in particular to such apparatus having one or more compartments to be refrigerated by means of a forced flow of air circulated in heat exchange relationship with an evaporator.

2. Description of the Prior Art

In the Sigl et al. U.S. Letters Pat. No. 3,411,312, owned by the assignee hereof, a refrigerator with a convertible compartment is shown and described as utilizing a forced air system wherein the air delivered to the different compartments is passed in heat exchange relationship with a fin and tube evaporator. In the apparatus thereof, the air is returned from the different compartments to a common inlet portion of the evaporator after being passed in heat exchange relationship with an accumulator.

In the Mann et al. U.S. S. Letters Pat. No. 3,027,732, a refrigerating apparatus is shown to comprise a refrigerator-freezer apparatus wherein air is circulated in heat exchange relationship with an evaporator to the refrigerator and freezer compartments. As shown in FIG. 5 of that patent, the air from the refrigerator compartment is passed over one end of the evaporator having widely spaced fins and then successively through second and third portions of the evaporator having normally closely spaced fins. The air from the freezer compartment is delivered in heat exchange relationship only with the third portion of the evaporator.

Additional patents which show refrigeration apparatus related to the above discussed apparatuses are those of Solley, Jr. U.S. Pat. No. 3,111,817; Schumacher U.S. Pat. No. 3,126,717; and Frohbieter U.S. Pat. No. 3,389,575, which is also owned by the assignee hereof.

SUMMARY OF THE INVENTION

The present invention comprehends an improved refrigeration apparatus wherein air from a freezer compartment is firstly circulated in heat exchange relationship with the end turns of the evaporator prior to the delivery thereof to the normal flow path through the evaporator as defined by the fins. In the specific embodiment of the invention disclosed herein, the freezer compartment is a convertible compartment which, at times, may be maintained at above-freezing temperatures and at other times at below-freezing temperatures.

The inventio further comprehends the provision of means cooperating with at least one of the fins at one side of the evaporator to form a wall means defining a flow passage for conducting the air from the convertible compartment over the end turns of the evaporator before delivery thereof to a plurality of normal flow paths defined by the fins. The air delivered from the end turn flow path is delivered to a chamber in which the accumulator is located at the inlet portion of the evaporator. The air from the refrigerator compartment may be delivered to the same chamber at the opposite side of the evaporator for flow primarily through a portion of the plurality of the paths defined by the fins different from the portion of the plurality of paths defined by the fins through which the air from the convertible compartment flows. Thus, it has been found that any tendency to frost over at the inlet to the evaporator in the paths through which the air from the refrigerator normally flows will cause this air to tend to flow through the paths through which the air from the convertible compartment normally flows. As the air from the convertible compartment is effectively dehumidified, these latter paths are effectively maintained open for extended operation of the apparatus before defrosting thereof is required. The invention further comprehends returning the freezer compartment air to a location in the paths defined by the fins spaced from the inlet portion of the evaporator whereby frosting as a result of the introduction of the low temperature air into the air returned from the refrigerator compartment and convertible compartment (particularly when the convertible compartment is operated as a refrigerator compartment) is effectively avoided.

The invention comprehends that approximately 20 percent of the heat exchange surface of the evaporator be located in the end turn flow path from the convertible compartment for effectively optimum dehumidification of the air prior to the delivery thereof to the normal heat exchange paths defined by the fins.

The air flow control means of the present invention is extremely simple and economical of construction while yet providing the highly improved operation of the apparatus as discussed above.

BRIEF DESCRIPTION OF THE DRAWING

Other features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawing wherein:

FIG. 1 is a front elevation of a refrigeration apparatus embodying the invention, with the doors to the different compartments omitted;

FIG. 2 is a side elevation with a portion thereof shown in vertical section;

FIG. 3 is a fragmentary enlarged vertical section taken substantially along the line 3—3 of FIG. 2;

FIG. 4 is a fragmentary section generally similar to that of FIG. 3 but illustrating the air flow upon a partial frosting over of the inlet portion of the evaporator by the refrigerator air;

FIG. 5 is an enlarged fragmentary section taken substantially along the line 5—5 of FIG. 3; and

FIG. 6 is an enlarged fragmentary section taken substantially along the line 6—6 of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the exemplary embodiment of the invention as disclosed in the drawing, a refrigeration apparatus generally designated 10 is shown to include a cabinet 11 defining a plurality of compartments to be refrigerated including an above-freezing temperature refrigerator compartment 12, a below-freezing temperature freezer compartment 13, and a convertible compartment 14 arranged to be selectively alternatively refrigerated to either an above-freezing temperature or a below-freezing temperature so that compartment 14 may selectively comprise a second refrigerator compartment or a second freezer compartment as desired. As discussed above, one such convertible compartment refrigeration apparatus is shown in the Sigl et al. U.S. Pat. No. 3,411,312 owned by the assignee hereof.

As shown in FIGS. 1 and 2 of the drawing, the refrigeration of the compartments is effected by the flow of refrigerated air therethrough by a suitable air moving

means, such as fan **15**. The circulated air is refrigerated as a result of being passed in heat exchange relationship with a fin and tube evaporator **16** which is suitably refrigerated by conventional means, such as apparatus **17** including a conventional compressor **18**, condenser **19**, refrigerant supply duct **20**, and refrigerant return duct **21**. The refrigeration apparatus functions in the conventional manner to provide refrigerated refrigerant fluid to the serpentine tube portion **22** of the evaporator and an accumulator, or header, **23**, is provided between portion **22** and the return duct **21** to collect any liquid refrigerant which may have passed through tube portion **22** of the evaporator. As illustrated in FIG. **3**, evaporator **16** is further provided with a plurality of heat conducting fins **24** which are in heat exchange relationship with the tube **22** and cooperatively define a plurality of paths **25** through which the air is flowed to have the desired heat exchange relationship with the evaporator structure. The evaporator **16** further includes end plates **52** and **53** which support the evaporator and are used to mount the evaporator within freezer compartment.

In the illustrated embodiment, evaporator **16** comprises a vertical evaporator disposed behind a rear panel **26** of freezer compartment **13** so that the air flow paths extend vertically upwardly from a lowermost inlet portion **27** of the evaporator to an uppermost outlet portion **28** thereof. Fan **15** is disposed upwardly of the outlet portion **28**, as shown in FIG. **3**, so as to draw the air through the evaporator paths **25** and discharge it through suitable air ducts **29** and **30** to the different compartments. As illustrated in FIG. **1**, air is delivered from duct **29** through a grill outlet **31** to the refrigerator compartment **12**, and through a grill outlet **32** to the convertible compartment **14**. The air is delivered from duct **30** through a grill outlet **33** to the freezer compartment **13**.

As disclosed in the Sigl, et al. patent, in such a multiple-compartment refrigeration apparatus, suitable damper controls may be provided for regulating the air flow so as to provide selectively the desired temperature conditions in the different compartments, and more specifically herein, controls **34** are provided to include means for permitting control of the temperature conditions in compartment **14** so that the compartment may be operated convertibly either as a freezer compartment or as a refrigerator compartment as discussed above. As will be obvious to those skilled in the art, any suitable means for effecting this temperature control of the different compartments may be employed within the scope of the invention. The present invention is concerned primarily with the control of the flow of the air back to and through the evaporator so as to provide an improved high efficiency operation of the apparatus.

More specifically, as shown in FIGS. **1** and **3**, the air from refrigerator compartment **12** is delivered to the chamber **35** below the inlet portion **27** of the evaporator behind the freezer chamber rear panel **26** and forwardly of the rear cabinet wall **36** through an opening **37** in an upright divider wall **38** of the cabinet. Air is returned from convertible compartment **14** through a grill outlet **39** in the rear wall **40** of compartment **14** at one side of delivery duct **29** to flow downwardly therefrom through a flow passage **41** rearwardly of rear walls **40** and **26**. Outlet **39** communicates with flow passage **41** through an opening **42** in a horizontal divider wall **43** defining the top of freezer compartment **13** and the bottom of convertible compartment **14**.

Flow passage **41** is arranged to conduct the returning air from convertible compartment **14** in heat exchange relationship with the end turns **44** of the evaporator **16** prior to the delivery thereof to the vertical flow paths **25** between the fins. To this end, the passage **41** is defined by the lefthand side wall **45** of cabinet **11**, the rear wall **36** of cabinet **11**, the panel **26** of compartment **13**, a partition wall member **47** and an air divider **46** which cooperates with lefthand fins **24***a* and **24***b* of the evaporator. As shown in FIG. **5**, the air divider member **46** may comprise a formed sheet element having a flat end **48** secured to the rear cabinet wall **26** and a V-section portion **49** extending into the space **25***a* defined by the fin **24***a* and the rightwardly adjacent fin **24***b*.

As shown in FIG. **3**, partition wall **47** extends downwardly from the horizontal cabinet wall **43** to the inlet portion **27** of the evaporator. A portion **54** of divider wall **47** extends between fins **24***a* and **24***b* and terminates on the top of tube **22** to assure that air in passage **41** passes first over end turns **44** then through passages **25**. As shown in FIG. **6**, the partition wall **47** is a generally rectangular member formed of molded polystyrene foam or other similar material. Inasmuch as partition wall **47** closes off space **25***a* between fins **24***a* and **24***b*, cover **26** seals across the same fins at their front face and the V-section portion **49** of air divider **46** seals the same fins at their rear face, fins **24***a* and **24***b* enclose a non air flow space **25***a* which effectively forms an extension of partition **47**.

Thus, as shown in FIG. **3**, flow passage **41** conducts air from convertible compartment **14** in heat exchange relationship with the lefthand end turns **44**, end plate **53** and fin **24***a* of the evaporator downwardly to chamber **35** to be further in heat exchange relationship with the accumulator **23** before turning and flowing upwardly through the lefthand paths **25** of the evaporator. As a result, humidity in the air returning from the convertible compartment is effectively removed by the heat transfer association thereof with the end turns **44**, end plate **53** and fin **24***a* thereby effectively avoiding frosting of the lower end of the flow paths **25** through which this air is flowed to effect the further refrigeration thereof.

In the illustrated embodiment, approximately 20 percent of the heat exchange surface of the evaporator is provided in the flow passage **41** and approximately **80** percent thereof is provided at the flow paths **25**.

As best seen in FIG. **1**, the air returning to the evaporator from the freezer compartment **13** flows through the grill outlet **50** in the rear wall **26** so as to enter the evaporator space at a location **51** spaced upwardly from the entrance portion **27** thereby effectively preventing frosting and snow at the entrance portion which could occur if the relatively cold freezer air were delivered to entrance **27** to mix thereat with the moist air from the refrigerator compartment **12**.

It has been found that in the use of such a refrigeration apparatus having a convertible freezer-refrigerator compartment, the temperature, humidity and the flow rate through the evaporator of the air from the convertible compartment may vary over a wide range. When compartment **14** is operated by the control **34** to comprise a refrigerator compartment at above-freezing temperature, the air returned to the evaporator therefrom has a relatively high humidity. At this time, the

flow rate of the air is made relatively low, i.e., approximately 10 times less than when the compartment is operated as a freezer compartment.

As illustrated in FIGS. 3 and 4, in the normal operation of the apparatus, relatively moist air from the refrigerator compartment 12 flows from passage 37 upwardly through the righthand flow paths 25 defined by the spaced fins 24. In flowing from passage 37 to the inlet portion 27 of the evaporator, this air is firstly caused to pass over the accumulator, or header, 23 so as to effect at least a partial moisture removal from the air as a result of the relatively low temperature of the accumulator.

When the convertible compartment is being operated as a refrigerator compartment, the relatively low flow rate permits the air from passage 41 to flow primarily through the lefthand paths 25 as discussed above. When the compartment 14 is operated as a freezer compartment to have a relatively high flow rate, the flow through the paths 25 is nevertheless maintained primarily through the lefthand paths. This desirable operation is automatically effected by the control of the frosting of the evaporator at the entrance portion 27 effected by the pre-drying of the air from compartment 14 as a result of its heat exchange relationship with the evaporator end turns 44, end plate 53 and fin 24*a* prior to the delivery thereof to the entrance portion 27 of the evaporator. There is always a tendency for frost buildup at the entrance portion to the evaporator at the righthand flow paths, as shown in FIGS. 3 and 4, and as such buildup occurs the air from compartment 12 tends to flow more leftwardly toward the lefthand flow paths which are maintained relatively open as a result of the moisture removed from the air from passage 41 before the delivery thereof to the lefthand flow paths. Resultingly, as the righthand paths become progressively more blocked, the flow of refrigerator compartment air is caused to shift away from blocked air paths to the relatively clear lefthand air paths thereby substantially extending the period of operation of the apparatus before defrosting of the evaporator is required. Thus, while the flow rate of the air stream entering the evaporator at 27 from passage 41 varies over a 10 to 1 range, the paths the air streams follow through the evaporator remain essentially unchanged even though the humidity of the air stream leaving convertible compartment 14 varies greatly.

A baffle 55 in the form of a molded polystyrene foam block is provided between the right side of evaporator 16 and wall 38 to prevent air from compartment 12 from bypassing vertical paths 25 through the evaporator. A defrost heater, not shown, is provided to periodically heat the evaporator to melt any frost accumulated thereon. One such suitable heater is shown and described in the copending application of Raymond Tobey, Ser. No. 141,478, filed May 10, 1971 and assigned to the assignee of this application.

The improved operation of the air refrigeration means of the present invention is obtained with effectively minimum cost by proper proportioning of the evaporator air flow paths by the simple addition of the partition wall means 47 and the air divider means 46 to the conventional evaporator structure. The invention permits the selective use of the convertible compartment 14 without adversely affecting the air flow conditions in the evaporator or the temperature conditions in compartments 12 and 13, but rather to the contrary, the convertible compartment return air flow in conjunction with the proper proportioning of the air flow through vertical paths 25 provides a desirable extended refrigerating operation of the apparatus between defrosting operations.

The foregoing disclosure of specific embodiments is illustrative of the broad inventive concepts comprehended by the invention.

Having described the invention, the embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a forced air refrigeration apparatus having means defining a compartment which may have selectively different humidity conditions including a high humidity condition, a refrigeration means including an evaporator having a serpentine tube portion defining a plurality of end turns and a plurality of fins defining a plurality of paths for flow of air to be refrigerated in heat transfer association therewith from an inlet portion at one end of the evaporator to an outlet portion at the opposite end of the evaporator, and means for circulating air from said evaporator outlet portion through said compartment and back to said evaporator for cooling said compartment to a below-freezing temperature, the improvement comprising means for causing only low humidity air to be circulated in heat transfer association with said evaporator fins comprising means for conducting the air from said compartment sequentially in heat transfer association with said end turns and then to said paths defined by said fins, the amount of heat transfer surface of said end turns contacted by said conducted air being preselected to effect dehumidification of high humidity compartment air to convert said air to low humidity air prior to the conduction thereof into said paths.

2. The refrigeration apparatus of claim 1 wherein said means for conducting the air from said compartment comprises a wall member and a divider member cooperating with at least one of said fins to define a boundary of the flow path for the air over said end turns.

3. The refrigeration apparatus of claim 1 wherein said means for conducting the air from said compartment comprises a wall member and a divider member cooperating with at least one of said fins to define a boundary of the flow path for the air over said end turns, said end turns associated with said flow path comprising approximately 20 percent of the heat exchange means of the evaporator.

4. The refrigeration apparatus of claim 1 including an accumulator upstream of the inlet portion of the evaporator, said means for conducting the air from said compartment being constructed to conduct the air firstly in heat exchange relationship with the end turns and then in heat exchange relationship with said accumulator prior to flow through said paths defined by said fins.

5. In a forced air refrigerator-freezer apparatus having means defining a below-freezing compartment, an above-freezing refrigerator compartment, and a compartment convertible selectively to be an above-freezing refrigerator compartment or a below-freezing freezer compartment, refrigeration means including an evaporator having a serpentine tube portion defining a plurality of end turns and a plurality of fins defining a plurality of paths for flow of air to be refrigerated in heat transfer association therewith from an inlet portion at one end of the evaporator to an outlet portion

at the opposite end of the evaporator, and means for circulating air from said evaporator outlet portion through said compartments and back to said evaporator, the improvement comprising:

means for conducting the air fron said convertible compartment sequentially in heat transfer association with said end turns and then to said paths defined by said fins.

6. The refrigerator-freezer apparatus of claim **5** wherein said circulating means causes the air from said refrigerator compartment to flow primarily through a portion of said plurality of paths different from the paths through which the air from said convertible compartment is flowed.

7. The refrigerator-freezer apparatus of claim **5** wherein said circulating means includes means for delivering the air from said freezer compartment to a portion of said paths spaced from said inlet portion of the evaporator.

8. The refrigerator-freezer apparatus of claim **5** wherein said circulating means causes the air from said refrigerator compartment to flow primarily through a portion of said plurality of paths different from the paths through which the air from said convertible compartment is flowed, and said circulating means includes means for delivering the air from said freezer compartment to substantially all of said paths at a location spaced from said inlet portions of the evaporator.

9. The refrigerator-freezer apparatus of claim **5** wherein said evaporator is a vertical evaporator and said paths defined by said fins extend vertically with said inlet portion of the evaporator lowermost.

10. The refrigerator-freezer apparatus of claim **5** wherein said evaporator is located in a compartment defined by the rear wall of the below-freezing compartment and an evaporator cover, said means for conducting air from said convertible compartment comprising:

a passage within said evaporator compartment defined by said rear wall, a side wall of the evaporator compartment, a partition wall bridging the space between said rear wall and said cover extending from the top edge of the evaporator compartment to the outlet portion of the evaporator, and an air divider member cooperating with at least one of said evaporator fins to form an extension of said partition wall to the inlet portion of said evaporator to thereby separate air flowing from said convertible compartment in heat transfer association with said end turns and air flowing in heat transfer association with said plurality of paths.

* * * * *