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2,730,867

REFRIGERATION UNIT

Filed March 19, 1954

3 Sheets-Sheet 1

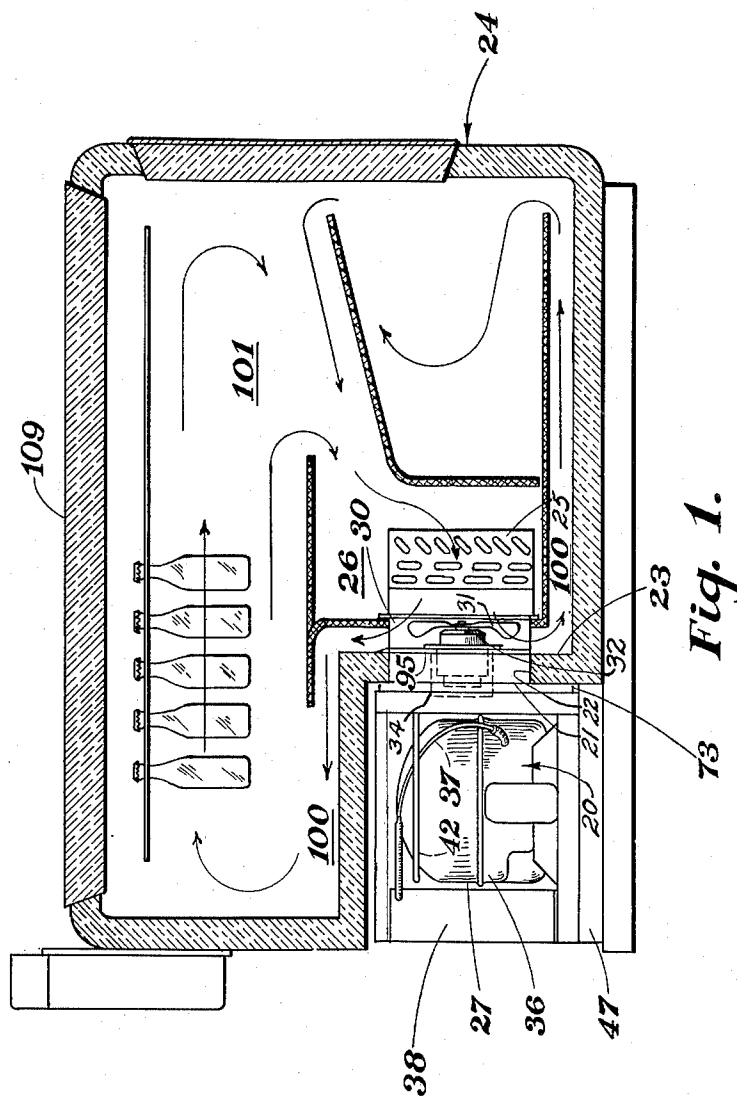


Fig. 1.

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3 Sheets-Sheet 3

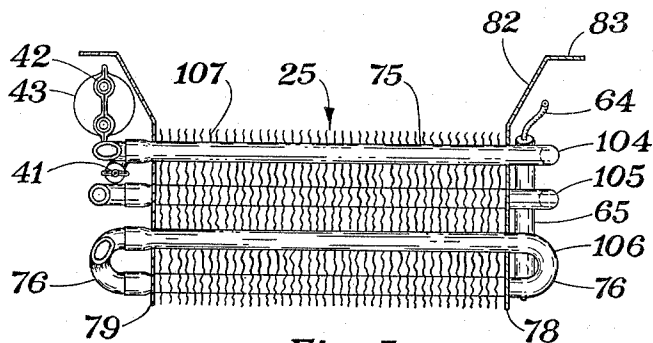


Fig. 5.

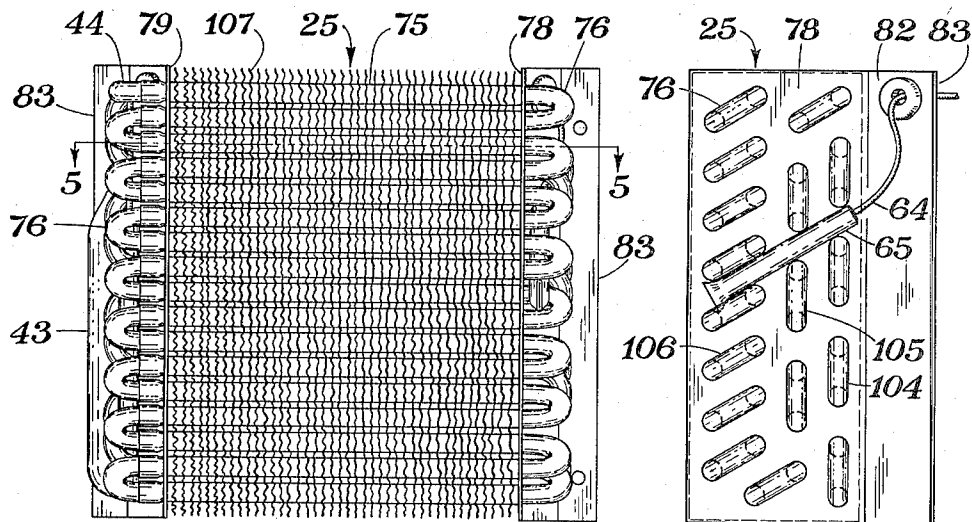


Fig. 4.

Fig. 6.

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REFRIGERATION UNIT

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10 Claims. (Cl. 62—4)

The present invention relates to refrigerators and more particularly to a refrigerator of the type in which the cooling element, the refrigerating medium circulating mechanism, the insulating wall between the element and mechanism form a unitary assembly which can be inserted into or removed from a refrigerator cabinet as a unit, and further relates to a refrigerator of the type in which a fan is employed for effecting substantially continuous flow of air through the cooling element and the refrigerated compartment of the cabinet.

In some types of refrigerators, it is desirable to augment flow of air by forced circulation. In such refrigerators, problems arise as to the disposition of the circulating fan and the motor therefor, such problems being the locating of the fan where it is most effective, positioning of the fan and motor therefor where space is of least value and where the rotating fan is least dangerous to those who insert and remove articles in and out of the refrigerator compartment.

In the present invention, the cooling element, the refrigerating medium circulating mechanism, the insulating wall between the elements, the fan for circulating the air in the compartment to be cooled and the motor therefor are constructed as a unitary assembly. The cooling element is disposed adjacent to but spaced from the insulating wall of the assembly so as to provide a passage for air between the cooling element and the interior wall of the cooling compartment. The fan is disposed in that space and the fore part of the driving motor for the fan is also disposed in that space and the rear part of the motor is disposed in a recess in the insulating wall of the assembly.

Moisture from the circulating air condenses on the cooling element and, in systems in which the air must be cooled to below water freezing temperature, this condensate freezes on the cooling element. This coating of ice impedes the heat exchange between the circulating air and the cooling element and impedes the flow of air through the cooling element. Such impedings cause erratic and inefficient operation of the refrigerating system and non-uniform temperatures in the refrigerated compartment.

The cooling element of the refrigerating system usually includes a plurality of runs of ducts that are connected in series circuit relation. These runs are arranged to traverse the paths of air and are spaced laterally of one another, longitudinally of the path of air cooled thereby. Refrigerating medium is usually admitted to the cooling element at one end of the latter and withdrawn from the other end. The outlet end or section of the duct system of the cooling element is relatively warmer than the inlet end or section. When the cooling element is an evaporator, in which the runs are connected in series circuit relation, the outlet end or section of the evaporator is warmer than the inlet end or section, due to the fact that the outlet section contains a larger volume of gaseous refrigerant than the inlet section; less heat is absorbed by

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gaseous refrigerant than is absorbed by the liquid refrigerant.

In practicing the present invention, air to be cooled by the cooling element (evaporator) is circulated first about the ducts of the outlet section of the cooling element and then through the relatively colder part of the cooling element. Although the refrigerant outlet section is warmer than the refrigerant inlet section, in normal operation the said outlet section cools the air passing thereabout to below the dew point. The condensate, in the form of liquid, will drip off the refrigerant outlet section. Under certain conditions, particularly when the relative humidity is high, some moisture will condense and freeze on the ducts. However, since most of the moisture is extracted before the air reaches the relatively colder part of the cooling element, the collection of frost or ice on the cooling element is relatively slow timewise.

The control for the refrigerating medium circulating mechanism includes a temperature responsive element which is substantially solely responsive to the temperature of the refrigerating medium, i. e. it is shielded from the path of circulating air. Therefore, although the refrigerating of the air by the cooling element is impaired, due to the accumulation of an excessive amount of frost or ice on the cooling element, which impedes the flow of air through the cooling element, the withdrawal of heat from the cooling element by the circulating mechanism being substantially constant, the temperature of the refrigerating medium will be decreased quickly. When the temperature of the refrigerating medium is decreased to a predetermined low degree, the circulation of refrigerating medium is decreased or stopped, if desired. The control mechanism is so adjusted that the normal refrigerating effect of the refrigerating system is delayed until the entire cooling element temperature is well above the melting point of the frost, i. e. the normal refrigerating effect is not resumed until all of the frost and ice is melted.

Further objects and advantages will be apparent from the following description, reference being had to the accompanying drawing wherein a preferred embodiment of the invention is illustrated.

In the drawings:

Fig. 1 is a vertical cross-sectional view of a refrigerator cabinet with the mechanism for effecting refrigeration, namely the refrigerating assembly, shown in elevation, except a wall has been removed to show the motor-compressor unit;

Fig. 2 is a top plan view of the assembly, parts thereof being shown in section, the parts shown in section being taken on line 2—2 of Fig. 3;

Fig. 3 is a side view of the assembly, with the greater portion of the side wall of the shroud removed to expose the parts therein;

Fig. 4 is a front view of the evaporator;

Fig. 5 is a sectional view taken on line 5—5 of Fig. 4; and

Fig. 6 is a side view of the evaporator, said side view being the opposite to that shown in Fig. 3.

Referring in general to the drawings, the refrigerating mechanism assembly is shown at 20. It includes all of the elements for effecting refrigeration, and includes an insulating wall 21. This insulating wall complements an opening 22 in a wall 23 of a refrigerator cabinet 24. When the assembly is in position in a refrigerator cabinet, the cooling element 25 is disposed in one of the refrigerated compartments 25 of the cabinet; the refrigerating medium circulating mechanism 27 is disposed outside said compartment; and the insulating wall 21 closes the opening 22.

The cooling element 25 is disposed adjacent the insulating wall 21 but is spaced therefrom to provide a passage 30 for air between cooling element 25 and the wall

23 of the cabinet. A fan 31 is utilized to augment the circulation of air in the refrigerated compartments. This fan is disposed in the passage 30. The fore part of the driving motor 32 for the fan is disposed in passage 30 and the rear part of the motor extends into a recess 34. This recess confronts the rear of the cooling element 25.

Referring more in detail to the drawings, the refrigerating mechanism, selected to show one embodiment of the invention, comprising a refrigerating system of the compression-condensing-expanding type wherein a volatile refrigerating medium is employed. The cooling element 25 is an evaporator and the refrigerant medium circulating mechanism includes a compressor or pump. The compressor may be any of those now being used and may be of the unit type wherein the compressor and electric driving motor therefor are contained in a hermetically-sealed casing 36. The casing only is shown and since such motor-compressor unit is conventional, details thereof are not shown and the unit will be referred to as the refrigerating medium circulating mechanism 27 or motor-compressor unit 27.

Gaseous refrigerant under high pressure is conveyed from casing 36 of unit 27 by a tube 37 to a condenser 38 where it is cooled and liquefied, the lower portion of the condenser 38 functioning as a receiver. Fins 39, on the tubes 40 of the condenser, aid in conducting heat from the refrigerant in the tubes. Liquefied refrigerant from the bottom or liquid receiver portion of the condenser 38 is conveyed by a tube 41 to the evaporator 25. Tube 41 is of such small inside diameter and of such length as to function as a restrictor between the receiver and the evaporator whereby the desired differential in pressure is maintained between the receiver and evaporator while gaseous refrigerant is being withdrawn, by the compressor, from the evaporator. Gaseous refrigerant is withdrawn, by the compressor, from the evaporator 25 through a tube 42, there being a closed expansion container 43 between the outlet 44 of the evaporator and the inlet 45 of tube 42. Air passing about the container assures vaporization of any liquid refrigerant which may flow from the evaporator.

Unit or element 27 is supported on and suitably secured to a horizontal base 47. This base also carries the condenser 38, the condenser being disposed to the left of the unit 27, as viewed in the drawings. A shroud 48 is provided for the unit 27 and condenser 38. This shroud includes a top wall 49, side walls 50 and 51, and end walls 52 and 53.

A steel frame 54 is secured to and carried by base 47. The side wall 53 is spot welded to frame 54. The top wall 49 and side wall 51 are impervious but the side wall 50 and end wall 52 are provided with openings 56 and 57, respectively, for the egress and ingress of air from and to the compartment 58 formed by the shroud 48.

A fan 59 is disposed within compartment 58 and is located substantially centrally of the opening 56 in wall 50. The fan is driven by an electric motor 60, which latter is suitably carried by a bracket 61. A duct 62 is arranged concentrically with the axis of the fan and is carried by the said wall 50. Air from outside the compartment 58 is drawn through the opening 57 in end wall 52, then over the condenser 38, then about the motor-compressor unit 27, whence it is expelled through the duct 62 and through the opening 56 in side wall 50. The duct 62 effects a direct draft of air about the unit 27.

A controller is utilized for maintaining the desired temperature of the evaporator 25. The controller employs a closed thermostatic system including a volatile fluid. One end of a tube 64 of the system is suitably connected with a bulb 65. This bulb is secured, as by solder, with exterior walls of various sections or runs of the evaporator 25 and is so located on the evaporator as to respond substantially concomitantly with the change of mean temperature of the evaporator, i. e. there is a temperature gradient between different parts of the evaporator and

the bulb's contact with the evaporator spans sufficient parts of the evaporator so as to respond approximately to the mean temperature of the various parts of the evaporator with which it is in intimate contact. The other end of the tube 64 is connected with the interior of a bellows or diaphragm (not shown) which forms a part of a pressure-responsive electric switch, indicated generally at 66. Switch 66 is carried by end wall 52.

Switch 66 controls the starting and stopping of the motor of the motor-compressor unit 27 and the fan motor 60. These motors are preferably connected in parallel circuit relation. When one motor is operating, the other is also operating, and when one is not operating, the other is not operating. The pressures at which the switch 66 opens can be selected by a manually-operated knob 67 which is connected to the switch 66 and extends outwardly of wall 52. Preferably, the switch is set to start the motor for unit 27 and the fan motor 60 when the temperature of the refrigerant in the evaporator is above water-freezing temperature, for the reason hereinafter more fully explained. Since the pressure in the thermostatic system is a result of the temperature of the refrigerant in the evaporator, or substantially so, the temperature of the refrigerant controls the starting and stopping of the motor-compressor unit 27.

The bottom of frame member 54 is suitably secured to the base 47. The right side of member 54 carries an endless gasket 73, which, as seen in Fig. 1, engages the left side of the vertical wall 23 of a refrigerator cabinet 24. Wall 21, formed of insulating material, is suitably secured to and carried by frame member 54.

The evaporator 25 comprises a tube having runs 75 connected in series circuit relation by elbows 76. A casing 77 surrounds the major portion of the evaporator 25. This casing includes opposite side walls 78 and 79, a bottom wall 80, and a top wall 81. The side walls 78 and 79 flare outwardly rearwardly as at 82, and then form flanges 83. The bottom wall 80 forms a drip pan 85 having upright flanges 86. An upright plate 90, having a large centrally-disposed opening, slightly larger than the fan 31, supports the drip pan 85. Horizontally extending bolts 95, secured in the frame member 54, extend through openings in the rear wall 90 and the flanges 83 of casing 77. Nuts 93, threaded on bolts 92, clamp the casing 77 in position. Spacing elements 94 are clamped between the front of wall 21 and the rear of wall 90.

Thus the motor-compressor unit 27, the condenser 38, the base therefor, the shroud 48, the frame member 54, the partition wall 21, the evaporator 25, the casing 77 therefor, form an assembly, which can be inserted into and removed from a refrigerator cabinet as such. A gasket 95 embraces and surrounds the periphery of the fore part of the insulating wall. This gasket is formed of resilient material so that it seals the space between the outer periphery of the wall 21 and the inner periphery of the opening 22.

Rear wall 90 is open for the free flow of air there-through and forms the exit of the evaporator casing 77. The flow of air in the cabinet and through the evaporator is augmented by the fan 31; this fan is rotated by the electric motor 32. A plate 96, having a central opening, is secured to the right side of wall 21. A ring-shaped frame 97 is secured to the plate and carries the fan motor 32. The recess 34 is formed in that side of the wall 21 which confronts the evaporator 25. The rear part of the fan motor 32 is disposed in this recess and the fore part of the motor lies in the space between the front of wall 21 and the rear of the evaporator.

As is more clearly shown in Fig. 1, the rear of the evaporator 25 is disposed adjacent the wall 23 of the refrigerator but is spaced from said wall to provide the passage 30 for air. Air is withdrawn from the evaporator casing 77, forced into passages 30 and 100 and into the refrigerator storage compartment 101, whence it flows through compartment 26 to the evaporator. By

placing the fan and fan motor, as herein shown, between the evaporator and a wall of the cabinet, said fan is not only highly effective but it and the motor are located in space having the least value; also the evaporator casing provides a guard for protecting the user of the refrigerator against accidental touching of the rotating fan.

The drip pan 85 slopes downwardly and rearwardly. The rear of this pan is connected with a tube 102. This tube extends through wall 21, frame member 54, and into the machine compartment 58. Condensate flowing from the evaporator drops into drip pan 85 and is conducted by tube 102 into a pan (not shown) in the machine compartment. Heat generated in the machine compartment, by the condenser and motor-compressor unit, causes this condensate to vaporize. The vapor is carried out of the machine compartment by the air circulating through the compartment.

Refrigerant tubes 37 and 42 and tube 64 of the thermostatic controller system also extend through holes provided therefor in the wall 21 and frame member 54.

Referring more in detail to the evaporator 25, it will be seen that it includes, for illustrative purpose, a section including two series of serpentine-shaped portions 104 and 105. These portions lie in vertical planes and each includes generally horizontally extending runs 75 which are connected with one another by elbow sections 76. These runs are spaced longitudinally of the general direction of air passing through casing 77. The evaporator also includes oblong helical section 106 which extends vertically. This section 106 also comprises runs 75 connected with elbows 76. It is to be understood that the sections are connected in series circuit relation by suitable elbow portions. The runs 75 traverse the casing 77 and extend through the opposite side walls 78 and 79; the elbow portions of the tube are disposed outside the casing. Vertically-extending metallic heat exchange fins 107 are connected in intimate heat exchange relation with the runs 75 of the evaporator.

The section 106 lies forwardly, in the air stream, with respect to sections 104 and 105. The fins 107 lie parallel with the general direction of air flowing through the casing, and thus provide a plurality of air passages through the evaporator.

Liquid refrigerant from the restrictor 41 is delivered to the rearmost portion 104 of the evaporator and gaseous refrigerant is withdrawn from the uppermost run of the foremost section 106.

The bulb 65 of the thermostatic control system is shielded from the air passing through the evaporator by the sheath or casing 77, particularly by the side wall 78 of the sheath. This bulb 65 is in intimate heat exchange relation with elbows of the rear section 104-105 and the front section 106 of the evaporator. It is preferably soldered to these elbows. Since the bulb is shielded from the main draft of air and is in intimate heat exchange relation with the evaporator sections, outside the casing, the temperature thereof closely follows the temperature of the refrigerant in the evaporator. Obviously, the mean temperature of the evaporator varies when more heat is delivered thereto than is dissipated in the refrigerant, or when less heat is being absorbed by the evaporator than is dissipated in the refrigerant. Also, since the bulb is in contact with portions of the evaporator linearly throughout the length of the evaporator, its temperature, and that of the volatile fluid therein, will vary substantially simultaneously with and will be substantially the same, at all times, as the mean temperature of the refrigerant in the evaporator, whatever said mean temperature may be.

The switch 66 of the thermostatic control system is set to close the motor circuits for the unit 27 and the fan 59 when the mean temperature of the evaporator 25 is above the freezing point of water, for example at 38° F. When this temperature is reached, all frost and ice will have been melted off the evaporator. The

switch 66 is opened when the mean temperature of the evaporator 25 has been reduced to a predetermined low temperature, for example between 6° and 12° F. The desired low temperature can be selected through switch-adjusting knob 67.

In the event that the fins and runs become so coated with ice as to materially impede the heat exchange between the relative warm air and the refrigerant in the runs and materially impede the flow of air through the evaporator, and since the unit 27 and the condenser 38 are functioning to dissipate heat at a substantially constant rate, the temperature of the refrigerant in the evaporator will be decreased rapidly to the selected low mean evaporator temperature. The unit 27 will then remain idle until the mean temperature of the evaporator again reaches, for example, 38° F. Refrigeration of the air, however, will continue during the idle phase of the unit, since the fan 31 continues to withdraw air from the refrigerated compartment 101, through the ice on the evaporator and return the air to said compartment. If desirable, a door-operated switch may be connected in series with the fan motor 32. The circuit for the motor 32 would be closed at all times except when the lid 109 was lifted.

As is well known, there is an increment of temperature from the inlet end to the outlet end of the duct system of the type of evaporator herein shown. I have discovered that exceptionally less frost or ice is accumulated on the evaporator when the direction of air flow is contra to the general direction of the flow of refrigerant through the evaporator. It will be observed that the air flow through the evaporator is from right to left while the general direction of the refrigerant flow is from left to right. I have found that the front or right section of the evaporator, that is, the warmer section, cools the air to below the dew point and the major moisture precipitation takes place at the front section of the evaporator. While some condensation and freezing of water takes place on the runs 75, by causing the air to flow contra to the flow of refrigerant, materially less frost and ice collects on the evaporator, more even temperature is maintained, and a higher efficiency of the refrigerating system is obtained than when the air enters the coldest section of the evaporator. When air enters the coldest section of the evaporator, the heat exchange between the air and the relatively coldest refrigerant is too high, resulting in freezing of the condensate before such condensate forms drops of water of sufficient weight to break the cohesive force between the condensate and the runs or fins; under such condition, the spaces between the fins of the evaporator are quickly clogged with ice, resulting in quickly impeding the flow of air and a resulting erratic fluctuation in temperature of the evaporator and consequent material variation of the temperature in the compartment to be cooled.

It will be observed that section 106 is so constructed that liquid refrigerant drains downwardly and the gaseous refrigerant can always escape upwardly. This prevents entrapment or pocketing of either liquid or gaseous refrigerant. This in effect prevents violent ebullition which would tend to blow liquid refrigerant through the outlet of the evaporator.

Another advantage in having the thermostat bulb in control with the evaporator linearly throughout the length of the evaporator, lies when some refrigerant has escaped from the system. Such escape occurs occasionally due to a slow leak in the system. The detrimental effect of such insufficiency is particularly pronounced and disadvantageous in a forced-air system, although a fraction of an ounce only has escaped. If the bulb is placed adjacent the refrigerant inlet end of the evaporator, short cycling will result. If it is placed adjacent the refrigerant outlet end, the compressor operates substantially constantly. It is not only physically too difficult to place the bulb so that it is responsive to a portion only of the

evaporator, intermediate its ends, but such bulb would then be too sensitive to other undesirable environments. I have overcome these difficulties by connecting the bulb to the evaporator in such manner that it is influenced by temperatures through the linear length of the duct system of the evaporator. Accurate temperature can be maintained too in the event an excessive charge of refrigerant is placed in the system when the bulb 65 is connected as described. Thus, variance of charges of refrigerant in the system is no longer critical.

While the form of mechanism herein shown and described constitutes a preferred form, it is to be understood that other forms may be adopted falling within the scope of the claims that follow.

I claim:

1. A refrigerator, comprising in combination, walls forming an insulated compartment, one of said walls having an opening therein; a refrigerating unit including a cooling element and an element operatively connected with the cooling element for circulating a refrigerating medium through the cooling element, said refrigerating unit including an insulating wall interposed between said elements, said insulating wall lying in substantially the plane of said one wall and closing the opening in said one wall of the first-mentioned walls and having a recess therein on the side confronting the cooling element, the refrigerating medium circulating element being disposed outside the compartment, said cooling element being disposed within the compartment adjacent to but spaced from said wall having the opening to provide a passage for air between the cooling element and said last-mentioned wall; a fan in said space; and a motor for driving the fan, said motor having at least a part thereof extending into said recess.

2. A refrigerator as defined in claim 1, characterized in that at least a portion of the motor is disposed in the passage.

3. A refrigerating system comprising in combination, means forming a compartment to be cooled; a cooling element; a substantially constantly operating fan for circulating air through the cooling element and the compartment, said cooling element including a plurality of runs of ducts connected in series circuit relation and spaced from one another longitudinally of the path of circulating air and spaced from one another to provide passages for air; means for circulating refrigerating medium through the cooling element, said cooling element having a refrigerating medium inlet and a refrigerating medium outlet connected with the refrigerating circulating means, said inlet being connected to receive refrigerating medium at the outlet of said air passages and said outlet being connected to discharge refrigerating medium at the inlet of the air passages; and means in intimate contact with and varying with the mean temperature of the cooling element for controlling the circulation of refrigerating medium by the refrigerating medium circulating means.

4. A refrigerating system as defined in claim 3, characterized in that the cooling element is an evaporator.

5. A refrigerating system as defined in claim 3, characterized in that the ducts carry fins and the fins are arranged longitudinally of the path of air flowing through the cooling element.

6. A refrigerating system as defined in claim 3, characterized in that said control means includes a temperature responsive element connected in intimate heat exchange relation with a portion of the cooling element near the refrigerant inlet thereof and with a portion of the cooling element near the refrigerant outlet thereof.

7. A refrigerating system as defined in claim 3, characterized in that said control means includes a temperature responsive element connected in intimate heat exchange relation with a portion of the cooling element near the refrigerant inlet thereof and with a portion of the cooling element near the refrigerant outlet thereof, and further characterized to include means for shielding the temperature responsive element from direct air currents produced by the fan.

8. A refrigerating system as defined in claim 3, characterized to include a sheath surrounding a substantial portion of the cooling element, opposite ends of the sheath being open for the passage of air to and from the cooling element, a portion of the inlet end and a portion of the outlet end of the cooling element extending outside the sheath, and further characterized in that said control means includes a temperature responsive element connected in intimate heat exchange relation with the said extending portions of the cooling element.

9. A refrigerating system as defined in claim 3, characterized to include a sheath surrounding a substantial portion of the cooling element, opposite ends of the sheath being open for the passage of air to and from the cooling element, portions of said longitudinally spaced ducts extending outside said sheath, and further characterized in that said control means includes a temperature responsive element connected in intimate heat exchange relation with the said extending portions of said ducts.

10. In a refrigerating system of the type in which air is circulated substantially constantly through a cooling element and a compartment, which cooling element is of the type including a plurality of runs of ducts connected in series circuit relation and spaced laterally from one another longitudinally of the air paths through the cooling element, which system also includes a refrigerating medium circulating mechanism connected with the cooling element for delivering refrigerating medium to one end of the cooling element and for withdrawing refrigerating medium from the opposite end of the cooling element, those steps in the method of refrigeration which consists in causing the air to flow longitudinally through the cooling element in paths contra to the longitudinal flow of refrigerating medium, and controlling the refrigerating medium circulating mechanism directly in accordance with variations of the mean temperature of the cooling element.

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