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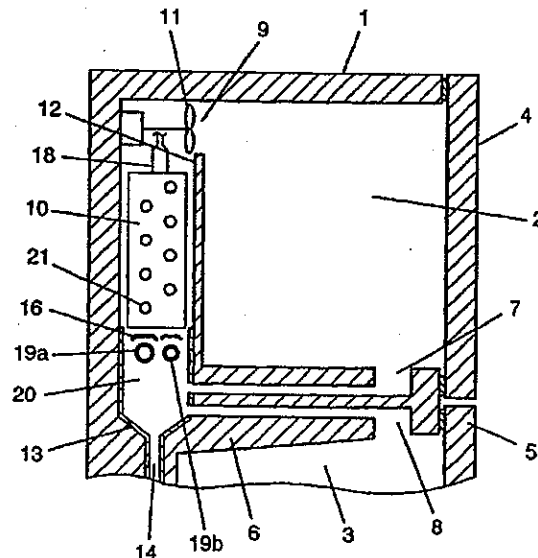
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(54) Title: REFRIGERATOR

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(57) Abstract: As a defrosting means for an evaporator having a combustible refrigerant sealed therein and included in a refrigerating cycle, a plurality of glass tube heaters are installed in the vicinity of the evaporator. And, the electricity passing time or the applied voltage is controlled such that the surface temperature of the glass tube heaters is less than the ignition temperature of the combustible refrigerant. Further, the glass tube heaters and the evaporator fins are brought into contact with each other to lower the surface temperature of the glass tube heaters. Further, the glass tube heaters are of multiple construction and a sealing member is installed on the end surface. With such arrangement, in a refrigerator using a combustible refrigerant, even if defrosting is effected in a combustible refrigerant-leaking environment, firing of the combustible refrigerant can be prevented and so can be non-cooling due to the residue of the frost.

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DESCRIPTION

REFRIGERATOR

TECHNICAL FIELD

The present invention relates to defrosting for a refrigerator employing a combustibile refrigerant.

BACKGROUND ART

As a prior-art refrigerator, Japanese Patent Non-examined Publication No. H8-54172 discloses a refrigerator using a combustibile refrigerant. First will be described the prior-art refrigerator with reference to drawings. Fig. 31 shows a vertical sectional view illustrating the essential part of a prior-art refrigerator.

In Fig.31, refrigerator 1 has freezer compartment 2 and cold-storage compartment 3 therein, and to which, freezer door 4 and storage door 5 are fixed, respectively. Freezer compartment 2 and cold-storage compartment 3 are separated by dividing wall 6. The air in freezer compartment 2 is captured through inlets 7, and the air in cold-storage compartment 3 is captured through inlet 8. Outlet 9 blows cold air into freezer compartment 2. The cold air is circulated by fan 11. Evaporator dividing wall 12 is disposed between freezer compartment 2 and evaporator 10. Glass-tube heater 15 for defrosting has a structure in which a coiled nichrome-wire is covered with a glass tube. Roof 16 protects heater 15 from being directly hit by a drip of melted frost that will give a sputter sound on evaporation. Metallic bottom plate 17 is disposed, in insulation, between dripping pan 13 and heater 15. Accumulator 18 is disposed at the exit of evaporator 10.

Now will be described how the aforementioned prior-art refrigerator

works.

When cooling the freezer compartment 2 and cold-storage compartment 3, evaporator 10 is cooled by a refrigerant flowing through evaporator 10. At the same time, fan 11 expels warmed air in freezer compartment 2 through inlet 7, similarly, expels warmed air in cold-storage compartment 3 through inlet 8, into cooling chamber 20. The warmed air is cooled at evaporator 10 by heat exchange, and then supplied through outlet 9 to freezer compartment 2. At the same time, a portion of the cooled air is fed from freezer compartment 2 through a communication opening (not shown) to cold-storage compartment 3. The air that does heat-exchange at evaporator 10 has high moisture due to the air flown from outside into the refrigerator each time door 4 or door 5 is opened, and due to evaporation of moisture from stored foods in both compartments. Therefore, the moisture in the warmed air turns into frost on evaporator 10 where the temperature is lower than the air. Accumulator 18 works to constantly feed refrigerant in cooling cycle operations. In addition, accumulator 18 protects a compressor from damage caused by direct return of liquid refrigerant, or minimizes a flowing noise of the refrigerant.

The more increase the amount of the frost on evaporator 10, the less increase the efficiency of heat-exchange between the surface of evaporator 10 and the air to be cooled. Further, the buildup of the frost blocks a smooth airflow, inviting insufficient cooling. To eliminate said inconveniences, the application of heat has been employed for defrosting – passing an electric current through the nichrome-wire in the glass-tube heater 15 and, with heat rays emitted therefrom, melting the frost into water around evaporator 10, dripping pan 13, and drainage hole 14.

The water is collected into dripping pan 13; the dripping water partly goes directly down into pan 13, and partly hits roof 16 as a guard of heater 15

and then down into pan 13. The water collected in pan 13 is drained through drainage hole 14 to the outside. On the application of heat, some of the heat rays radiated from heater 15 toward dripping pan 13 are reflected off bottom, plate 17 and then scattered toward evaporator 10.

However, such structured conventional refrigeration cycle employing a combustible refrigerant has problems below. A combustible refrigerant has relatively large latent heat. In pipe arrangement of evaporator 10 where the combustible refrigerant stays for a period, such a property of the refrigerant invites insufficient defrosting, thereby leaving frost in the pipe arrangement. As a result, residual frost hampers heat transfer, resulting in poor refrigeration.

Besides, not only the nichrome-wire, but also the surface of the glass-tube heater has highly heated surfaces. The fact has been facing a problem; if a combustible refrigerant leaks at somewhere in the pipe arrangement of evaporator 10, the heat generated from heater 15 can trigger catching fire.

DISCLOSURE OF THE INVENTION

The present invention addresses the problem above. It is therefore the object to provide a refrigerator equipped with a defrosting means capable of: not only preventing a combustible refrigerant from catching fire even if the defrosting operation is performed in an environment where leakage of the combustible refrigerant occurs at somewhere in the area having the defrosting means, but also improving a poor refrigeration due to residual frost.

According to a first aspect of the invention, there is provided a refrigerator comprising:

a combustible-refrigeration-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator; and

means for defrosting the evaporator,

wherein the defrosting means is formed of a plurality of glass-tube heaters disposed in an upper section and in a lower section of the evaporator having any one of in-contact and out-of-contact arrangements with the evaporator.

According to a second aspect of the invention, there is provided a refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator; and

means for defrosting the evaporator,

wherein the defrosting means is formed of a plurality of glass-tube heaters, and at least one of the plurality of glass-tube heaters is disposed within the evaporator.

According to a third aspect of the invention, there is provided a refrigerator comprising:

a combustible-refrigeration-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator; and

means for defrosting the evaporator,

wherein the defrosting means is formed of a plurality of glass-tube heaters, and at least one of the plurality of glass-tube heaters is disposed any one of i) in a lower section of the evaporator and ii) below the evaporator, and remaining glass-tube heaters are disposed any one of iii) in front of the evaporator and iv) behind the evaporator.

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According to a fourth aspect of the invention, there is provided a refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator; and

means for defrosting the evaporator,

wherein the defrosting means is formed of a plurality of glass-tube heaters, and a period through which an electric current is applied to the plurality of glass-tube heaters is controlled so that a surface temperature of the heaters is kept below an ignition temperature of the combustible refrigerant.

According to a fifth aspect of the invention, there is provided a refrigeration comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator; and

means for defrosting the evaporator,

wherein the defrosting means is formed of a plurality of glass-tube heaters, and an application of voltage to the plurality of glass-tube heaters is controlled so that a surface temperature of the heaters is kept below an ignition temperature of the combustible refrigerant.

According to a sixth aspect of the invention, there is provided a refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator; and

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a glass-tube heater disposed below the evaporator; and
a plurality of fins disposed in the evaporator,
wherein an outer wall of the glass-tube heater makes contact with each bottom
end of the fins.

According to a seventh aspect of the invention, there is provided a
refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive
connections of following elements: a compressor, a condenser, a pressure
reduction mechanism, and an evaporator;

a glass-tube heater disposed in a lower section of the evaporator;

a plurality of fins disposed in the evaporator; and

a shield plate disposed between the glass-tube heater and the fins,
wherein the shield plate makes contact with the fins.

According to a eighth aspect of the invention, there is provided a
refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive
connections of following elements: a compressor, a condenser, a pressure
reduction mechanism, and an evaporator;

a glass-tube heater with a tube-in-tube structured disposed in any one of in
a lower section of the evaporator and below the evaporator; and

a sealing member disposed at an end of the glass-tube heater,
wherein the multi-structured glass tubes include an inner tube and an outer tube,
the sealing member integrally contains an inner-tube holder and an outer-tube
holder, the inner-tube holder supports the inner tube and the outer-tube holder
supports the outer tube, the inner-tube holder has a lapping section at an end of

4c

an outer wall of the inner tube, and the outer-tube holder has an alignment section for proper positioning of an end of the outer tube.

According to a ninth aspect of the invention, there is provided a refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator;

a glass-tube heater with a tube-in-tube structured disposed in any one of in a lower section of the evaporator and below the evaporator; and

a sealing member disposed at an end of the glass-tube heater, wherein the multi-structured glass tubes include an inner tube and an outer tube, the sealing member integrally contains an inner-tube holder and an outer-tube holder, the inner-tube holder supports the inner tube and the outer-tube holder have a lapping section at an end of an outer wall of the inner tube and an end of an outer wall of the outer tube, respectively.

According to a tenth aspect of the invention, there is provided a refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator;

a glass-tube heater with a tube-in-tube structured disposed in any one of in a lower section of the evaporator and below the evaporator; and

a sealing member disposed at an end of the glass-tube heater, wherein the sealing member is formed of a plurality of supporting members.

4d

The structure above can suppress an input for each glass-tube heater when the evaporator and its surroundings are heated by the glass-tube heaters in the defrosting operation. This allows the surface temperature of the glass-tube heater to maintain below a temperature at which the combustible refrigerant can catch fire. As another plus, effective heating on the area having a large amount of frost can provide a uniform defrosting, thereby enhancing the efficiency of defrosting and eliminating residual frost.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a schematic view illustrating the refrigeration cycle of a refrigerator in accordance with a first exemplary embodiment of the present invention.

Fig. 2 is a vertical sectional view showing the essential part of the refrigerator of the first exemplary embodiment.

Fig. 3 is a schematic view illustrating the essential part of the refrigerator shown in Fig. 2.

Fig. 4 is a sectional view of a glass-tube heater, with the essential part enlarged, of the refrigerator shown in Fig. 2.

Fig. 5 is a vertical sectional view showing the essential part of a refrigerator of a second exemplary embodiment.

Fig. 6 is a vertical sectional view showing the essential part of a refrigerator of a third exemplary embodiment,

Fig. 7 is a vertical sectional view showing the essential part of a refrigerator of a fourth exemplary embodiment.

Fig. 8 is a vertical sectional view showing the essential part of a refrigerator of a fifth exemplary embodiment.

Fig. 9 is a vertical sectional view showing the essential part of a refrigerator of a sixth exemplary embodiment.

Fig. 10 is a vertical sectional view showing the essential part of a refrigerator of a seventh exemplary embodiment.

Fig. 11 is a vertical sectional view showing the essential part of a refrigerator of an eighth exemplary embodiment.

Fig. 12 is a view, partially in perspective, of a refrigerator of a ninth exemplary embodiment.

Fig. 13 is a front view, looking in the direction of arrow B of Fig. 12.

Fig. 14 is a view, partially in perspective, of another evaporator and glass-tube heater of a refrigerator of the ninth exemplary embodiment.

Fig. 15 is a front view, looking in the direction of arrow C of Fig. 14.

Fig. 16 is a view, partially in perspective, of an evaporator and a glass-tube heater of a refrigerator of a tenth exemplary embodiment.

Fig. 17 is a front view, looking in the direction of arrow D of Fig. 16.

Fig. 18 is a view, partially in perspective, of an evaporator and a glass-tube heater of a refrigerator of an eleventh exemplary embodiment.

Fig. 19 is a front view, looking in the direction of arrow E of Fig. 18.

Fig. 20 is a view, partially in perspective, of an evaporator and a glass-tube heater of a refrigerator of a twelfth exemplary embodiment.

Fig. 21 is a front view, looking in the direction of arrow F of Fig. 20.

Fig. 22 is a view, partially in perspective, of an evaporator and a glass-tube heater of a refrigerator of a thirteenth exemplary embodiment.

Fig. 23 is a front view, looking in the direction of arrow G of Fig. 22.

Fig. 24 is a partially enlarged sectional view of a glass-tube heater of the refrigerator shown in Fig. 22.

Fig. 25 is a view illustrating the refrigeration cycle of a refrigerator of a

fourteenth exemplary embodiment.

Fig. 26 is a partially sectional view of a glass-tube heater of the refrigerator of the fourteenth exemplary embodiment.

Fig. 27 is a partially sectional view of another glass-tube heater of the refrigerator of the fourteenth exemplary embodiment.

Fig. 28 is a partially sectional view of a glass-tube heater of a refrigerator of a fifteenth exemplary embodiment.

Fig. 29 is a partially sectional view of a glass-tube heater of a refrigerator of a sixteenth exemplary embodiment.

Fig. 30 is a partially sectional view of a glass-tube heater of a refrigerator of a seventeenth exemplary embodiment.

Fig. 31 is a sectional view illustrating the essential part of a prior-art refrigerator.

DETAILED DESCRIPTION OF CARRYING OUT OF THE INVENTION

The exemplary embodiments of the present invention are described hereinafter with reference to the accompanying drawings.

FIRST EXEMPLARY EMBODIMENT

Fig. 1 shows a schematic view illustrating the refrigeration cycle of a refrigerator in accordance with the first exemplary embodiment of the present invention. Fig. 2 is a vertical sectional view showing the essential part of the refrigerator of the first exemplary embodiment. Fig. 3 is a schematic view illustrating the essential part of the refrigerator shown in Fig. 2. Fig. 4 is a sectional view of a glass-tube heater, with the essential part enlarged, of the refrigerator shown in Fig. 2.

In Fig. 1, refrigeration cycle 301 has successive connections of the

following elements: compressor 302, condenser 303, pressure reduction mechanism 305, and evaporator 306. A combustible refrigerant is sealed in refrigeration cycle 301. Besides, defrosting means 307 is disposed close to evaporator 306.

Here will be described the structure of an exemplary refrigerator having the refrigeration cycle shown in Fig. 1, with reference to Figs. 2 through 4.

In Figs. 2 through 4, the refrigerator of the first embodiment contains two glass-tube heaters 19a and 19b as an example of the defrosting means shown in Fig. 1. Each heater has a structure in which heater wire 24 made of metallic material, such as nickel chrome, is formed into a spiral shape and then inserted in a glass tube. Heaters 19a and 19b are placed below evaporator 1 in a side-by-side arrangement; more specifically, heater 19a is disposed close to lowermost pipe 21 of evaporator 10. In explanations will be given from now on, glass-tube heaters 19a and 19b may often be referred to glass-tube heater 19 as a unit.

In cooling chamber 20, as shown in Fig. 2, evaporator 10, fan 11, roof 16, and glass-tube heater 19 are disposed. A pair of supporting members 22, each one is disposed at each end of heater 19, fixes heater 19a together with heater 19b.

Hereinafter will be described the workings of a refrigerator having aforementioned structure of the first exemplary embodiment.

After the expiration of a predetermined time interval, fan 11 stops to remove frost from evaporator 10, and a refrigerant stops flowing through evaporator 10. After that, the electric current is supplied through glass-tube heater 19 for generating heat to melt the frost on evaporator 10. When a defrost-completion detector (not shown) detects the completion of defrosting, the current-supply to heater 19 is stopped, so that defrosting operation completes.

When fan 11 comes to a stop, the combustible refrigerant liquid in evaporator 10 flows down, by its own weight, to lowermost pipe 21 that collects higher amounts of the refrigerant than other pipes in evaporator 10. After that, heat generated from first glass-tube heater 19a evaporates the high amounts of the combustible refrigerant having high latent heat in the pipe.

In the process, heater 19a, which is located near by lowermost pipe 21, encourages to evaporate the high amounts of the combustible refrigerant in the pipe at the lower section of evaporator 10. With the application of heat, the combustible refrigerant is changed into hot gas, moving up toward the pipes in the upper section of evaporator 10. The pipes in the upper section of evaporator 10 are kept cool due to the frost on evaporator 10. The hot gas of the refrigerant moved from the lower section is now cooled by the pipes and the fan and changed into liquid. For turning into liquid, the hot gas radiates the heat toward frost deposited on the upper section of evaporator 10. Defrosting is thus carried out. In the process, the gaseous combustible refrigerant, due to its high latent heat, radiates a large amount of heat required for changing into liquid, whereby the defrosting is accelerated. In this way, a thermo-siphon effect facilitates the defrosting of evaporator 10. At the same time, direct radiation of the heat generated from heater 19 melts the frost on evaporator 10 and peripheral components and walls. Besides, the ambient air warmed up by the heat moves around. All the actions above contribute to a thorough defrosting of evaporator 10.

On the other hand, second glass-tube heater 19b is disposed, next to first glass-tube heater 19a, below evaporator 10. That is, by virtue of the structure having plural heaters, the application of an electric current per heater can be smaller than that in the prior-art structure. This allows the surface temperature of a glass-tube heater to keep lower than the ignition temperature

of the combustible refrigerant; in the case of employing isobutane as the refrigerant, the surface temperature of the heater can be kept below 460 °C. Generally, an amount of radiation is proportional with the surface area of a hot body. Compared to a structure with a single heater, a structure formed of a plurality of heaters 19 has larger surface area, accelerating heat-transfer to evaporator 10. Furthermore, the structure with plural heaters can effectively heat the lower section of the evaporator having high amounts of frost, ensuring a uniform defrosting. This enhances defrosting efficiencies, eliminating residual frost.

As described above, the thermo-siphon effect of the combustible refrigerant in the pipes, and heat directly radiated from heaters 19a and 19b contribute to uniform defrosting the entire surfaces of evaporator 10, enhancing defrosting efficiencies, as well as eliminating residual frost. Besides, disposing a plurality of glass-tube heaters (19a, 19b) can save the operating time per heater 19a (19b); accordingly, the radiating period of each heater is shortened. This ensures that the surface temperature of the heaters 19a and 19b is kept enough below the ignition temperature of the combustible refrigerant. Furthermore, a pair of supporting members holds glass-tube heaters 19a and 19b so as to be an integrated structure, providing not only a simple structure but also easy assembling work.

The refrigerator of the first exemplary embodiment, as described above, provides a structure having a plurality of glass-tube heaters for defrosting the evaporator. Thereby, the temperature of each glass-tube heater during the passage of an electric current can be kept lower than the ignition temperature of the combustible refrigerant. That is, defrosting can be carried out at temperatures below the ignition temperature of the refrigerant, without degradation in the efficiency of defrosting. The refrigerator of the embodiment

not only can prevent a combustible refrigerant from catching fire even if the defrosting operation is performed in an environment where leakage of the combustible refrigerant occurs at somewhere in the area having defrosting means, but also can improve a poor refrigeration due to residual frost.

SECOND EXEMPLARY EMBODIMENT

Fig. 5 is a vertical sectional view showing the essential part of a refrigerator of the second exemplary embodiment.

The second embodiment differs from the first embodiment in the following points.

In Fig. 5, a plurality of glass-tube heaters is located in opposed positions, sandwiching evaporator 10 therebetween. To be more specific, first glass-tube heater 25a is disposed at a position lower than evaporator 10; on the other hand, second glass-tube heater 25b is disposed at a position higher than evaporator 10 and close to accumulator 18.

Hereinafter will be described the workings of a refrigerator having the structure above.

As is the description in the first embodiment, the combustible refrigerant liquid in evaporator 10 flows down, by its own weight, to lowermost pipe 21 that collects higher amounts of the refrigerant than other pipes in evaporator 10. After that, heat generated from glass-tube heater 25a heats up the combustible refrigerant collected in the lowermost pipe and its vicinity. With the application of heat, the combustible refrigerant is changed into hot gas, moving up toward the pipes disposed in the upper section of evaporator 10. The hot gas of the refrigerant carried from the lower section is now cooled and again changed into a liquid by the pipes and radiation fins of the evaporator. For changing into liquid, the hot gas radiates the heat toward frost deposited on the upper

section of evaporator 10. The refrigerant liquid flows down to lowermost pipe 21. In this way, repeating the thermo-siphoned cycle thus carries out defrosting of the evaporator.

Due to structural difference in evaporator 10, an amount of the combustible refrigerant may not leave accumulator 18 for lowermost pipe 21. Such a position where the refrigerant tends to stay-on will be a slow-defrosted area. In the structure of the embodiment, however, heater 25b disposed above evaporator 10 can heat up the stay-on position, thereby shortening the defrosting time. In this way, the structure can uniformly remove frost from the evaporator and its surroundings, thereby enhancing the efficiency of defrosting and therefore eliminating residual frost. Furthermore, defrosting completes in a shortened operation-time of the glass-tube heater, which contributes to a power saving.

According to the refrigerator of the second embodiment, as described above, the glass-tube heaters have an opposing location via the evaporator; one is disposed above, the other is disposed under the evaporator. The arrangement of the heaters allows the evaporator to be uniformly heated up from the top and the bottom. Besides, the structure having plural heaters allows an individual heater to have small heating value, thereby keeping the surface temperature of the heater below the ignition temperature of the combustible refrigerant. The uniform defrosting enhances the efficiency of defrosting, contributing to energy conservation. Furthermore, the accumulator, which is located above the evaporator, can be properly defrosted without residual frost. In this way, the refrigerator of the embodiment not only can prevent a combustible refrigerant from catching fire even if the defrosting operation is performed in an environment where leakage of the combustible refrigerant occurs at somewhere in the area having the defrosting means, but

also can improve a poor refrigeration due to residual frost.

A slow-defrosting area may vary according to the structure of an evaporator. In this case, the second glass-tube heater can be disposed close to the area where frost persists.

The glass-tube heaters can be placed in an opposite arrangement in a widthwise direction of the evaporator; one is in front of, and the other is at rear of the evaporator. The arrangement can protect glass-tube heater 25a against direct dripping-down of melted frost from evaporator 10. Thereby, roof 16 can be removed from the structure.

THIRD EXEMPLARY EMBODIMENT

Fig. 6 is a vertical sectional view showing the essential part of a refrigerator of the third exemplary embodiment.

The structure of the third embodiment differs from those of the aforementioned embodiments in the following point.

In Fig. 6, first glass-tube heater 26a is disposed below evaporator 10; on the other hand, second glass-tube heater 26b is disposed at an intermediate position in evaporator 10.

Hereinafter will be described the workings of a refrigerator having the structure above.

In the defrosting operation, an electric current is fed through heater 26b, as well as heater 26a. Most of the heat from heater 26a by the passage of electric current directly heats up, as radiant heat, evaporator 10. The hot surface of the glass-tube heater 26a warms up the ambient air to go upward, as an upward-moving stream, along evaporator 10. The upward-moving hot air warms up frosted evaporator 10 from the bottom toward the upper sections. At the same time, heat radiated from heater 26b disposed within evaporator 10

heats up a low-temperature area in the mid toward the upper sections.

Of radiant heat from heater 26a disposed below evaporator 10, upwardly radiated heat directly warms up evaporator 10; while downwardly radiated heat reaches the evaporator as reflection off dripping pan 13. On the other hand, heater 26b, since it is located inside evaporator 10, can directly heat up evaporator 10 in upward and downward (or frontward and backward) directions. The arrangement of the heaters can provide the evaporator with a rapid and uniform defrosting, allowing the surface temperature of the glass-tube heaters to keep below the ignition temperature of the combustible refrigerant. In this way, the refrigerator of the embodiment not only can prevent a combustible refrigerant from catching fire even if the defrosting operation is performed in an environment where leakage of the combustible refrigerant occurs at somewhere in the area having the defrosting means, but also can improve a poor refrigeration due to residual frost.

FOURTH EXEMPLARY EMBODIMENT

Fig. 7 is a vertical sectional view showing the essential part of a refrigerator of the fourth exemplary embodiment.

The structure of the fourth embodiment differs from those of the aforementioned embodiments in the following points.

In Fig. 7, first glass-tube heater 27a is disposed below evaporator 10; on the other hand, second glass-tube heater 27b is disposed either in front of or behind of evaporator 10. Evaporator 10 has indent 28 at a part of the fins to place heater 27b. Besides, heater 27a disposed below evaporator 10 has a capacity larger than that of heater 27b that is located higher than heater 27a.

Hereinafter will be described the workings of a refrigerator having the structure above.

The defrosting operation begins with the application of an electric current to heaters 27a and 27b. Heater 27a, which is disposed below evaporator 10, defrosts the evaporator upwardly from the bottom. On the other hand, heater 27b disposed at the front (or the behind) of evaporator 10 warms up a low-temperature area – the area having a slow-rise in temperature despite of the thermo-siphon effect in evaporator 10 – and effectively removes the frost from the surface of evaporator 10. In addition, by virtue of having a capacity larger than heater 27b, heater 27a can properly defrost the bottom of evaporator 10 having a large amount of frost, thereby enhancing the defrost efficiency. That is, the quick and uniform defrosting can suppress the surface temperature of glass-tube heaters 27a and 27b below the ignition temperature of the combustible refrigerant. As a result, the refrigerator of the embodiment not only can prevent a combustible refrigerant from catching fire even if the defrosting operation is performed in an environment where leakage of the combustible refrigerant occurs at somewhere in the area having the defrosting means, but also can improve a poor refrigeration due to residual frost.

Indent 28 is formed at a part of the fins of evaporator 10 so as to accept heater 27b that is placed either in the front of or behind the evaporator. The arrangement can minimize waste space caused by installing heater 27b.

In addition, the arrangement – regardless of whether heater 27b is disposed at the front, or at the behind of the evaporator – is effective in protecting heater 27b from a drip of melted frost. Accordingly, the structure can do away with the need to additional installment of the roof, which can be a barrier to air course when fan 11 is in operation.

FIFTH EXEMPLARY EMBODIMENT

Fig. 8 is a vertical sectional view showing the essential part of a

refrigerator of the fifth exemplary embodiment.

The structure of the fifth embodiment differs from those of the aforementioned embodiments in the following points.

In Fig. 8, temperature sensor 29 detects the surface temperature of glass-tube heater 19. Controller 30 is responsible for ON/OFF controlling the application of voltage to heater 19. Heater 19 has heating wire 31 therein.

Hereinafter will be described the workings of a refrigerator having the structure above.

In defrosting operation, an electric current is fed through heating wire 31 in heater 19; meanwhile, temperature sensor 29 detects the surface temperature of the glass tube, and controller 30 performs ON/OFF control of the application of voltage to heater 19, thereby keeping the surface temperature of heater 19 below the ignition temperature of the combustible refrigerant. The defrosting is thus performed with reliable thermal control. R600a (isobutane), which is a known combustible refrigerant, has an ignition temperature of 460 °C. In employing R600a for the refrigerant, the surface temperature of heater 19 is kept below the ignition temperature, for example, 450 °C or lower while current is applied to the heater in defrosting.

In this way, the refrigerator of the embodiment can prevent a combustible refrigerant from catching fire even if the defrosting operation is performed in an environment where leakage of the combustible refrigerant occurs at somewhere in the area having the defrosting means. For example, the risk of catching fire can be avoided even in the cases that undesired high voltage is applied to the glass-tube heater for some reasons, or that unnecessary defrosting is carried out because the completion of defrosting is not properly detected for some reasons.

SIXTH EXEMPLARY EMBODIMENT

Fig. 9 is a vertical sectional view showing the essential part of a refrigerator of the sixth exemplary embodiment.

The structure of the sixth embodiment differs from those of the aforementioned embodiments in the following points.

In Fig. 9, temperature sensor 29 detects the surface temperature of glass-tube heater 19. Controller 32 increases or decreases the application of voltage to heater 19. Heater 19 has heating wire 31 therein.

Hereinafter will be described the workings of a refrigerator having the structure above.

In defrosting operation, an electric current is fed through heating wire 31 in heater 19; meanwhile, temperature sensor 29 detects the surface temperature of the glass tube, and controller 32 increases or decreases the application of voltage to heater 19, thereby keeping the surface temperature of heater 19 below the ignition temperature of the combustible refrigerant. The defrosting is thus performed with reliable thermal control. R600a (isobutane), which is a known combustible refrigerant, has an ignition temperature of 460 °C. In employing R600a for the refrigerant, voltage to be applied to the heater is properly controlled so that the surface temperature of heater 19 is kept below the ignition temperature, for example, 450 °C or lower while current is applied to the heater in defrosting.

In this way, the refrigerator of the embodiment can prevent a combustible refrigerant from catching fire even if the defrosting operation is performed in an environment where the combustible refrigerant leaks at somewhere in the area having the defrosting means. For example, the risk of catching fire can be avoided even in the cases that undesired high voltage is applied to the glass-tube heater for some reasons, or that unnecessary defrosting is carried out

because the completion of defrosting is not properly detected for some reasons. Furthermore, the high/low control of the application of voltage can minimize variations in temperature of the heating wire, which can protect the heating wire from a break; accordingly, protecting the combustible refrigerant from electric spark caused by breaking of wire.

SEVENTH EXEMPLARY EMBODIMENT

Fig. 10 is a vertical sectional view showing the essential part of a refrigerator of the seventh exemplary embodiment.

In Fig. 10, refrigerator 101 contains outer case 102, inner case 103, and rigid polyurethane foam-made heat insulating material 104. The space between outer case 103 and inner case 102 is filled out with insulating material 104. Cold-storage compartment 105 and freezer compartment 106 are separated by partition wall 107. Evaporator 108 is disposed at the rear of freezer compartment 106. Polystyrene foam 109 is disposed at the front of evaporator 108 so as to provide electrical insulation between freezer compartment 106 and the chamber accommodating evaporator 108 therein. On the outside of polystyrene foam 109, molded-resin decorative laminate 110 is disposed. Cold-air outlet 111 is integrally formed with decorative laminate 110. Cold-air inlet 112 is formed between the bottom edge of laminate 110 and inner case 103.

Cold-air mixing fan motor 113 is fixed at a section of decorative laminate 110. Fan motor 113 spews out cold air, which has been cooled in evaporator 108, into freezer 106 and other chambers having different temperatures (not shown). Dripping pan 114 is disposed under evaporator 108. The upper opening of pan 114 is formed slightly larger than the bottom shape of evaporator 108. Glass-tube heater 115 is fixed between evaporator 108 and dripping pan

114. Evaporation pipe 116 and fin 117 are secured by press fitting, caulking, or the like.

Evaporation basin 119 is located under dripping pan 114 so as to collect water dripped in receiver 114. Radiation pipe 120, which is disposed in basin 119, heats up the water collected in basin 119 and evaporates it. In the structure, the outer wall of heater 115 maintains at-all-times contact with an edge of fin 117. Fin 117 is formed of vertically arranged continuous fin. In addition, Ni-Cr wire is employed for the resistance wire for heater 115.

Hereinafter will be described the workings of a refrigerator having the structure above.

Cold air cooled in evaporator 108 is spewed out by fan motor 113 from cold-air outlet 111. After used for heat exchange in freezer compartment 106, the air goes through cold-air inlet 112 back to evaporator 108. Repeating the air circulation above cools freezer compartment 106 at a predetermined temperature. A portion of the cold air cooled in evaporator 108 is distributed, via a duct and damper (not shown), to cold-storage compartment 105 and other chambers having different temperature ranges, whereby each chamber is kept properly cool.

With the passage of time, evaporator 108 is gradually covered with frost. In the refrigeration cycle, an electric current is periodically applied to heater 115 to defrost so that the flow of the cold air is not blocked by the build-up of frost. Evaporation basin 119 collects the water from melted-frost via dripping pan 114, and then radiation pipe 120 heats up the water to evaporate.

According to the refrigerator of the seventh exemplary embodiment, the refrigeration cycle has successive connections of the following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator. The refrigeration cycle contains a combustible refrigerant to circulate

therethrough. The structure in which heater 115 contacts with an end of fin 108 can defrost the evaporator by heat transferred from heater 115, as well as by radiant heat from the heater, thereby improving the defrost efficiency. At the same time, radiation effect resulted from heat-transfer to fin 108 keeps the surface temperature of glass-tube heater 115 cool, with the amount of heat radiated from heater 115 maintained. This allows the surface temperature of heater 115 to keep below an ignition temperature (e.g. isobutane has an ignition temperature of 460 °C) of a combustible refrigerant. Therefore, the structure has no danger of catching fire in the event that a combustible refrigerant leaks at somewhere in the refrigerator.

Besides, fin 117 disposed in evaporator 108 is formed of vertically arranged continuous fin; the structure enhances radiation effect resulted from heat-transfer to fin 117, increasing the efficiency of defrosting. Furthermore, the structure can lower the surface temperature of heater 115, with the amount of heat radiated from the heater maintained. Thereby, the surface temperature of the heater can be kept below the ignition temperature of a combustible refrigerant.

In addition, Ni-Cr wire is employed for the resistance wire for heater 115. Even in the use of the heating wire at low temperatures, the Ni-Cr resistance wire has no brittle fracture that would be observed in a Fe-Cr resistance wire at approx. 470 °C, thereby protecting the heating wire from a break.

EIGHTH EXEMPLARY EMBODIMENT

Fig. 11 is a vertical sectional view showing the essential part of a refrigerator of the eighth exemplary embodiment.

The structure of the eighth embodiment differs from that of the seventh embodiment in the following points.

In addition to the structure of the seventh embodiment, each of a plurality of fins 121 of the structure in the eighth embodiment has half-round indent 122 conforming to the outer wall of glass-tube heater 115, as shown in Fig. 11. Continuous fins 121 make contact, at indent 122, with the outer wall of heater 115.

Hereinafter will be described the workings of a refrigerator having the structure above.

In addition to the structure of the seventh embodiment, the structure of the eighth embodiment, in which each indent 122 makes contact with the outer wall of heater 115, can increase the contact area between the fin and the heater, accordingly, enhancing the efficiency of heat transfer. The improved efficiency further accelerates defrosting. With the amount of heat radiated from heater 115 maintained, the surface temperature of the heater can be kept sufficiently lower than the ignition temperature of a combustible refrigerant.

NINTH EXEMPLARY EMBODIMENT

Fig. 12 is a view, partially in perspective, of a refrigerator of the ninth exemplary embodiment. Fig. 13 is a front view, looking in the direction of arrow B of Fig. 12. Fig. 14 is a view, partially in perspective, of another evaporator and glass-tube heater of a refrigerator of the ninth exemplary embodiment. Fig. 15 is a front view, looking in the direction of arrow C of Fig. 14.

In Fig. 12, each fin 123 has L-shape bend 124 at the bottom end of the fin. Bend 124 makes contact with the outer wall of glass-tube heater 115. Fin 123 is arranged, as shown in Fig. 13, so as to have interval 125 between the edge of bend 124 and adjacent fin. The fin also can have a structure as that shown in Fig. 14 — each fin 126 has half-round indent 127 at an end so as to conform to the

outer wall of glass-tube heater 115, and the end having indent 127 further has L-shape bend 128.

Now will be described the workings of a refrigerator having the structure above.

As is shown in Figs. 12 and 13, each fin 123 has an L-shape bend at an end having contact with the outer wall of heater 115. The structure allows each fin 123 to couple to the outer wall of heater 115 through line contact, enhancing the efficiency of heat transfer. Besides, interval 125 formed between an edge of bend 124 and adjacent fin can upwardly transfer the radiant heat from heater 115.

On the other hand, Figs. 14 and 15 show another structure in which an end of each fin 126 has half-round indent 127 so as to conform to the outer wall of heater 115, and the end is further bent into an L shape. The structure allows each fin 126 to couple to the outer wall of heater 115 through area contact, further improving the efficiency of heat transfer.

The structure of the embodiment, as described above, can provide further improved defrost efficiency. At the same time, the surface temperature of heater 115 can be kept further lower, with the amount of heat radiated from the heater maintained. Thereby, the surface temperature of the heater can be retained below the ignition temperature of a combustible refrigerant.

TENTH EXEMPLARY EMBODIMENT

Fig. 16 is a view, partially in perspective, of an evaporator and a glass-tube heater of a refrigerator of a tenth exemplary embodiment. Fig. 17 is a front view, looking in the direction of arrow D of Fig. 16.

In Figs. 16 and 17, both ends of glass-tube heater 115 are fixed by holder 129. Holder 129 is formed of partially notched vertical flange 131 of side plate

130 that is disposed on the side surface of the evaporator. Fixing heater 115 to holder 129 provides contact between the outer wall of the heater and each edge of fin 117.

Now will be described the workings of a refrigerator having the structure above.

Holder 129 is formed of partially notched vertical flange 131 of side plate 130 that is disposed on the side surface of the evaporator. Therefore, holder 129 can securely hold heater 115 with no danger of falling down, when both ends of the heater are fixed to the holder. That is, such a structure has no need for preparing additional fixing member in assemble work, providing a low-cost product. In addition, the consistent positional relation of the structure can establish a reliable connection between heater 115 and fin 117, providing a consistent heat transfer. As a result, the defrosting effect is preferably increased. At the same time, the advantage can enhance the defrosting effect. As a result, the surface temperature of heater 115 can be kept lower, with the amount of heat radiated from the heater maintained. Thereby, the surface temperature of the heater can be retained below the ignition temperature of a combustible refrigerant.

ELEVENTH EXEMPLARY EMBODIMENT

Fig. 18 is a view, partially in perspective, of an evaporator and a glass-tube heater of a refrigerator of the eleventh exemplary embodiment. Fig. 19 is a front view, looking in the direction of arrow E of Fig. 18.

In Figs. 18 and 19, shield plate 132 is inserted between evaporator 108 and glass-tube heater 115. The top surface of shield plate 132 makes contact with each bottom end 133 of fin 117. Both ends 134 of shield plate 132 are integrally fixed to side-end fin 135 by caulking or the like.

Now will be described the workings of a refrigerator having the structure above.

When an electric current is applied to heater 115, heat from the heater is conveyed to shield plate 132. Through the connection between the top surface of shield plate 132 and each bottom end 133 of fin 117, the heat from heater 115 can be radiated to fin 117. That is, the surface temperature of heater 115 can be kept lower than the ignition temperature of a combustible refrigerant, with the amount of heat from the heater maintained. In addition, shield plate 132 receives a drip of melted frost from evaporator 108, thereby avoiding a splash of the water from the evaporator directly down to heater 15. This can eliminate the noise, such as a sputter, which is produced when drippings instantly evaporates on hot heater 115.

TWELFTH EXEMPLARY EMBODIMENT

Fig. 20 is a view, partially in perspective, of an evaporator and a glass-tube heater of a refrigerator of a twelfth exemplary embodiment. Fig. 21 is a front view, looking in the direction of arrow F of Fig. 20.

In Figs. 20 and 21, each long fin 136 has L-shaped bend 138 at the bottom end. Bend 138 makes contact with the outer wall of glass-tube heater 115. On the other hand, each short fin 137 is formed shorter than long fin 136 in length, therefore the bottom end of the short fin have no contact with the heater. Interval "a" between adjacent two long fins is determined longer than interval "b" between long fin 136 and short fin 137.

Now will be described the workings of a refrigerator having the structure above.

Each long fin 136 has an L-shape bend at an end having contact with the outer wall of heater 115. The structure allows each long fin 136 to couple to the

outer wall of heater 115 through line contact, thereby enhancing the efficiency of heat transfer from heater 115 to long fin 136. Long fin 136 and short fin 137 of the evaporator are arranged so that the interval between adjacent fins in the upper section is larger than that in the lower section, i.e., interval "a" is longer than interval "b". The arrangement protects the lower section of the evaporator from being heavily covered with frost. In other words, frost uniformly covers the evaporator, thereby realizing a less frequent defrosting operation. This fact can suppress power consumption required for defrosting, contributing to energy saving.

THIRTEENTH EXEMPLARY EMBODIMENT

Fig. 22 is a view, partially in perspective, of an evaporator and a glass-tube heater of a refrigerator of a thirteenth exemplary embodiment. Fig. 23 is a front view, looking in the direction of arrow G of Fig. 22. Fig. 24 is a partially enlarged sectional view of a glass-tube heater of the refrigerator shown in Fig. 22.

In Figs. 22 to 24, glass-tube heater 139 has a tube-in-tube structure formed of inner tube 140 and outer tube 141. Outer tube 141 accommodates inner tube 140 therein, keeping a predetermined interval from the outer wall of inner tube 140. Inner tube 140 contains resistance wire heater 143 therein. Both ends of both tubes are integrally fixed by cap 142 so as to be set in position. In the structure, outer tube 141 of heater 139 is always maintained in contact with each bottom end of fin 117.

Now will be described the workings of a refrigerator having the structure above.

When an electric current is applied to heater 139, heat from resistance wire heater 143 is radiated from the surface of outer tube 141 via inner tube 140.

In the heat transfer process, the space between inner tube 140 and outer tube 141 serves as an insulator, so that the surface temperature of the outer tube becomes lower than that of the inner tube. That is, the surface temperature of heater 115 can be kept lower than the ignition temperature of a combustible refrigerant, with the amount of heat from the heater maintained. This also improves defrosting efficiency. Besides, integrally formed cap 142 securely holds both ends of heater 139, whereby the positional relationship between the two tubes is properly maintained. Such a structure not only minimizes variations in the surface temperatures of the glass tubes, but also offers a simple assembling work.

FOURTEENTH EXEMPLARY EMBODIMENT

Fig. 25 is a view illustrating the refrigeration cycle of a refrigerator of a fourteenth exemplary embodiment. Fig. 26 is a partially sectional view of a glass-tube heater of the refrigerator of the fourteenth exemplary embodiment.

In Fig. 25, refrigeration cycle 201 has successive connections of the following elements: compressor 202; condenser 203; pressure drier 204; capillary tube 205 as a reduction mechanism; and evaporator 206. A combustible refrigerant is sealed in the refrigeration cycle. Glass-tube heater 207 as defrosting means is disposed below evaporator 206 to defrost the evaporator at regular intervals.

In Fig. 26, sealing member 208 has inner-tube holder 209 and outer-tube holder 210, which are integrally formed of rubber. Inner-tube holder 209 and outer-tube holder 210 support the ends of inner tube 211 and outer tube 212 of the tube-in-tube structure, respectively. Heating wire 213, which is made of iron-chrome, nickel-chrome, or the like material, is accommodated in inner tube 211, with a predetermined interval from the inner wall of tube 211 maintained.

Heating wire 213 is caulked with lead-out wire 215 at joint 214, and lead-out wire 215 goes out from the lower side or the bottom of sealing member 208.

Fig. 27 is a partially sectional view of another glass-tube heater of the refrigerator of the fourteenth exemplary embodiment.

In Fig. 27, sealing member 216 has inner-tube holder 217 and outer-tube holder 218, which are integrally formed of rubber. Inner-tube holder 217 supports inner tube 219 in such a way that lap 221 laps over inner tube 219 by length "c", similarly, outer-tube holder 218 supports outer tube 220 in such a way that lap 222 laps over outer tube 220 by length "d". End surface 224 (i.e., plane "T" in Fig. 27) of lap 222 is outwardly located than end surface 223 (i.e., plane "H") of lap 221.

Now will be described the workings of a refrigerator having the structure above.

In the defrosting process, an electric current is applied to heating wire 213 of glass-tube heater 207 to periodically remove frost from evaporator 206. Heat from the glass-tube heater is transmitted, through inner tube 211 and outer tube 212, to evaporator 206 to remove frost therefrom. Glass-tube heater 207 has a tube-in-tube structure. In the heat transfer process, the space between inner tube 211 and outer tube 212 serves as an insulator, so that the surface temperature of the outer tube becomes lower than that of the inner tube. That is, the surface temperature of outer tube 212 can be kept lower than the ignition temperature (e.g. 460 °C for isobutane) of a combustible refrigerant, with the amount of heat from the heater maintained.

Disposing sealing member 208 at the end of the glass tube ensures the positioning of the glass tube in the tube-in-tube structure, thereby properly maintaining the interval between the inner tube and the outer tube; accordingly, it minimizes variations in the surface temperatures of the glass tubes. Besides,

inner-tube supporter 209 and outer-tube supporter 210, which are integrally formed with sealing member 208, suppress airflow from outside into the glass tube. This can minimize the risk of catching fire if the combustible refrigerant leaks in the refrigerator.

Sealing member 216 of Fig. 27 contains inner-tube holder 217 and outer-tube holder 218 as an integral structure, providing a cost-decreased product and reliable assembling work due to minimized variations in dimensions. In addition, inner-tube holder 217 and outer-tube holder 218 contain lap 221 and lap 222, respectively, at the end of each outer wall of the glass tubes. The structure can properly suppress airflow from the outside into the glass tube.

Furthermore, end surface 224 (i.e., plane "I" in Fig. 27) of lap 222 is outwardly located than end surface 223 (i.e., plane "H") of lap 221. The positional relationship allows the radiant heat from inner tube 219 to be easily transferred, enhancing the efficiency of defrosting. At the same time, the structure invites an easy attachment of outer tube 220 to sealing member 216, enhancing the efficiency of assembling work.

Although the structure of the fourteenth embodiment employs a rubber-made sealing member, it is not limited thereto; the similar effect will be expected as long as the material has heat-resisting property.

FIFTEENTH EXEMPLARY EMBODIMENT

Fig. 28 is a partially sectional view of a glass-tube heater of a refrigerator of the fifteenth exemplary embodiment.

In Fig. 28, sealing member 225 has inner-tube holder 226 and outer-tube holder 227, which are integrally formed of rubber. Inner-tube holder 226 supports inner tube 228 in such a way that lap 230 laps over inner tube 228 by length "e", similarly, outer-tube holder 227 supports outer tube 229 in such a

way that lap 231 laps over outer tube 229 by length "e". End surface 233 of lap 231 contains a plane (i.e., plane "J") common with end surface 232 of lap 230. Inner tube 228 and outer tube 229 measure the same in length, each end of which is located on a common plane, i.e., plane "K" in Fig. 28.

Now will be described the workings of a refrigerator having the structure above.

The glass-tube heater contains inner tube 228 and outer tube 229. Sealing member 225 holds the two tubes so that the end surface 233 of the outer-tube holder's lap contains a plane common with the end surface 232 of the inner-tube holder's lap. Lapping inner-tube holder 226 and outer-tube holder 227 by the same length of "e", providing good sealing between the glass-tubes. The structure effectively suppresses airflow from outside into the glass tube, thereby minimizing the risk of catching fire if the combustible refrigerant leaks in the refrigerator. In addition, inner tube 228 and outer tube 229 are identical in length. This therefore simplifies manufacturing processes, that is, provides an easy manufacturing of glass tubes.

SIXTEENTH EXEMPLARY EMBODIMENT

Fig. 29 is a partially sectional view of a glass-tube heater of a refrigerator of the sixteenth exemplary embodiment.

In Fig. 29, sealing member 234 is formed of a plurality of supporting members: inner-tube supporting member 235, outer-tube supporting member 236 separately formed from member 235. Inner-tube holder 237 of inner-tube supporting member 235 holds an end of the outer wall of inner tube 239. Similarly, outer-tube holder 238 of outer-tube supporting member 236 holds an end of the outer wall of outer tube 240. Outer-tube supporting member 236 fits snugly against a part of the exterior of inner-tube supporting member 235.

Inner-tube supporting member 235 is formed of material having high heat resistance, on the other hand, outer-tube supporting member 236 is formed of material having heat resistance lower than that of member 235.

Now will be described the workings of a refrigerator having the structure above.

Sealing member 234 is formed of inner-tube supporting member 235 and outer-tube supporting member 236, each of which has a separate structure. This allows sealing member 234 to employ different material between the two members 235 and 236, increasing design flexibility of sealing member 234.

Inner-tube supporting member 235 is formed of material having high heat resistance, on the other hand, outer-tube supporting member 236 is formed of material having heat resistance lower than that of member 235. Employing a high-temperature-resistant material increases reliability of the sealing member. At the same time, employing materials that differ in heat resistance can decrease the use of a heat-resistant material, which invites high production cost. As a result, a low-cost sealing member can be obtained.

SEVENTEENTH EXEMPLARY EMBODIMENT

Fig. 30 is a partially sectional view of a glass-tube heater of a refrigerator of the seventeenth exemplary embodiment.

In Fig. 30, sealing member 241 has inner-tube holder 242 and outer-tube holder 243, which are integrally formed of rubber. Inner-tube holder 242 supports inner tube 244 in such a way that lap 246 laps over inner tube 244 by length "f", similarly, outer-tube holder 243 supports outer tube 245 in such a way that lap 247 laps over outer tube 245 by length "g". End surface 249 (i.e., plane "M" in Fig. 30) of lap 247 of outer-tube holder 243 is inwardly located than end surface 248 (i.e., plane "L") of lap 246 of inner-tube holder 242.

Now will be described the workings of a refrigerator having the structure above.

The glass-tube heater is so arranged that end surface 249 of the lap of outer-tube holder 243 is inwardly located than end surface 248 of the lap of inner-tube holder 242. The arrangement allows outer-tube holder 242 to have sufficient lapping length of "g", accordingly, offering good sealing between the glass tubes. The structure therefore effectively suppresses airflow from outside into the glass tube, thereby minimizing the risk of catching fire if the combustible refrigerant leaks in the refrigerator.

Besides, lapping length "f" of lap 246 of inner-tube holder 242 can be relatively decreased, accordingly, holder 242 considerably escapes from being affected by radiant heat from heating wire 213. The fact can protect the inner-tube holder from undesired rise in temperature caused by the radiant heat when an electric current is applied to the glass tube. Therefore, there is no need to employ an extra high-temperature-resistant material for sealing member 241, whereby the production cost can be decreased.

INDUSTRIAL APPLICABILITY

The refrigerator of the present invention has a plurality of glass-tube heaters as a means for defrosting the evaporator that is disposed in a combustible refrigerant-sealed refrigeration cycle. A current-carrying period or an application of voltage to the glass-tube heater is controlled so that the temperature of the heater is kept below the ignition temperature of a combustible refrigerant. This not only protects the combustible refrigerant from the risk of catching fire, but also avoids poor refrigeration caused by residual frost. In a structure of the invention, a glass-tube heater makes contact with fins of the evaporator to decrease the surface temperature of the

glass-tube heater. In another structure of the invention, the glass-tube heater has a tube-in-tube structure, and a sealing member is disposed on an end of the glass tube. Such structures can protect a combustible refrigerant from the risk of catching fire even if the defrosting operation is carried out in an environment where leakage of the combustible refrigerant occurs.

CLAIMS:

1. A refrigerator comprising:
a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator; and
means for defrosting the evaporator,
wherein the defrosting means is formed of a plurality of glass-tube heaters disposed in an upper section and in a lower section of the evaporator having any one of in-contact and out-of-contact arrangements with the evaporator.
2. A refrigerator comprising:
a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator; and
means for defrosting the evaporator,
wherein the defrosting means is formed of a plurality of glass-tube heaters, and at least one of the plurality of glass-tube heaters is disposed within the evaporator.
3. A refrigerator comprising:
a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator; and
means for defrosting the evaporator,
wherein the defrosting means is formed of a plurality of glass-tube heaters, and at least one of the plurality of glass-tube heaters is disposed any one of i) in a lower section of the evaporator and ii) below the evaporator, and

remaining glass-tube heaters are disposed any one of iii) in front of the evaporator and iv) behind the evaporator.

4. The refrigerator of Claim 3, wherein the glass-tube heater, which is disposed any one of i) in front of the evaporator and ii) behind the evaporator, is located in an indent formed in a part of the evaporator.

5. The refrigerator of Claim 1, wherein the glass-tube heater any one of i) located in a lower section of the evaporator and ii) located below the evaporator has capacity greater than the glass-tube heater any one of iii) located in an upper section of the evaporator and iv) located above the evaporator.

6. A refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator; and

means for defrosting the evaporator,

wherein the defrosting means is formed of a plurality of glass-tube heaters, and a period through which an electric current is applied to the plurality of glass-tube heaters is controlled so that a surface temperature of the heaters is kept below an ignition temperature of the combustible refrigerant.

7. A refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator; and

means for defrosting the evaporator,

wherein the defrosting means is formed of a plurality of glass-tube heaters, and an application of voltage to the plurality of glass-tube heaters is

controlled so that a surface temperature of the heaters is kept below an ignition temperature of combustible refrigerant.

8. A refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive connections of the following elements: a compressor, a condenser, a pressure reductions mechanism, and an evaporator; and

a glass-tube heater disposed below the evaporator; and

a plurality of fins disposed in the evaporator,

wherein an outer wall of the glass-tube heater makes contact with each bottom end of the fins.

9. The refrigerator of Claim 8, wherein an indent conforming to the outer wall of the glass-tube heater is formed at each bottom end of the fins.

10. The refrigerator of Claim 8, wherein a bend conforming to the outer wall of the glass-tube heater is formed at each bottom end of the fins.

11. The refrigerator according to any one of Claims 8 through 10, wherein both ends of the glass-tube heater are fixed to a side plate of the evaporator.

12. A refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator;

a glass-tube heater disposed in a lower section of the evaporator;

a plurality of fins disposed in the evaporator; and

a shield plate disposed between the glass-tube heater and the fins,

wherein the shield plate makes contact with the fins.

13. The refrigerator of Claim 8 or Claim 12, wherein the fins are continuously arranged fins in a vertical direction.

14. The refrigerator of Claim 13, wherein the fins are disposed in such a way that an interval between adjacent fins in a lower section measures greater than that in an upper section.

15. The refrigerator of Claim 8 or Claim 12, wherein the glass-tube heater has a tube-in-tube structure.

16. The refrigerator of Claim 8 or Claim 12, wherein a resistance-wire of the glass-tube heater is a Ni-Cr wire.

17. The refrigerator of Claim 15, wherein a cap fixes an end of the glass tube of the heater having the tube-in-tube structure.

18. A refrigerator comprising:

a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator;

a glass-tube heater with a tube-in-tube structured disposed in any one of in a lower section of the evaporator and below the evaporator; and

a sealing member disposed at an end of the glass-tube heater,

wherein the multi-structured glass tubes include an inner tube and an outer tube, the sealing member integrally contains an inner-tube holder and an outer-tube holder, the inner-tube holder supports the inner tube and the outer-tube holder supports the outer tube, the inner-tube holder has a lapping section at an end of an outer wall of the inner tube, and the outer-tube holder has an alignment section for proper positioning of an end of the outer tube.

19. A refrigerator comprising:
- a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator.
 - a glass-tube heater with a tube-in-tube structured disposed in any one of in a lower section of the evaporator and below the evaporator; and
 - a sealing member disposed at an end of the glass-tube heater,
- wherein the multi-structured glass tubes include an inner tube and an outer tube, the sealing member integrally contains an inner-tube holder and an outer-tube holder, the inner-tube holder supports the inner tube and the outer-tube holder supports the outer tube, and the inner-tube holder and the outer-tube holder have a lapping section at an end of an outer wall of the inner tube and an end of an outer wall of the outer tube, respectively.
20. The refrigerator of Claim 19, wherein a tip face of the lapping section of the outer-tube holder is located outwardly than a tip face of the lapping section of the inner-tube holder.
21. The refrigerator of Claim 19, wherein a tip face of the lapping section of the outer-tube holder is disposed to share a plane common with a tip face of the lapping section of the inner-tube holder.
22. The refrigerator of Claim 19, wherein a tip face of the lapping section of the outer-tube holder is located inwardly than a tip face of the lapping section of the inner-tube holder.
23. A refrigerator comprising:
- a combustible-refrigerant-sealed refrigeration cycle having successive connections of following elements: a compressor, a condenser, a pressure reduction mechanism, and an evaporator;

a glass-tube heater with a tube-in-tube structured disposed in any one of in a lower section of the evaporator and below the evaporator; and

a sealing member disposed at an end of the glass-tube heater,

wherein the sealing member is formed of a plurality of supporting members.

24. The refrigerator of Claim 23, wherein the plurality of supporting members is formed of an inner-tube supporting member and an outer-tube supporting member separately structured from the inner-tube supporting member.

25. The refrigerator of Claim 18 or Claim 19, wherein the glass tubes of the heater having the tube-in-tube structure are identical in length.