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Nijo

[11] **3,861,167**

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[54] **DEFROSTING APPARATUS**

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[52] **U.S. Cl.** **62/209**, 62/227

[51] **Int. Cl.** **F25b 41/00**

[58] **Field of Search** 62/156, 209, 227

[56] **References Cited**

UNITED STATES PATENTS

2,940,278	6/1960	Thompson	62/227
3,097,502	7/1963	Krueger	62/209
3,703,086	11/1972	Nijto	62/209

FOREIGN PATENTS OR APPLICATIONS

21,865	1970	Japan	62/209

Primary Examiner—Meyer Perlin

[57] **ABSTRACT**

A defrosting apparatus for a refrigerator or the like wherein supply of cooling medium to a coil-fin type evaporator is initiated and stopped by sensing the temperature of the evaporator at three locations, namely near the cooling medium inlet of the coil, near a location where the evaporator has the lowest temperature in case the condensation temperature of the cooling medium becomes high due to a rise of atmospheric temperature or the like, and near the cooling medium outlet of the coil, by means of temperature sensing devices switching at 0° C. An electric control circuit is provided which stops the supply of cooling medium when the temperatures at said three locations have dropped to 0° C and initiates again the supply of cooling medium when the temperatures at said three locations have risen above 0° C, so that the supply of cooling medium is not reopened until frost which was formed on the evaporator first and melts last has been removed. Thus, frost formed on the evaporator is necessarily removed perfectly and automatically even when condensation temperature of cooling medium is elevated.

5 Claims, 2 Drawing Figures

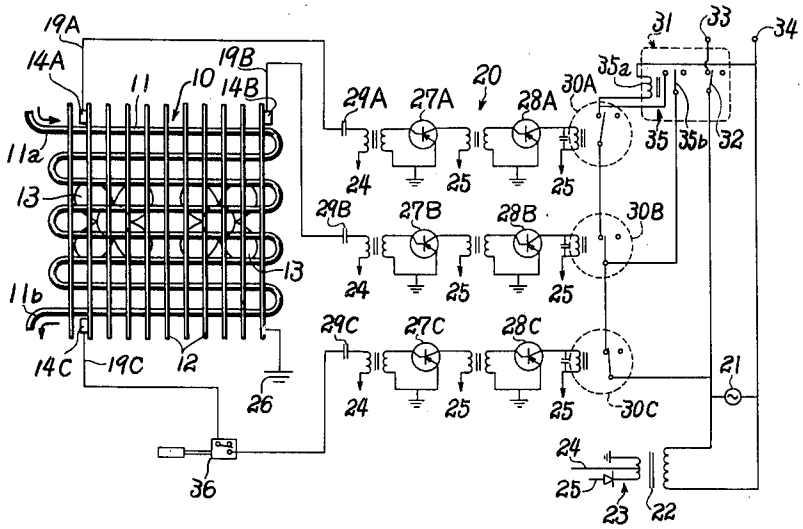

Fig. 2.

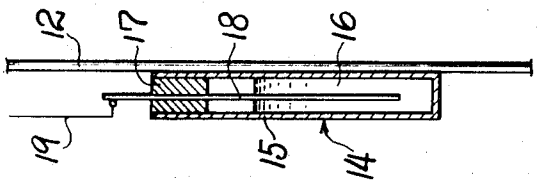
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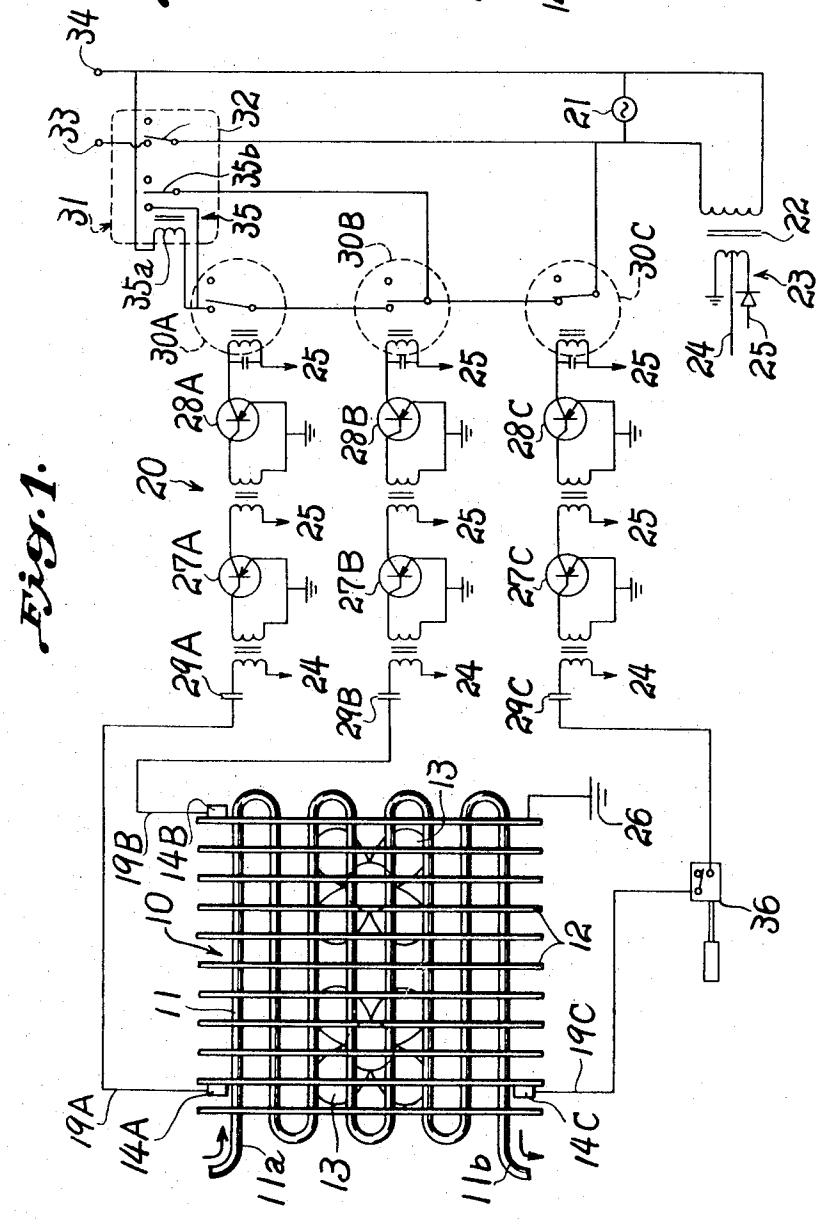
Fig. 1.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DEFROSTING APPARATUS

This invention relates to a defrosting apparatus in a domestic refrigerator or the like having an evaporator, and more particularly to a defrosting apparatus which always avoids excessive accumulation of frost on an evaporator for a domestic refrigerator or the like.

The inventor previously developed a novel temperature sensing device which comprises a pair of electrodes and water between the electrodes, thereby switching at 0° C due to the difference in resistivity between liquid water and ice, as disclosed, for example, in U.S. Pat. No. 3,514,735. By utilizing such temperature sensing devices, the inventor further developed a novel defrosting apparatus for a domestic refrigerator or the like wherein first and second temperature sensing devices are arranged respectively near the cooling medium inlet and outlet of a cooling coil of an evaporator for a domestic refrigerator or the like. An electric control circuit is provided which stops the supply of cooling medium to the evaporator when water in both of the first and second sensing devices has frozen and does not permit further supply of cooling medium until ice in both of the first and second sensing devices has melted, as disclosed, for example, in said U.S. Pat. No. 3,514,735 (see FIG. **6** and the corresponding disclosure of said Patent). In this defrosting apparatus, frost formed on the evaporator is removed by melting during the stopping of the supply of cooling medium to the evaporator and said supply of cooling medium or cooling operation is reopened first when frost on cooling fins near the inlet of cooling coil, where frost is usually formed first, has been removed. The supply of cooling medium or the cooling operation is continued until frost has been formed on cooling fins near the outlet of cooling coil, where frost is formed last, and then is stopped. By such cyclic cooling and defrosting, temperature in the domestic refrigerator or the like is also maintained at approximately constant value.

The above defrosting apparatus is based on an assumption that the temperature of an evaporator always has its lowest value at the inlet of a cooling coil and, therefore, frost is formed first necessarily at a location near said inlet. It is well known, however, that the condensation temperature of a cooling medium rises when atmospheric temperature is high, such as in summer and, in this case, the cooling medium has its lowest temperature at a somewhat lower reach of the cooling coil rather than at the inlet of said coil, namely immediately after the expansion valve for the cooling medium, so that frost is formed on the evaporator first at such lower reach. The aforestated defrosting apparatus, therefore, exhibits the following disadvantages when the condensation temperature of the cooling medium becomes high due to a rise of atmospheric temperature or other reasons.

That is, the cooling operation is reopened when some frost still remains on the evaporator because such reopening of cooling operation is ordered by the first sensing device which takes its "ON" state when frost near the cooling medium inlet has been removed, but frost at such lower reach, where frost was formed first, has not yet been removed. Such too earlier reopening of the cooling operation will, of course, cause excessive cooling of the atmosphere within the domestic refrigerator or the like so that reserves in the refrigerator will often be deteriorated due to excessive cooling of the same. Further, frost always remaining on the evaporator at such lower reach prevents heat exchange between the evaporator and the atmosphere in the refrigerator so that cooling efficiency is lowered, requiring more power or energy for cooling. For eliminating such disadvantages, it is considered that said first temperature sensing device is displaced according to atmospheric temperature or condensation temperature of cooling medium but, in practice, that is too inconvenient.

Accordingly, the present invention aims at providing a novel defrosting apparatus which eliminates the aforestated disadvantages of the defrosting apparatus according to the prior art.

The invention and its attendant advantages will become more readily apparent as the specification is considered in conjunction with the accompanying drawings in which:

FIG. **1** is a diagrammatic view of an embodiment of the defrosting apparatus according to the present invention; and

FIG. **2** is an enlarged sectional view of a temperature sensing device employed in the defrosting apparatus shown in FIG. **1**.

Referring now to the drawings, there is shown in FIG. **1** an evaporator **10** for a domestic refrigerator or the like. The evaporator **10** comprises a cooling coil **11** for flowing cooling medium or coolant therethrough and a number of spaced cooling fins **12** which are fixedly attached to the coil. The coil **11** has a coolant inlet **11***a* and a coolant outlet **11***b* and, as is usual, between the inlet and the outlet is connected a refrigerating mechanism comprising compressor or refrigerating machine, condenser, expansion valve and the like (not shown). Behind the evaporator **10** is arranged a pair of cooling fans **13** which are always driven to rotate so that the air in the refrigerator is forcedly brought into convection current.

According to the present invention, three temperature sensing devices, namely first, second and third temperature sensing devices **14A**, **14B** and **14C**, are provided in a manner detailed hereinafter. The first device **14A** is fixedly attached to a cooling fin **12** near the inlet **11***a* of the cooling coil **11** so that said device **14A** senses the temperature of the evaporator **10** near said inlet **11***a*. The second device **14B** is fixedly attached to a cooling fin **12** near a location on the evaporator **10** where said evaporator has its lowest temperature in case the condensation temperature of the cooling medium reaches the highest value during use of the refrigerator so that said device **14B** senses the temperature of the evaporator **10** at such location. Further, the third device **14C** is fixedly attached to a cooling fin **12** near the outlet **11***b* of the cooling coil **11** so that said device **14C** senses the temperature of the evaporator **10** near said outlet **11***b*.

Each of the first, second and third temperature sensing devices **14A**, **14B** and **14C** is constructed in a fashion as shown in FIG. **2**. The temperature sensing device **14** shown in FIG. **2** comprises a cylindrically shaped housing **15** of metal, which contains water **16**. A plug **17** of non-conductive material seals the upper opening of the housing **15**. An electrode **18** extends through the plug **17** into the housing **15** so as to be immersed in the water **16**. A terminal **19** is connected to the electrode **18**, and the housing **15** is fixedly attached to a cooling fin **12**, as in the case of the aforestated devices **14A**, **14B** and **14C**. When an electric potential is applied be-

tween the terminal **19** and the housing **15**, an electric current flows between said terminal **19** and the housing **15** when the water **16** is in liquid state due to the small resistivity of liquid water. However, a current does not flow substantially when the water **16** becomes solidified into ice at 0° C due to the relatively high resistivity of ice. Therefore, the device **14** acts as a switch operating at 0° C whereby a temperature of 0° C is sensed.

In general, each of the first, second and third temperature sensing devices employed in the defrosting apparatus according to the present invention comprises a pair of electrodes (in the case of the device shown in FIG. **2**, the housing **15** and the electrode **18**) and water between the electrodes, thereby switching at 0° C due to the difference in resistivity between liquid water and ice. Variations and modifications of such temperature sensing device are disclosed, for example, in said U.S. Pat. No. 3,514,735.

Turning again to a consideration of FIG. **1**, an electric control circuit **20** is connected to said first, second and third devices **14A**, **14B** and **14C**. The circuit **20** includes an electric power source **21** which is connected through a transformer **22** to a power output **23** having a terminal **24** connected to the terminals **19A**, **19B** and **19C** of the devices **14A**, **14B** and **14C** and another terminal **25** for supplying electric power to each of transistors detailed later. The housings of the devices **14A**, **14B** and **14C** are commonly grounded at **26** through the coil **11** and the fins **12**. Each of the terminals **19A**, **19B** and **19C** of the devices **14A**, **14B** and **14C** is connected to the bases of a pair of series-connected transistors **27A**, **28A**; **27B**, **28B**; or **27C**, **28C** through a condenser **29A**, **29B** or **29C** so that electric current flowing between the emitter and base of each transistor is amplified by electric current flowing between the electrode and housing of each of the temperature sensing devices. Each pair of the transistors is in turn connected to a micro-relay **30A**, **30B** or **30C** so that the micro-relay is energized when electric current flowing between the emitter and base of associated transistors is amplified. The control circuit **20** further includes a relay **31** which is connected to the power source **21** and to the micro-relays **30A**, **30B** and **30C**. The relay **31** in turn includes a switch **32** for actuating the refrigerating machine driving means (not shown) which is connected to terminals **33** and **34**. The relay **31** further includes a so-called self-maintenance circuit **35** having a coil **35***a* and a movable contact **35***b*, which circuit is connected to the micro-relays so that the circuit **35** opens the switch **32** when all of the three micro-relays **30A**, **30B** and **30C** have been deenergized and closes said switch **32** when all of said three micro-relays have been energized, as shown in FIG. **1**.

In the embodiment shown in FIG. **1**, a further temperature sensing switch means **36** is provided in the refrigerator for sensing the temperature of atmosphere in said refrigerator. Said means **36** is such that is employed in a usual thermostat and makes a switching operation at a variable set temperature so that it takes an ON state above the set temperature and an OFF state below said temperature. The switch means **36** is connected in series to the third temperature sensing device **14C**, as shown in FIG. **1**.

The defrosting apparatus shown in FIG. **1** operates as follows: Before the refrigerator is cooled, considerable current flows through each of the first, second and third temperature sensing devices **14A**, **14B** and **14C** so that all of the micro-relays **30A**, **30B** and **30C** are energized by the transistors **27A**, **28A**; **27B**, **28B**; and **27C**, **28C**, whereby the switch **32** is closed to operate the refrigerating machine. Thus, cooling medium is supplied to the evaporator **10** so that the atmosphere in the refrigerator is gradually cooled. In this case, the temperature sensing switch means **36** is, of course, in an ON state.

As cooling proceeds, frost is formed gradually on the evaporator **10**. This formation of frost begins at a location on the evaporator where the cooling coil **11** or cooling medium flowing therethrough has the lowest temperature. Therefore, frost is formed on the evaporator **10** first near the first device **14A** when the condensation temperature of the cooling medium is relatively low and near the second device **14B** when said condensation temperature becomes high due to a rise of atmospheric temperature or other reasons. In any event, water in the first or second detector **14A** or **14B** near which frost is formed first becomes solidified into ice first so that the micro-relay **30A** or **30B** associated with the particular device is deenergized. In this case, however, the switch **32** in the relay **31** is not opened due to electric current flowing through the coil **35***a* of the self-maintenance circuit **35** which current keeps the movable contact **35***b* in the ON position.

When cooling proceeds further, frost is formed on the evaporator **10** near the second or first device **14B** or **14A** which still contains liquid water so that water in the said device **14B** or **14A** becomes solidified, whereby the micro-relay **30B** or **30A** associated with said device is deenergized. In this case, too, the switch **32** is not opened due to the presence of the self-maintenance circuit **35**. The switch **32** for actuating the refrigerating machine is opened first after a further cooling either when frost has been formed near the outlet **11***b* of the cooling coil **11** and the third device **14C** so that water in the third device **14C** becomes solidified into ice or when the atmosphere in the refrigerator has been cooled to the set temperature on the switch means **36**. In this case, the micro-relay **30C** is deenergized so that electric current flowing through the coil **35***a* is cut off to cause displacement of the movable contact **35***b* to OFF position whereby the switch **32** is opened. The supply of cooling medium to the evaporator **10** is thus stopped. At this point in time, frost formed on the evaporator near the first and second devices **14A** and **14B** has been supercooled below 0° C.

During the stopping of the supply of cooling medium to the evaporator **10**, frost on said evaporator gradually melts. This melting or removal of frost proceeds gradually from the lower reach of the coil **11** to the upper reach of said coil. Due to stopping of the supply of cooling medium, the third sensing device **14C** or the switch means **36** which has taken an OFF state takes an ON state due to thte melting of ice in the device **14C** or a rise in the temperature of the atmosphere in the refrigerator to the set temperature on the means **36** so that electric current begins to flow through the third device **14C** whereby the micro-relay **30C** is energized again. In this case, however, the switch **32** for actuating the refrigerating machine is not closed because the movable contact **35***b* in the self-maintenance circuit **35** is in the OFF position. As the stopping of the supply of cooling medium to the evaporator **10** continues further, frost on the evaporator near the first and second devices **14A** and **14B** begins to melt. The melting of

frost at such locations occurs first near the first device **14A** or **14B** which was turned into the OFF state later than the other device **14A** or **14B**, as can easily be understood, and occurs then near the other device **14A** or **14B** which was turned into an oFF state earlier than said first device. The switch **32** is still not closed, when only one of the first and second devices **14A** and **14B** turns into the ON state due to melting of frost near said one device and therefore melting of ice in said one device, because energizing of only one of the micro-relays **30A** and **30B** does not cause displacement of the movable contact **35***b* to its ON position. The switch **32** for actuating the refrigerating machine is closed only when both of the first and second devices **14A** and **14B** turn to an ON state so that both of the micro-relays **30A** and **30B** are energized. Supply of cooling medium to the evaporator **10** is thus initiated again or reopened only when frost on said evaporator has been removed perfectly. Thereafter, the defrosting apparatus shown in FIG. **1** repeats the above operation.

During the stopping of the supply of cooling medium to the evaporator **10**, frost, especially supercooled frost near the first and second sensing devices **14A** and **14B**, takes heat or calories corresponding to latent heat for melting away from air surrounding the frost as said frost melts so that said air is cooled. Such cooled air is forcedly circulated in the refrigerator by the fans **13** so that the temperature of the atmosphere in the refrigerator is maintained at approximately constant value even when the supply of cooling medium to the evaporator is stopped.

In addition, when humidity in the refrigerator is very low or the water content of reserves in the refrigerator is low, little frost is formed on the evaporator. Even in this case, the defrosting apparatus shown in FIG. **1** operates in a like manner because the temperature of the evaporator is lowered and raised in a same manner as stated before.

As can be understood from the above, the defrosting apparatus according to the present invention removes frost on an evaporator employed in a refrigerator perfectly and automatically even when the condensation temperature of the cooling medium becomes high due to a rise of atmospheric temperature or other reasons such as, for example, a rise in the temperature of repeatedly used cooling air for a condenser for condensing the cooling medium before the evaporator. Further, as can also be understood now, the defrosting apparatus acts as a temperature control apparatus which always maintains temperature in the refrigerator at an approximately constant value notwithstanding various changes in atmospheric temperature and the amount and character of reserves in the refrigerator.

Needless to say, the defrosting apparatus according to the present invention is much simpler in construction and is offered with much lower cost than a defrosting apparatus of water spray type, heater type, hot gas type or the like according to the prior art. In addition, the third temperature sensing device arranged near the outlet of the cooling coil prevents so-called liquid return to a compressor for the cooling medium because the said device stops the flow of cooling medium when the medium is going to leave the evaporator below a temperature of 0° C.

While the invention has been described by means of a specific example and in a specific embodiment, it is not intended to be limited thereto, for obvious modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In a domestic refrigerator having an evaporator comprising a cooling coil and cooling fins attached to the cooling coil, a defrosting apparatus comprising a first temperature sensing device mounted in heat transfer relation with a cooling medium inlet of the cooling coil for sensing the temperature of the evaporator near said inlet, a second temperature sensing device mounted in heat transfer relation with the evaporator where said evaporator has its lowest temperature in case the condensation temperature of the cooling medium becomes high due to a rise of atmospheric temperature for sensing the temperature of the evaporator near said location, a third temperature sensing device mounted in heat transfer relation with a cooling medium outlet of the cooling coil for sensing the temperature of the evaporator near said outlet, each of the temperature sensing devices comprising a pair of electrodes and water between the electrodes for switching at 0° C due to the difference in resistivity between liquid water and ice, and an electric control circuit for stopping the supply of cooling medium to the evaporator when water in all of the first, second and third sensing devices has frozen and continues stopping of the supply of cooling medium until ice on all of the first, second and third sensing devices has melted.

2. The defrosting apparatus as claimed in claim **1** wherein said first, second and third temperature sensing devices are attached to the cooling fins.

3. The defrosting apparatus as claimed in claim **1** including temperature sensing switch means which senses the temperature of atmosphere in the domestic refrigerator and takes an ON state above a required temperature and an OFF state below a required temperature connected in series to said third temperature sensing device.

4. The defrosting apparatus as claimed in claim **1** wherein said electric control circuit controls initiating and stopping of refrigerating machine connected to said evaporator.

5. The defrosting apparatus as claimed in claim **4** wherein said electric control circuit includes amplifying means for electric current flowing between the electrodes of each of the sensing devices, a micro-relay for each sensing device which is energized by electric current flowing between the electrodes of the associated sensing device and through said amplifying means, and a relay including switch means for initiating and stopping the refrigerating machine, the said relay further including a self-maintenance circuit which opens the switch means when all of the three micro-relays have been deenergized and closes the switch means when all of the three micro-relays have been energized again.

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