

[54] DEFROST CONTROL

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62/234

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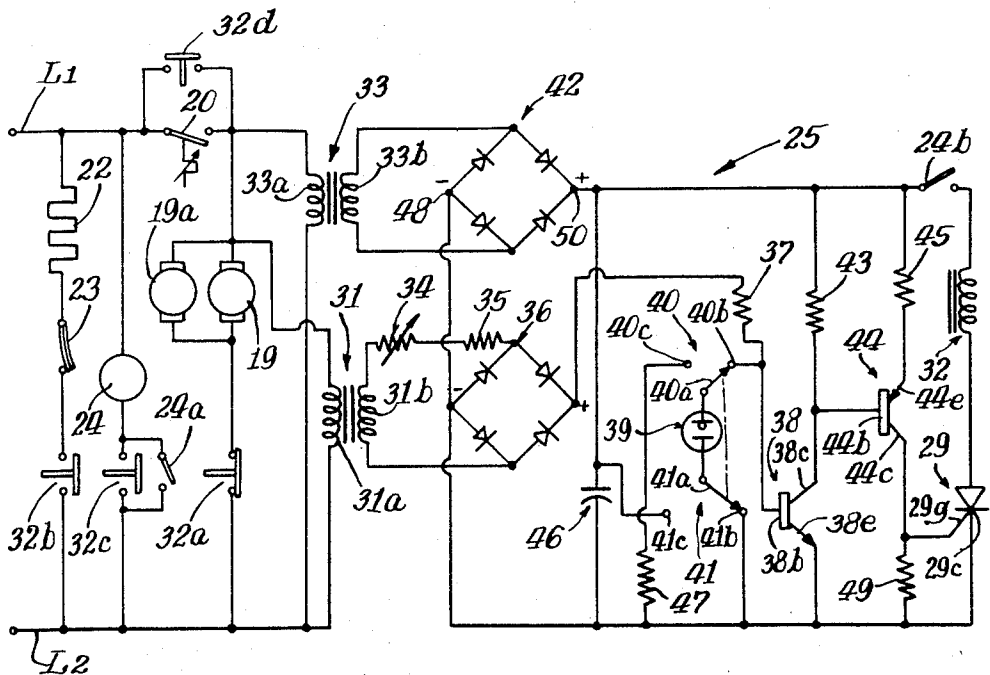
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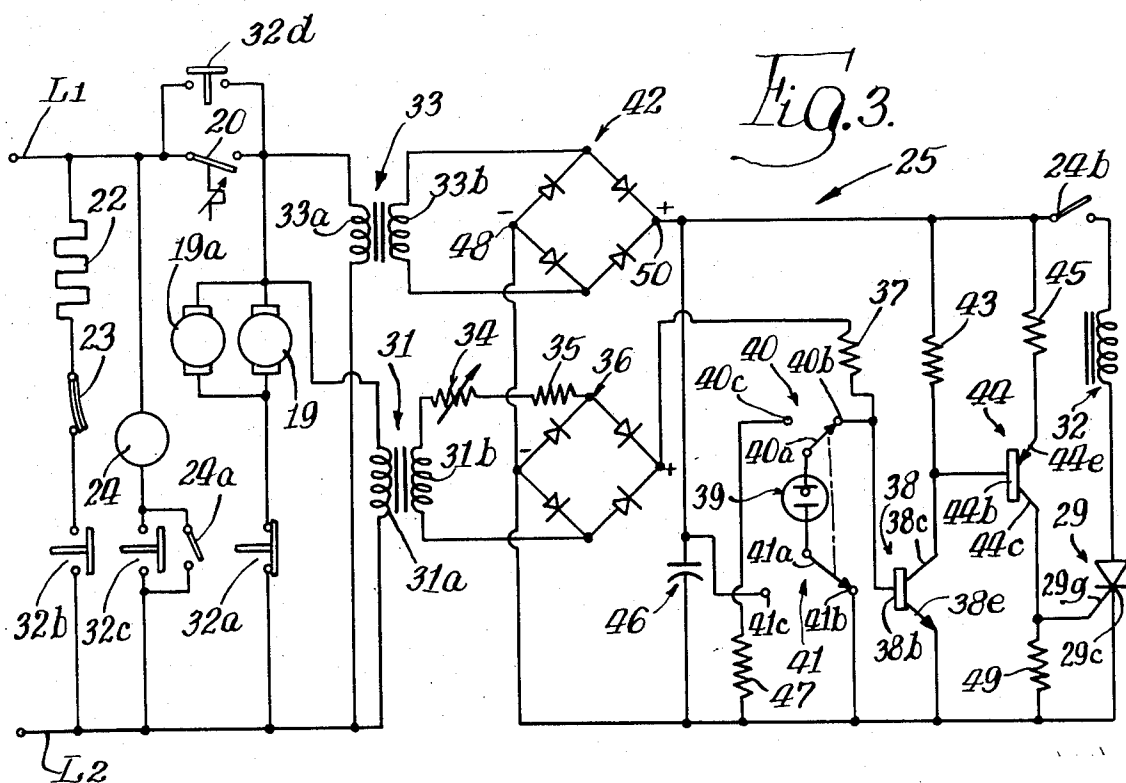
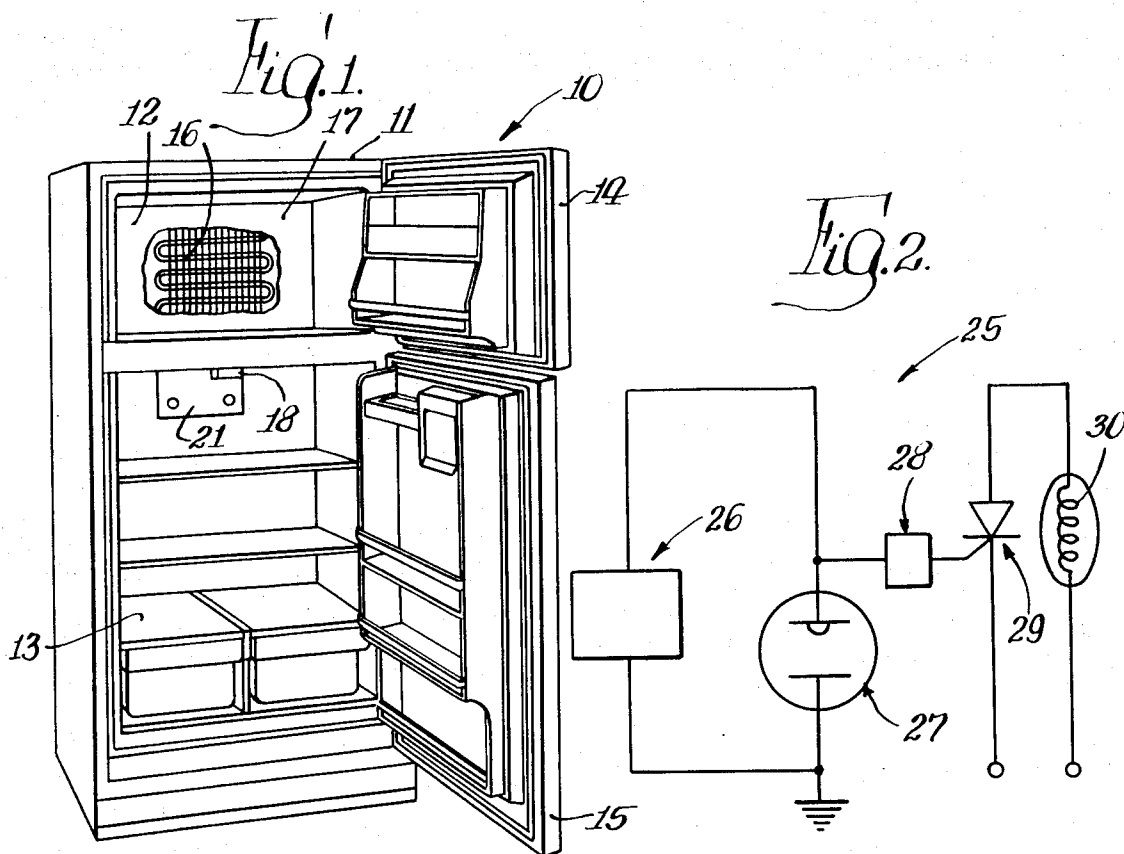
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[57] ABSTRACT

A refrigeration apparatus having means for automatically controlling cyclical defrosting thereof. The control includes means responsive both to humidity conditions within the apparatus and to time for providing automatically initiation of the defrosting operation as a function of both such parameters.

12 Claims, 3 Drawing Figures





DEFROST CONTROL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to refrigeration apparatus and in particular to means for controlling defrosting operations in such apparatus.

2. Description of the Prior Art

In one form of frost-free refrigeration apparatus, air is circulated in heat exchange relationship to a cooling means, such as an evaporator, and then to the different chambers to be refrigerated. The air is returned from the chambers back to the evaporator for recooling thereof in a closed loop within the refrigerator. From time to time, moisture is introduced into the circulated air as by opening of the doors to the different compartments and admitting ambient air thereinto, or from moisture on the items placed in the chambers to be refrigerated.

In such a forced air system, the moisture tends to collect as frost on the coldest part of the system, such as at the inlet to the evaporator, thereby effecting a frost-free cooling of the chambers. However, from time to time, it is necessary to defrost the apparatus, i.e., to remove the collected frost, for optimum operation thereof. Conventionally, timers have been employed for initiating the defrosting operation at preselected time intervals, such as once every 12 hours. Such preselected intervals are dependent on the worst operating conditions, i.e., conditions of high ambient humidity and temperature with frequent openings of the chamber doors. Where the refrigerator is not opened for periods of time, such as when the user is on vacation, such frequent defrosting is unnecessary, as once the moisture is removed from the circulated air, there is substantially no further addition of moisture to the circulated air to be removed.

Certain refrigeration systems of the art have controlled the defrosting operation as a function not only of time, but also the relative humidity of the ambient air. Such structures are shown in J. L. Lorenz Pat. No. 3,460,352, issued Aug. 12, 1969, for a Defrost Control, and E. L. West, Jr. United States Letters Pat. No. 3,518,841, issued July 7, 1970, for Refrigeration Apparatus with Variable Interval Defrost Means. In the Lorenz patent, a humidity responsive element is located in the machinery compartment of the refrigerator so as to sense the humidity of the ambient air. Lorenz teaches that the location of the humidity sensor should be externally of the refrigerated air flow path because the relative humidity of the air within the refrigerator is substantially zero. West, Jr. teaches the use of a manual control which may be set by the user in correlation with the humidity conditions for effecting the operation of the defrosting means. The control is arranged so that when the user sets the switch to a low humidity position, the timer runs in parallel with the refrigerator compressor, whereas when the user sets the switch to a high humidity position, the defrost timer is caused to run constantly to effect a minimum time interval between defrosting operations. In Dodge Pat. No. 3,474,638, a defrost control is shown to utilize a device accumulating compressor running time and door open time.

SUMMARY OF THE INVENTION

The present invention comprehends an improved re-

frigeration apparatus wherein the initiation of the defrost cycle is controlled by means responsive to the humidity conditions within the refrigerator. It has been found that contrary to the teaching of the Lorenz patent, the humidity of air within the refrigerator varies substantially depending on a number of factors such as the ambient temperature and humidity, the frequency of door openings, the sealing tightness of the refrigerator cabinet construction, the temperature at which the refrigerator is being operated, etc. Thus, the present invention comprehends the use of a humidity sensing means which correlates all of these different factors. Further, the present invention provides an accumulating means which functions in conjunction with the humidity sensing means to provide an integration of the humidity and time functions so as to effect initiation of the defrosting operation as a result of a preselected integrated amount of sensed humidity and time factors.

The control may be arranged to sense the humidity conditions within one of the chambers being refrigerated such as the above-freezing temperature refrigerator chamber. Preferably, the humidity condition is sensed adjacent the inlet to the cooling means which may conventionally comprise an evaporator.

The control is adapted to be reset during the defrosting operation so as to be available substantially immediately upon termination of the defrosting operation for controlling a subsequent timing interval prior to the initiation of the next defrost cycle. The accumulating means may be arranged to accumulate humidity-time information only during operation of the refrigerating device, such as the compressor. The accumulating means may be reset by providing a reverse current thereto during the defrost operation. Illustratively, the timer means may comprise a coulometer, such as an E-cell coulometer.

Thus, the present refrigeration apparatus defrost control effects a defrosting operation only when required as the result of integrating an accumulated amount of humidity and time input signals. Thus, increased efficiency in the operation of the refrigeration apparatus is obtained and undesirable effects on the products being stored in the refrigerator and freezer compartments resulting from unnecessary defrosting of the apparatus is avoided. The control is adapted for use with substantially all types of self-defrosting refrigeration apparatuses and is extremely simple and economical of construction while yet providing the highly desirable features discussed above.

BRIEF DESCRIPTION OF THE DRAWING

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

FIG. 1 is a perspective view of a refrigeration apparatus provided with a control means embodying the invention, with a portion of the apparatus broken away to facilitate illustration of the invention;

FIG. 2 is a block diagram illustrating the control means; and

FIG. 3 is a schematic wiring diagram of the control means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the exemplary embodiment of the invention as disclosed in the drawing, a refrigeration apparatus gener-

ally designated 10 is shown to comprise a cabinet 11 defining a below-freezing temperature freezer compartment 12 and an above-freezing temperature refrigerator compartment 13 selectively closed by doors 14 and 15, respectively. In the illustrated embodiment, refrigeration of chambers 12 and 13 is effected by forced flow of refrigerated air therethrough, the air being cooled by flow thereof in heat exchange relationship with an evaporator 16 provided within the rear wall 17 of the cabinet at the rear of chamber 12. Air is returned from refrigerator chamber 13 to the evaporator 16 through a passage 18 at the rear of chamber 13. The evaporator is cooled by flow of suitable refrigerant therethrough by means of a compressor (not shown) driven by a suitable electric motor 19 under the control of a thermostat 20 provided in a control console 21 at the upper rear of chamber 13. Air is circulated by means of a conventional evaporator fan (not shown) driven by a motor 19a. The evaporator fan motor 19a is connected in parallel with compressor motor 19 and accordingly is controlled by thermostat 20. The refrigeration apparatus may further include a defrost heater 22 connected in series with a defrost bimetal control switch 23. A conventional electric defrost timer 24 may be provided for timing the length of the defrost operation.

As indicated above, the invention comprehends an improved control generally designated 25 for effecting initiation of the defrost operation at intervals dependent on the humidity conditions within the apparatus 10 correlated with time. In the illustrated embodiment, the time parameter comprises the time of running of the compressor motor 19 as will be brought out more fully in the detailed description of the control.

Referring to FIG. 2, control 25 includes means generally designated 26 for providing a signal as a function of the humidity conditions within the apparatus 10. The humidity signal is applied to a coulometer timer generally designated 27 and the voltage developed across the coulometer 27 is delivered through an amplifier 28 to a silicon controlled rectifier (SCR) 29 connected in series with a suitable electrical transducer, such as solenoid coil 30, for initiating the defrost operation.

The invention comprehends the sensing of the humidity within apparatus 10 and more specifically, preferably within chamber 13 adjacent the inlet 18 to evaporator 16. As discussed above, it has been found that the humidity conditions within the self-defrosting refrigerator do vary, contrary to the teachings of the prior art, suitably to provide a sensed condition for integration with respect to time via a device such as coulometer 27 to provide efficient automatic control of the cyclical defrosting operations so as to initiate such operations only when required rather than at preselected fixed intervals such as has heretofore been effected by the devices of the prior art.

One specific control circuit for providing this improved defrost operation control is illustrated in FIG. 3. As shown therein, power is provided to the control from conventional power supply leads L_1 and L_2 . The primary winding 31a of a first stepdown transformer 31 is connected in series with the thermostat contacts 20 across the power supply leads. Transformer primary winding 31a is connected in parallel with a series circuit of the compressor motor 19 and a first, normally closed switch 32a controlled by relay coil 32. Defrost heater 22 and bimetal 23 are connected in series with

a second, normally open switch 32b controlled by coil 32 across power supply leads L_1 and L_2 . Defrost timer motor 24 is connected in series with a third, normally open switch 32c controlled by coil 32, across power supply leads L_1 and L_2 and a fourth, normally open switch 32d controlled by coil 32 is connected in parallel with thermostat switch 20. A switch 24a controlled by timer 24 is connected in parallel with switch 32c.

A second stepdown transformer generally designated 33 has its primary winding 33a connected in parallel with primary winding 31a of transformer 31. The secondary winding 31b of first transformer 31 provides a 7 volt power supply through a moisture dependent resistance 34 and a fixed resistor 35 to a bridge rectifier generally designated 36. The rectifier is connected to a resistor 37 in series with a transistor 38. A coulometer, or E-cell, 39 is connected through a first selector switch 40 and a second selector switch 41. The second stepdown transformer 33 has its secondary 33b connected to a second bridge rectifier 42 to provide a 20 volt direct current power supply to the transistor 38 through a resistor 43, a second transistor 44 through a resistor 45, and the coil 32 through a second timer-operated switch 24b and SCR 29. A capacitor 46 is connected across the output of the bridge 42. Switch 40 includes a moving contact 40a connected to the E-cell 39 and selectively engaging a first, fixed contact 40b connected between resistor 37 and the base 38b of transistor 38, and a second, fixed contact 40c connected through a resistor 47 to the common negative lead 48 of the bridge circuits 36 and 42. Switch 41 includes a moving contact 41a connected to the E-cell 39 and selectively engaging a first, fixed contact 41b connected to lead 48 and a second, fixed contact 41c connected to the positive terminal 50 of bridge circuit 42. The emitter 38e of transistor 38 is connected directly to lead 48. The base 44b of transistor 44 is connected between collector 38c of transistor 38 and resistor 43, and the collector 44c of transistor 44 is connected to between the gate 29g of SCR 29 and a resistor 49. SCR cathode 29c and resistor 49 are, in turn, connected to the common negative lead 48.

Capacitor 46 is connected between positive terminal 50 of the bridge rectifier 42 and the negative lead 48 to filter the direct current output thereof.

The moisture dependent resistor 34 is preferably connected to the secondary winding 31b of transformer 31 so as to be AC operated. However, the output of bridge rectifier 36 comprises a direct current signal which is a function of the resistance value of resistor 34 which is delivered through the coulometer 39 to permit integration of the humidity sensed by resistance 34 with time. As the primary windings 31a and 33a of transformers 31 and 33, respectively, are connected in series with the thermostat switch 20, delivery of current through resistor 34 and coulometer 39 may be effected only concurrently with the operation of compressor motor 19.

Transistor 38 effectively senses the voltage across the coulometer 39. Transistor 38 and transistor 44 function as high gain amplifiers for triggering the gate 29g of SCR 29 so as to turn the SCR on when the E-cell timer 39 reaches a high resistance state as a result of a preselected total time-current flow therethrough. Transistors 38 and 44 are normally off and turn on only when the voltage across E-cell timer 39 reaches the turn-on volt-

age of transistor 38 which, illustratively, is approximately 0.7 volts.

When SCR 29 is turned on, current flows through coil 32 so as to cause closing of switches 32a, 32b, 32c and 32d. Resultingly, defrost heater 22 is energized through the normally closed bimetal switch 23 and the now closed switch 32b to effect the desired defrosting operation. At the same time, defrost timer motor 24 is energized through now closed switch 32c to commence timing of the defrost cycle. Compressor motor 19 is de-energized by the opening of normally closed switch 32a. The connections to the timer E-cell 39 are reversed by the throwing of moving contacts 40a and 41a of switches 40 and 41, respectively, to contacts 40c and 41c, respectively, so as to reverse the polarity of the current flow through the E-cell 39 during the defrost operation. The current limiting resistor 47 controls the rate at which the E-cell 39 is returned to its initial state and is preselected to insure the resetting thereof during the normal defrosting period.

At the end of a defrosting operation, timer motor 24 opens switch 24b to open the circuit to the coil 32 and turn off SCR 29. Switch 24a is closed by timer 24 at the initiation of the defrost cycle or at some time prior to the opening of switch 24b. Switch 24a is caused to remain closed until such time as switch 24b is again closed and to open only when the timer 24 has returned to the "start" position.

Thus, timer 24 controls the duration of the defrosting operation and effectively resets the portion of the control which is controlled by the humidity responsive resistor 34 and E-cell 39 upon completion of the defrosting operation to initiate a subsequent determination of a suitable time period before re-initiation of another defrosting operation. The control 25 provides an automatic integration of an accumulated amount of humidity sensed by the resistor 34 with an accumulated amount of humidity sensed by the resistor 34 with an accumulated amount of time determined by the running time of the compressor 19 for initiating the defrosting operation as a result of a preselected integrated amount of the accumulated sensed humidity and time. The humidity is that within the refrigerator and not externally thereof so as to provide an improved accurate correlation with the conditions within the refrigerator taking into account all of the variables which may affect the internal humidity. In the illustrated embodiment, the humidity is sensed in the relatively high temperature moist area of the outlet of the refrigerator chamber 13 leading to the evaporator 16 to provide improved sensing of the humidity condition. In addition, the moisture dependent resistor employed in the present embodiment responds to the relative humidity of the surrounding air, as opposed to the absolute humidity thereof. The component values listed below were chosen to provide the desired performance when used with such a sensor.

Reference Numerical	ITEM
29	SCR — GE C106
32	Relay — 20VDC Relay
34	Humidity Sensor, 1K-5Mohms (PCRC-11)
	Resistor
35	Resistor, 6 Kilohms
37	Resistor, 100 ohms
38	Transistor, MPS 6521
43	Resistor, 150 Kilohms
44	Transistor, MPS 6518
45	Resistor, 6 Kilohms
46	Capacitor, 50 microfarads

47 Resistor, 10 Kilohms
49 Resistor, 1.5 Kilohms

As the defrost operation is thereby initiated only as actually required, the power requirements of the refrigeration apparatus are minimized and inimical or detrimental effects on the food products stored in the chambers 12 and 13 from unnecessary defrosting are avoided. By suitable control of the resistors 35 and 37, different integrated amounts of time and humidity sensing may be utilized for effecting the defrost initiation and, thus, the control is readily adapted for use with different self-defrosting refrigerator apparatuses as well as permitting ready adjustment of the desired defrost initiation conditions.

While the invention has been illustrated in connection with the use of an E-cell, as will be obvious to those skilled in the art, other forms of timers adapted for use cooperatively with a humidity sensing device such as resistor 34 may be employed to accumulate a predetermined humidity-time integral. Similarly, other humidity sensing devices suitable for use with the desired accumulating device to provide the desired integrated controlled output for suitable defrost control initiation may be employed.

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

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

1. In a refrigeration apparatus having means defining a chamber to be refrigerated, cooling means for providing refrigerated air within said apparatus to said chamber, and defrosting means for defrosting said cooling means, control means for controlling the operation of said defrosting means comprising:

humidity sensing means for sensing the humidity of said air within said apparatus;

accumulating means for integrating the amount of humidity sensed by said humidity sensing device with time; and

means for initiating a defrosting operation by said defrosting means as a result of a preselected integrated amount of said sensed humidity and time.

2. The refrigeration apparatus of claim 1 wherein said humidity sensing means is arranged to sense the humidity in said chamber.

3. The refrigeration apparatus of claim 1 wherein said cooling means are provided externally of said chamber, and said humidity sensing means is arranged to sense the humidity of the air prior to circulation thereof from said chamber to said cooling means.

4. The refrigeration apparatus of claim 1 wherein means are provided for operating said cooling means whenever the temperature in said chamber is above a preselected temperature, and said control means is arranged to integrate the sensed humidity with time only during operation of said cooling means.

5. In a refrigeration apparatus having means defining a chamber to be refrigerated, cooling means for providing refrigerated air within said apparatus to said chamber, and defrosting means for defrosting said cooling means, control means for controlling the operation of said defrosting means comprising:

humidity sensing means for sensing the humidity of said air within said apparatus;

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means for integrating the humidity sensed by said humidity sensing device with time for initiating a defrosting operation by said defrosting means as a result of a preselected integrated amount of said sensed humidity and time; and

means for resetting the integrating means during the defrosting operation to permit a subsequent defrost operation initiation upon again reaching said preselected integrated amount of sensed humidity and time.

6. The refrigeration apparatus of claim 5 wherein said integrating means comprises a coulometer E-cell and said resetting means comprises means for applying a reverse current to said E-cell during the defrosting operation.

7. The refrigeration apparatus of claim 5 including timing means for timing the duration of the defrosting operation and terminating the operation of said resetting means.

8. The refrigeration apparatus of claim 5 wherein said cooling means includes an evaporator, means for circulating air successively in heat exchange with said evaporator, to said chamber, and back to said evaporator, and said humidity sensing means is disposed to sense the humidity of the air being circulated back to the evaporator.

9. In a refrigerator having a refrigerated compartment, an evaporator for refrigerating the air within the compartment, and means for defrosting the evaporator, the method of controlling the initiation of a defrosting operation comprising the steps of:

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sensing the moisture content of the air within the compartment;
integrating the sensed moisture content with time;
and

initiating operation of the defrosting means upon the accumulation of a predetermined moisture content-time integral.

10. In a refrigerator having a refrigerated compartment, an evaporator for refrigerating the air within the compartment, and means for defrosting the evaporator, the method of controlling the initiation of a defrosting operation comprising the steps of:

sensing the relative humidity of the air within the compartment;

integrating the sensed relative humidity with time;
generating a signal which is dependent upon the accumulated humidity-time integral; and

initiating operation of the defrosting means in response to a predetermined state of the generated signal.

11. The method of initiating a defrosting operation as defined in claim 10 wherein the step of integrating humidity with time is carried out when air is being circulated over the evaporator and into the compartment.

12. The method of initiating a defrosting operation as defined in claim 10 further including the steps of de-energizing the defrosting means after a timed period of operation and initiating a subsequent period of sensing and integrating relative humidity with time.

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