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DEFROSTING SYSTEM FOR REFRIGERATING APPARATUS

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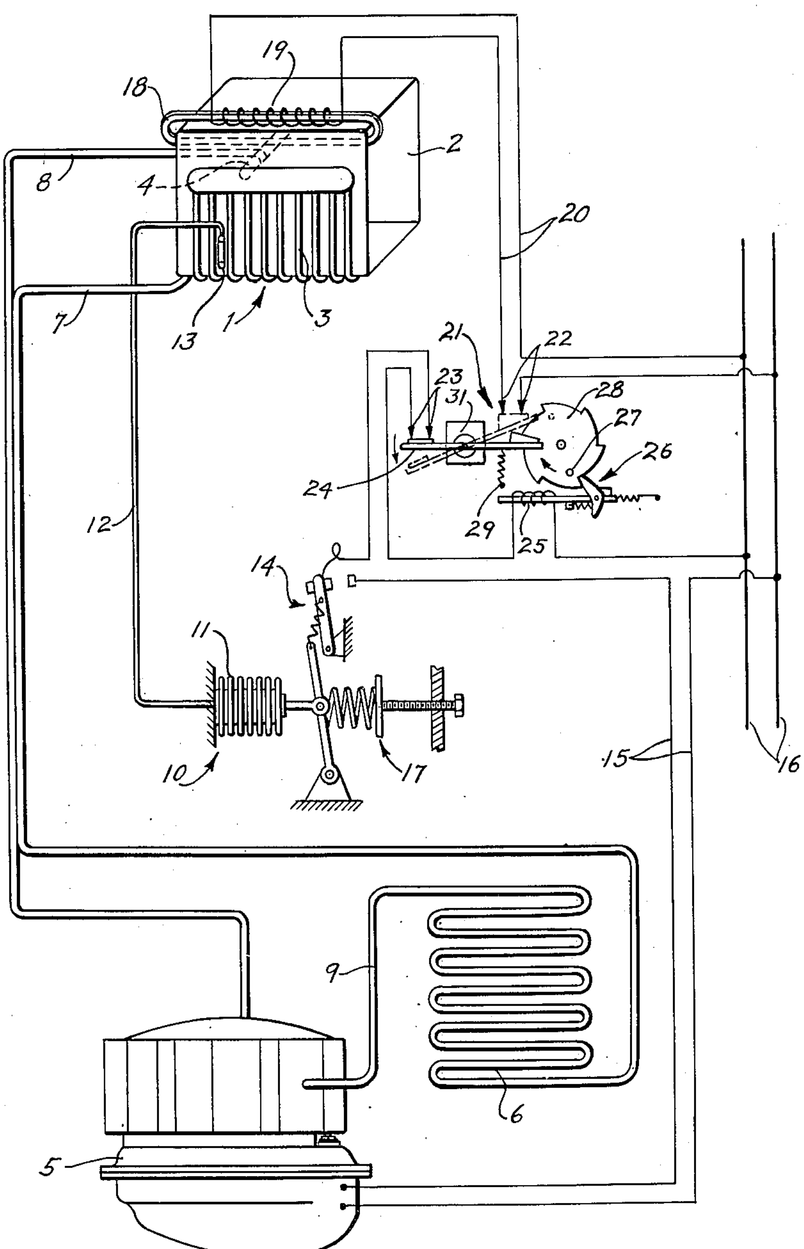

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DEFROSTING SYSTEM FOR REFRIGERATING APPARATUS

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The present invention relates to refrigeration and more particularly to defrosting means for the cold producing unit of an automatic refrigerator.

In commonly known refrigerating systems utilizing a cold poducing unit of the exposed evaporator type placed in the path of the circulating air to be cooled, moisture in said air condenses on the heat exchange surfaces of the evaporator, where the condensation is frozen. When such frost is permitted to accumulate on the evaporator surfaces, the cooling action of the evaporator is detrimentally affected, since the frost then acts as an insulating blanket, as is well known.

In order to prevent this effect, it is necessary to remove the frost from the evaporator surfaces at periodic intervals and this is usually accomplished by interrupting the refrigerating action of the system for a period of time sufficient to permit the box temperature to rise well above the freezing point so that defrosting may take place. Such methods of defrosting require a considerable length of time, during all of which time the evaporator is maintained at temperatures too high for the proper preservation of the frozen foods which may be stored therein, and the overall efficiency of the refrigeration system is reduced, as a result of the necessity of periodically re-freezing the ice cubes. In addition, the refrigerating effect of the melting frost and ice cubes is generally insufficient to maintain the desired temperature in the main food storage compartment.

It has heretofore been proposed to shorten the defrosting time by associating an electrical resistance heating unit with the evaporator in such a manner that the heat generated in said unit is transmitted by conduction, by radiation, or both, to the coating of ice which has collected on the evaporator. Such arrangements, however, have given rise to rather serious problems, as will become evident from the following.

For example, this type of apparatus necessitates the provision of specially designed heating units insulated from the exposed surfaces of the refrigerator to prevent the possibility of shocks, which danger is very apt to arise, particularly when the interior surfaces of the refrigerator have become damp. This can be seen from the fact that the voltage drop across many of the resistance heaters, employed heretofore, has been considerable, generally 110 volts. Since considerable heat must be generated, the ceramic or other insulation employed has been, of necessity, of a costly nature. Also, heaters of this type result

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in only localized, spot heating and, in order to effectively heat the entire coating of ice, heating units of unduly large size have been resorted to. These tend to obstruct the evaporator and, consequently, interfere with the thermal efficiency thereof.

Moreover, a very considerable quantity of energy is required since the ice is not heated directly, but only indirectly as a result of the heat which must first be accumulated in the resistance element itself. Further, because of the intense heat throughout the inherently large thermal mass necessary to the structure of a resistance heating unit, it will be appreciated that a relatively long period is required to cool such unit before the evaporator may resume its refrigerating action.

Broadly, it is an object of the present invention to provide a defrosting system which eliminates the aforesaid difficulties and which is capable of defrosting a refrigerator evaporator in the shortest possible time and without unduly delaying the resumption of the evaporator refrigerating action. To this end, the invention employs a novel apparatus for inductively heating the evaporator, in a manner fully set forth hereinafter. The system of the instant invention results in a high heating current directly in the evaporator itself, and immediately adjacent the frost or ice coating. This current is of such low voltage as to substantially negative the need for electrically insulating the evaporator. A magnetically permeable core is employed and there is, of course, no substantial voltage drop therein and, consequently, no danger of shocks arising therefrom. In addition, the primary winding to be described in connection with the invention, may conveniently be insulated and mounted in such a manner as to be hidden and inaccessible.

It is also an object of the invention to provide a defrosting system of the kind above mentioned which will operate automatically at certain predetermined intervals during operation of the refrigerator so that undesirable accumulation of frost on the evaporator is effectively prevented without requiring special attention on the part of the user.

Still another object of the invention is the provision of an automatically and periodically operable evaporator defrosting system utilizing electrical energy to induce a heating current in the evaporator shell and associated with the refrigerating system in such a manner that the defrosting system operates in timed relation with the operation of the refrigerating system, so that defrosting takes place during the most advantageous moment in the refrigerating cycle, to eliminate the danger of generating useless heat and prevent wastage of useful refrigeration.

Also, it is a characteristic feature of the invention to provide a simple effective defrosting system for the cold producing evaporator of a refrigerator, which system may be readily incorporated in the refrigerator structure without necessitating material changes therein and without materially affecting the operating cost thereof.

Other objects and advantages of the invention will appear from the following description based upon the accompanying drawing in which a practical embodiment is diagrammatically illustrated.

With more particular reference to the drawing, there is shown a cold producing unit or evaporator structure 1, comprising a tube-like shell 2 constructed of a material having good electrical conductivity and structurally defining a closed electrical circuit about one axis thereof. For instance, as is shown in the drawing, the evaporator shell preferably is of substantially tubular configuration having continuous side, top, and bottom walls defining said closed circuit and constituting continuous heat exchange surface portions, said side and bottom walls carrying suitable refrigerant circulating means which preferably is of the usual type including a refrigerant circulating path in the form of cooling coils 3 in communication with a cross-header 4.

Refrigerant is circulated in the evaporator cooling coils 3, in the customary manner, through the function of a suitable refrigerating system including a motor compressor 5, a condenser 6, a liquid line 7 leading from the condenser to the evaporator coils, and suction line 8 leading from the cross-header 4 to the motor compressor. The evaporator structure 1 is adapted to be mounted within a refrigerator cabinet (not shown) to refrigerate the food storage compartment by cooling the air circulated therein. In operation of the refrigerating system, heat is taken up by the refrigerant in the cooling coils 3, as will be well understood. The vaporized refrigerant is withdrawn through the suction line 8 by the motor compressor 5 which compresses said vaporized refrigerant and discharges it under relatively high pressure through a conduit 9 into condenser 6 wherein the refrigerant is cooled and condensed. The condensed liquid refrigerant then flows to the evaporator coils 3, through liquid line 7 which may be provided with the usual expansion device (not shown) functioning to reduce the pressure of the liquid refrigerant to the proper value for adequate operation of the evaporator.

Preferably the operation of the refrigerating system is controlled in response to the temperature of the evaporator and for that purpose a suitable thermostatic device generally indicated at 10 is utilized to switch the motor compressor on and off.

As shown in the drawing the thermostatic device may be of the expansible fluid type including an expansible bellows 11 connected by means of a tube 12 with a feeler bulb 13, the bellows 11 being adapted to actuate a snap action switch designated at 14 and included in the motor circuit 15, electrically connected to the A. C. power line 16. Actuation of the switch 14 closes and opens the motor circuit 15 in response to predetermined high and low evaporator temperatures in the manner well known in the art. Adjustable means 17 may be provided to regulate the upper and lower temperature values to which the switch responds.

As is well known, the air circulating within the storage compartment of a refrigerator cabinet contains a certain amount of moisture which is deposited and condensed on the heat exchange surfaces of the evaporator, where such condensed moisture freezes into a layer of frost.

In accordance with the present invention, accumulation of frost is prevented by providing a system capable of inducing electrical current in the evaporator shell 2 itself, in order to heat the latter rapidly to a point sufficient to melt the frost before it attains any substantial thickness.

A practical embodiment of such a system is shown in the drawing. As shown, a core 18 of suitable magnetically permeable material, such as silicon steel, encircles one of the continuous walls of said shell 2.

Wound about that portion of the core located outside the evaporator shell 2, is a coil 19 included in an electrical circuit 20 connected across the A. C. line 16, but separates and distinct from the motor compressor circuit 15. Circuit making and breaking means 21 is interposed in the coil circuit 20 to open and close the same.

It will be understood that the arrangement above described forms a structure which is essentially a transformer, in which the coil 19 constitutes a multi-turn primary and the evaporator shell 2 constitutes a single-turn secondary. Therefore, it will be appreciated that when the circuit 20 is closed, relatively low current at line voltage will flow through the coil 19 setting up alternating magnetic flux in the magnetic core 18 and thus inducing a large current at relatively low voltage in the evaporator shell 2. In this manner, the evaporator shell 2 becomes rapidly heated to melt such frost as has accumulated upon the heat exchange surfaces of said evaporator.

While, in the broader aspect of the present invention, any suitable type of circuit making and breaking device may be used to control the defrosting circuit 20, a device adapted to interrelate said defrosting circuit with the motor circuit 15 is preferred, in order to assure interruption of one circuit when the other circuit is energized, thereby obviating a possible unnecessary loss of refrigeration and electrical energy.

For that purpose, pairs of contacts 22 and 23 are respectively included in the defrosting circuit 20 and motor circuit 15, and a single switching member 24 common to both pairs of contacts is mounted therebetween so that, upon actuation of said switching member, the contacts of one circuit are opened when the contacts of the remaining circuit are closed. Thus upon reference to the drawing it may be seen that when, for instance, the switching member 24 is in its normal position, that is, the position indicated in full lines, the contacts 22 are open so that no current can flow through the defrosting circuit 20, and the contacts 23 are closed so that current may flow through the motor circuit 15 for actuation of the motor-compressor 5 upon closing of the thermostatically operated switch 14. However, when the switching member 24 is in the position indicated in dotted lines, the contacts 22 are closed so that current may flow through said defrosting circuit and contacts 23 are opened so that no current can flow through said motor circuit, even though the thermostatically operated switch 14 is closed.

In order to enhance the efficiency of the defrosting system by cutting down the time required to raise the temperature of the evaporator to a point sufficient to melt the frost, it is desirable that the operation of the switching member 24 to close the defrosting circuit take place at the initiation of an "on cycle" in the refrigerating system when the temperature of the evaporator, in the ordinary course of its operation, is at the highest level. For that reason, the operation of the switching member 24 to set the defrosting system in operation, is automatically controlled through the function of the motor circuit when the refrigerating system is initially set for operation, by closing of the thermostatically actuated switch 14. As illustrated, this may be accomplished by providing the motor circuit 15 with a solenoid 25 operatively associated with a pawl and ratchet mechanism 26 so that, upon energization of said circuit, the pawl and ratchet mechanism is actuated to bring a switch actuating element 27 (which may conveniently be mounted on the ratchet shell 28 of said mechanism) in engagement with the switch member 24, thus causing said member to move in position to open the motor circuit and close the defrosting circuit.

Under usual conditions, it is not necessary to defrost at every "on cycle" of the refrigerating system, and therefore the pawl and ratchet mechanism is preferably operated in steps to progressively advance the switch operating element 27 for a number of "on cycle" recurrences. For example, the drawing shows the ratchet wheel as being provided with six equally spaced teeth so that the energization of the defrosting circuit takes place upon the sixth consecutive closing of the switch 14. It is, of course, to be understood that any number of teeth may be provided on the ratchet wheel to obtain the most desirable result.

In the embodiment shown in the drawing, it will be noted that the switching member 24 is urged, for instance by means of a spring 29, to normal position wherein contacts 23 of the motor circuit 15 are closed and that said member is releasably held in its defrosting circuit closing position (shown in dotted lines) against the action of said spring, as will now be seen.

In order that the defrosting system may be made fully automatic, the trip device preferably includes a time delay mechanism 31. This mechanism may conveniently be controlled by clockwork, a dash pot, or any desired conventional means, adapted to actuate said trip device to release the switching member 24, after the lapse of a time sufficient to accomplish the defrosting. Such time delay devices are well known and, therefore, need not be described in detail herein. However, it is pointed out that, as illustrated, this time delay device 31 takes the form of a clockwork mechanism which is wound in response to movement of switching member 24 to the position shown in dotted lines, and which includes a latch maintaining the switching member in said position, until triggered by unwinding of the clockwork.

The automatic operation of the system as hereinbefore described may be summarized as follows:

During the normal use of the refrigerator, when the temperature of the evaporator 1 reaches its predetermined high level, the thermally responsive switch 14 closes the motor circuit 15 thereby initiating an "on cycle." During this cycle, the motor-compressor feeds refrigerant to the cooling coils 3, thereby bringing the evaporator temperature down to its predetermined low level, whereupon the switch 14 opens the motor circuit thus stopping the operation of the motor-compressor and terminating the "on cycle."

With each "on cycle," the pawl and ratchet mechanism 26 operates to advance the switch actuating element 27 step-by-step until it comes into engagement with the under surface of the switching member 24 whereupon, at the initiation of the next succeeding "on cycle," said switching member is operated, against the spring 29, to simultaneously open the motor circuit 15, to close the defrosting circuit 20, and to wind the clockwork 31.

The displacing movement of the switching member 24 is utilized, as above set forth, to set the time delay mechanism 31 in operation by winding the clockwork, so that at the completion of the defrosting period, said mechanism will function to actuate the latch and thereby release the switching member 24, which is then free to return to its normal position under action of the spring 29. Following this, the interrupted "on cycle" is immediately resumed. In this connection, it is to be noted that the switch actuating element 27 is so associated with the ratchet wheel 28 that said element will clear the switch member 24 when the latter finally assumes its defrosting circuit closing position.

From the foregoing description it will be appreciated that the present invention provides an arrangement whereby the difficulties inherent in the resistance systems previously employed are eliminated. Moreover, the evaporator shell itself constitutes an active element of the defrosting system in that heat is generated directly in the frost-laden body portions of said shell, due to the electric current induced therein. Because of this arrangement, it will likewise be appreciated that but a very short period of time is required to melt the frost which forms on the heat exchange surfaces of the evaporator, and that the system is such that the temperature of the evaporator is not affected for a sufficient period of time to detrimentally affect the frozen substances commonly stored therein.

While the defrosting system has been described in combination with an electrical-mechanical refrigerator utilizing the compression-expansion type of refrigerating system, it is to be understood that the invention, in its broadest sense, is not limited to any particular type of refrigerating system. It is also to be understood that other modifications in the structure herein set forth as a possible embodiment of the invention, may be made within the scope of the appended claims.

I claim:

1. In a refrigerating system: an evaporator having a refrigerant circulating path and structurally defining a closed circuit through which electric current may flow; means operable to initiate a refrigerant supply cycle through the refrigerant circulating path of said evaporator in response to the temperature thereof; and electromechanical means including a coil adapted for connection across a source of alternating current, a core magnetically linking said coil directly with said evaporator for magnetically inducing a current directly in the evaporator, and switch mechanism adapted to effect connection of said coil across said source upon occurrence of a predetermined number of operations of the first mentioned means, said switch mechanism including a time delay device operable to effect disconnection of the coil after a predetermined time interval following the connection thereof.

2. In a refrigerating system: an evaporator structurally defining a closed circuit through which electric current may flow; a motor-compressor; a refrigerant circuit interconnecting said evaporator and motor-compressor; an electric circuit connected with the motor-compressor, including energization means operable to initiate operation of said motor-compressor to supply refrigerant to said evaporator through said refrigerant circuit in response to the temperature of said evaporator; an electromagnetic circuit including a coil adapted for connection across a source of alternating current, and a core magnetically linking said coil directly with said evaporator for magnetically inducing a current directly in the evaporator; and controlling means including a switching member normally set to close said electric circuit and to open said electromagnetic circuit, and a mechanism associated with said electric circuit and switching member said mechanism operable to actuate said member upon periodic energization of the electric circuit.

3. A construction in accordance with claim 2, in which the mentioned mechanism includes a time delay device operable to reset the switching member after a predetermined interval of time.

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