

May 8, 1962

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3,033,004

DEFROST CONTROL RESPONSIVE TO FROST ACCUMULATION

Filed Jan. 8, 1960

4 Sheets-Sheet 1

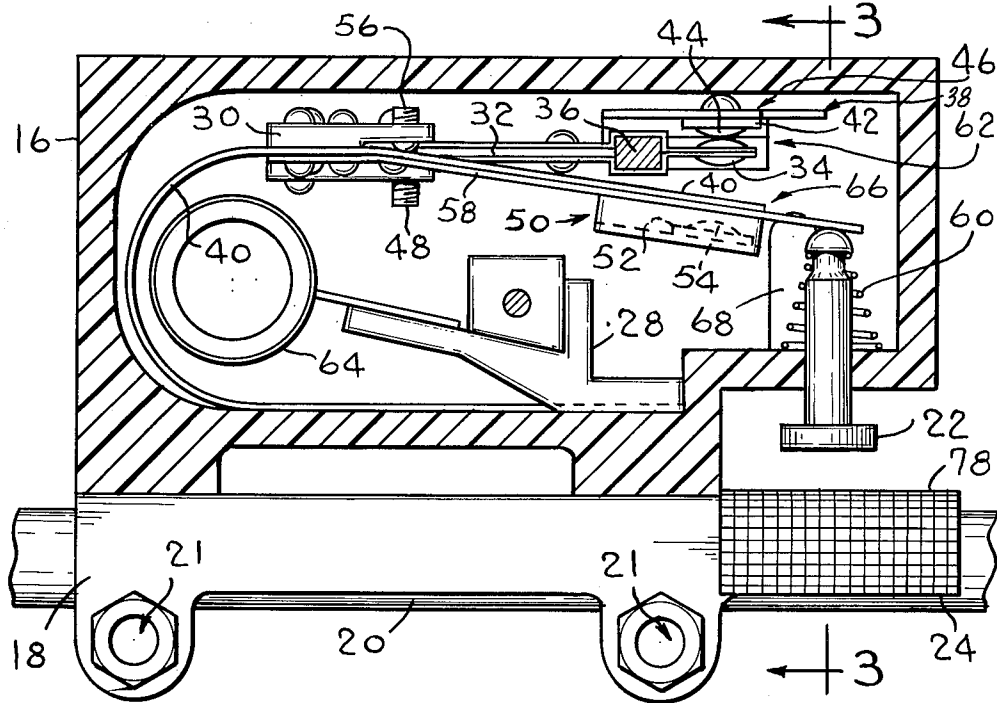


FIG. 1

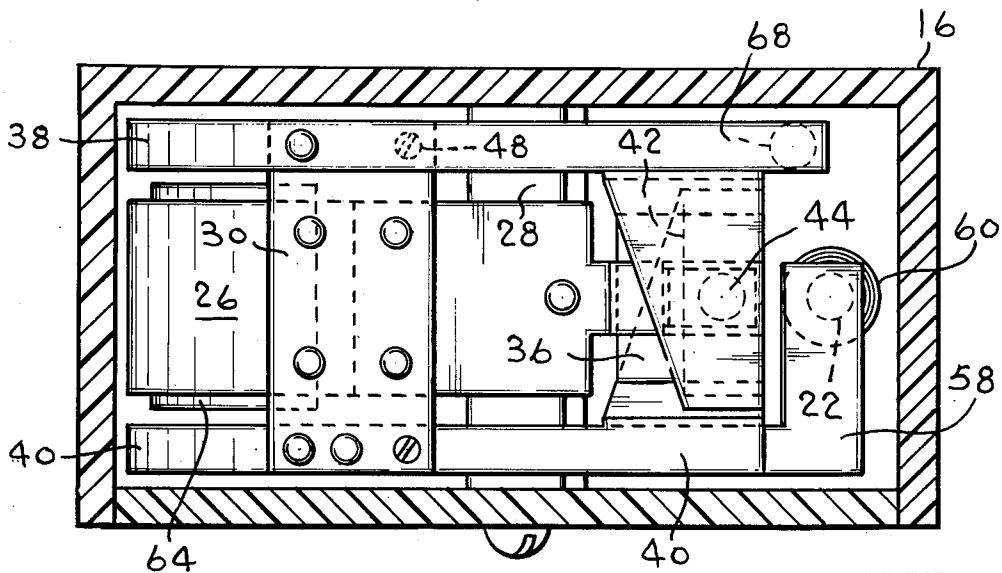


FIG. 2

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4 Sheets-Sheet 2

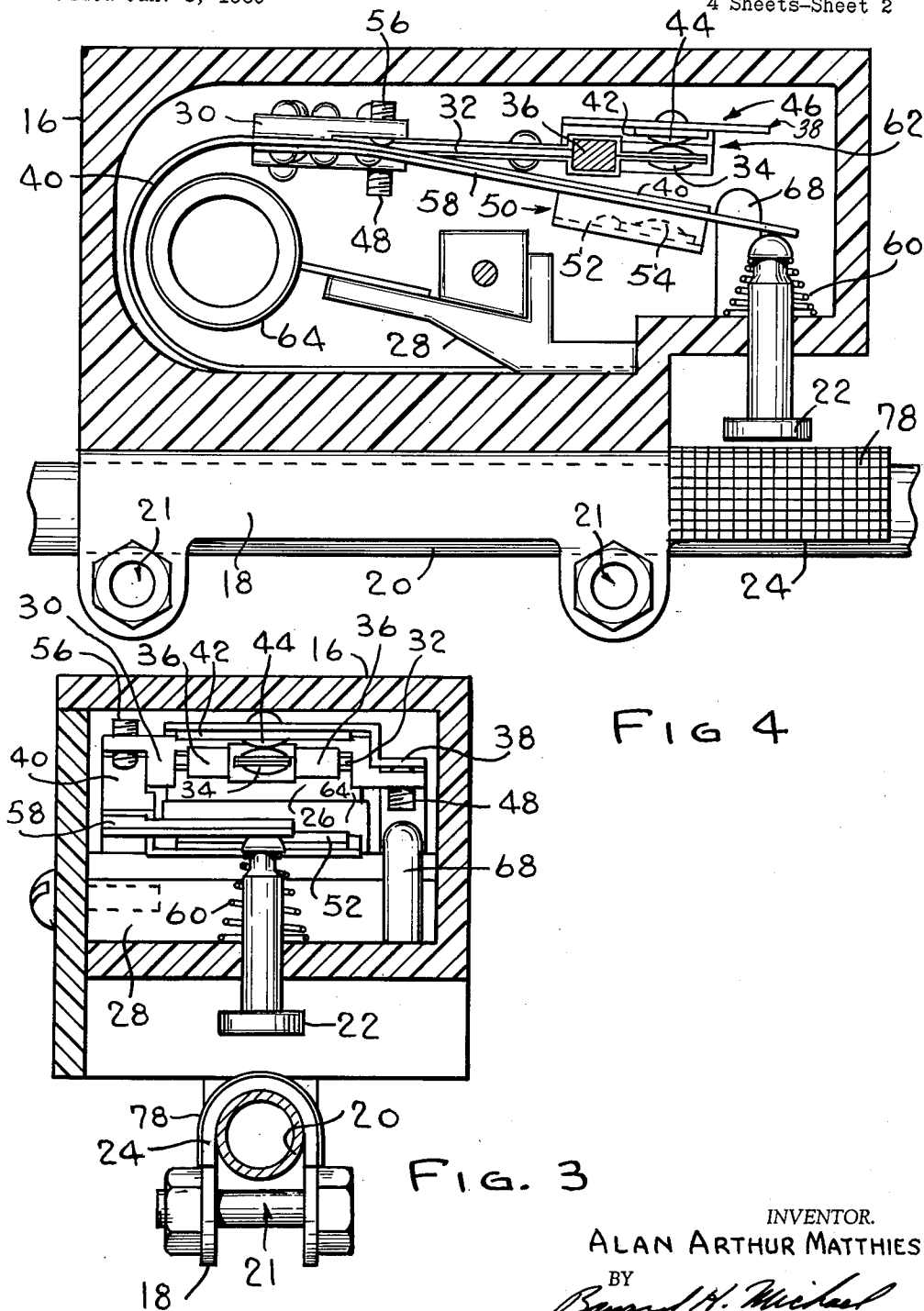


FIG 4

FIG. 3

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4 Sheets-Sheet 4

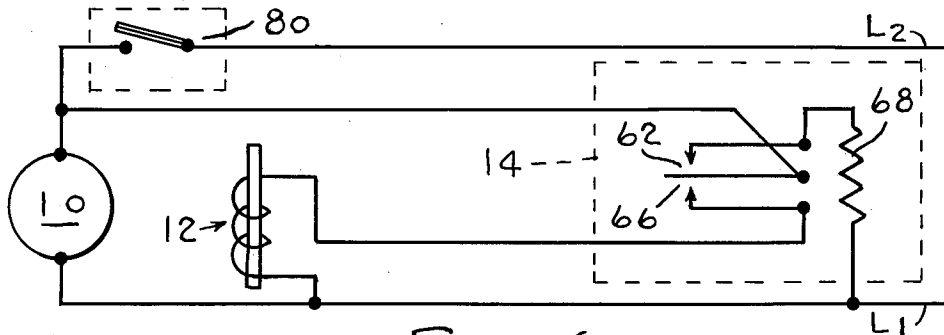


FIG. 6

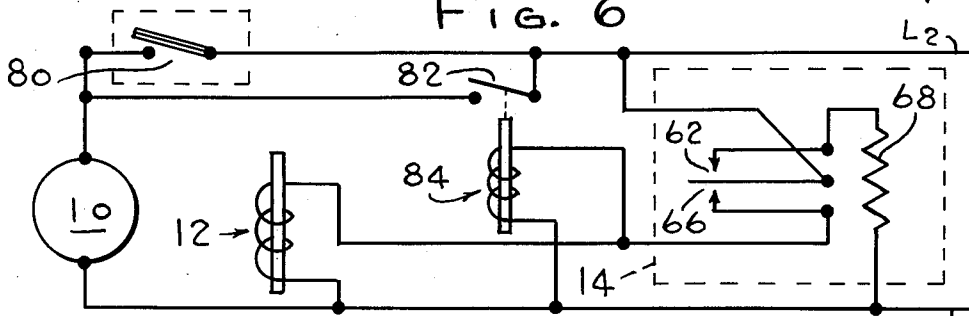


FIG. 7

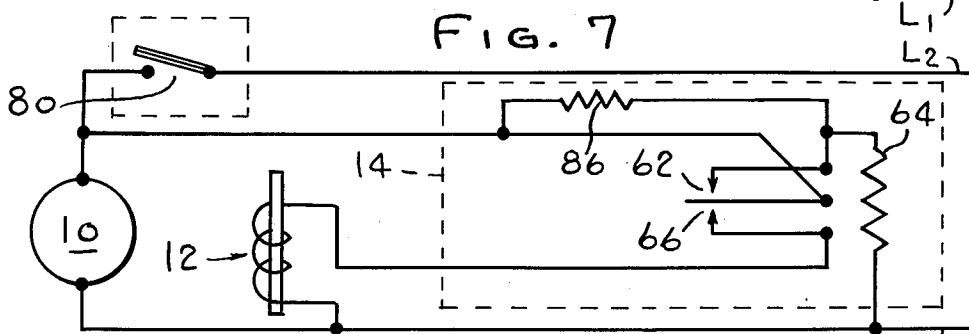
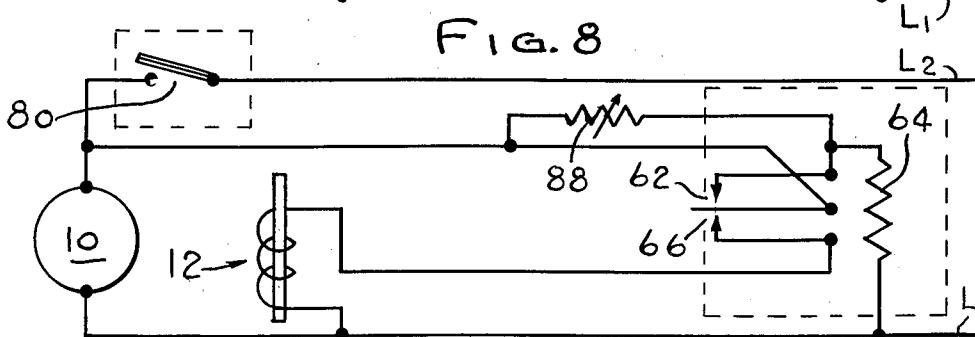


FIG. 8



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3,033,004

DEFROST CONTROL RESPONSIVE TO FROST ACCUMULATION

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Filed Jan. 8, 1960, Ser. No. 1,316

22 Claims. (Cl. 62-140)

This invention relates to refrigeration controls and particularly to devices for sensing and controlling the accumulation of frost on the refrigerating system.

It is generally recognized that an accumulation of frost on the coils of a refrigerating system is detrimental to the efficient operation and this is particularly significant in large commercial applications where economy of operation is of major importance. Defrosting is normally accomplished by preventing the compressor from starting or by changing the flow of refrigerant through the condenser and evaporator coils so as to pump hot gas through the evaporator coils to melt the frost. In so-called automatic systems defrost action is initiated periodically by counting the number of door openings or by sensing the accumulation of frost.

Where the defrost action is initiated on a time basis or on the number of door openings, the time of operation is based on the worst frost condition that is assumed will exist on the refrigerating system rather than on the actual frost condition that does exist. Where sensors have been used, an artificial condition has been created by the sensor touching the coil causing premature defrost action. Sensors which are supposed to move with the build-up of frost have been found to be inoperative since the frost merely accumulates on the sensor rather than moving the sensor.

An object of this invention is to provide a frost sensor which provides a more reliable means for determining the actual amount of frost on the refrigerating system.

The time of defrost action is of primary importance to efficient operation of the refrigerating system when it is realized that defrost action should be stopped as soon as the frost has been melted. Present systems operating on a predetermined defrost time cycle set the time of the cycle at an assumed period which it will take to melt the largest accumulation which will occur in a predetermined period of time. This assumption does not take into account the actual changes in temperature and humidity which exist throughout the country or occur in the different seasons of the year.

Another object of the invention is therefore to provide a frost sensor that relates the frequency of defrost action to the actual frost accumulation.

These objects are accomplished by continually cycling a sensing member into and out of engagement with a coil in the refrigerating system. A bimetal is used to move the sensing member by intermittently heating the bimetal to move the member to and from the coil. If the sensing member engages frost on the coil, the motion of the bimetal toward the coil is stopped and defrost action is simultaneously initiated. The time of defrost action is then based on the time for the bimetal to move away from the coil back to its starting position whereupon the defrost action is stopped. The motion of the bimetal away from the coil may be delayed to increase the defrost time to correspond to the actual amount of frost which has been sensed and to match the control to the installation. An advantage of this type system is that it provides a constant check for frost on the refrigerating system with a minimum of moving parts which are noiseless in operation.

A further object is to provide a control which senses

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a condition in addition to frost to insure a defrost cycle of proper duration to completely remove the frost. Thus, the control does not operate on assumed conditions but senses ambient temperature to prevent return to the refrigerating cycle before the ambient temperature has risen to a value insuring complete frost removal.

Other objects and advantages will be pointed out in, or be apparent from the specification and claims as will obvious modifications of the embodiments shown in the drawings in which:

FIG. 1 is a side elevation of the defrost control with part of the housing removed.

FIG. 2 is a top view of the defrost control.

FIG. 3 is taken on line 3-3 of FIG. 1 showing the bimetal in the upper position.

FIG. 4 is a side elevation showing the bimetal in the lower position.

FIG. 5 is a side elevation of a modified form of defrost control.

FIG. 6 is a circuit diagram of the defrost control in parallel with the compressor.

FIG. 7 is a modified circuit diagram of the defrost control in parallel with the compressor motor shunt relay.

FIG. 8 is a modified circuit diagram of a time delay circuit for the defrost control.

FIG. 9 is a modified circuit diagram with a variable resistor.

FIG. 10 is a modified circuit diagram of a time delay circuit in which a thermistor is connected in parallel with the defrost control.

FIGURE 6 schematically illustrates a refrigerating system of the type contemplated herein which includes a compressor motor 10, a solenoid actuated defrost device 12, such as a shut-off switch or reversing valve, and a frost sensor 14. As seen in FIGURES 1 through 4, housing 16 of the frost sensor is secured to mounting bracket 18 which is clamped on coil 20 of the refrigerating system. To maintain an accurate distance for the movement of sensing member 22, end 24 of the bracket is used as a frost accumulating surface. The bracket is clamped tightly to the coil by bolts 21 so that the same temperature conditions will exist on the bracket as are encountered on the coil.

A U-shaped bimetal 26 is secured to the bottom of the housing by support 28 and has a bridge 30 mounted on its free end. A rigid member 32 is attached at one end to the bimetal at the bridge and supports a double contact 34 and a magnet 36 at its other end. A pair of U shaped leaf springs 38, 40 are secured to the housing by support 28 and to the bimetal by bridge 30 and extend beyond the bridge. A permeable member 42 and a contact 44 are secured to the end of spring 38 to form heater switch armature 46 which is positioned to engage the magnet and double contact. Spring 38 is bent upward from the bridge by set screw 48 to bias the heater switch armature away from the magnet and double contact. Spring 40 has defrost switch armature 50 including permeable member 52 and contact 54 positioned to engage the magnet and double contact and is bent downward from the bridge by set screw 56 so that the defrost switch armature is biased away from the magnet and double contact. A flexible member 58 is secured to the bridge and extends downward from the bridge to engage sensing member 22. The flexible member underlies and supports leaf springs 40 and provides sufficient stiffness to overcome the bias of spring 60 on the sensing member.

The heater switch armature and the double contact form heater switch 62 which is connected in series with bimetal heater 64 supported adjacent the bimetal by support 28. The defrost switch armature and the double contact form defrost switch 66 which is connected in series with defrost control 12. The heater switch is held

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closed by the magnetic flux density of magnet 36 during the downward movement of the coil. The heater will be energized where the switch is closed to heat the bimetal causing it to warp downward moving the sensing member toward the coil.

If the sensing member moves toward the coil or contacts the coil without engaging a predetermined thickness of frost, the end of spring 38 will engage adjustable post 68 preventing further downward motion of the heater switch armature. The bimetal will continue to move downward until the heater switch armature is released from the field of the magnet thereby allowing the bias of spring 38 to open the heater switch and de-energize the heater. The bimetal will move away from the coil as it cools and the sensing member will follow the bimetal due to the bias of spring 60. When the bimetal approaches the end of its movement away from the coil the heater switch armature will abut the top of the housing. The bimetal will continue to move bending leaf spring 38 until the heater switch armature is attracted by the magnet and snapped against the double contact, starting a new sensing cycle.

If the sensing member, during the downward motion of the bimetal, engages a predetermined thickness of frost on the coil it will stop and flexible member 58 will prevent further movement of the defroster switch armature toward the coil. The bimetal will continue to move toward the coil until the double contact and magnet engage the defroster switch armature closing the defroster switch and initiating defrost action. Simultaneous with the initiation of defrost action the heater will be de-energized by opening the heater switch. This is accomplished by providing the magnet with sufficient flux density to hold only one switch armature at a time against the bias provided by the leaf springs. When the magnet is brought into contact with the defrost switch armature the flux density of the magnet will be divided between the two permeable portions of the switch armatures. The bias of leaf spring 38 is set so that it overcomes the force of the magnet when the flux density is divided between the armatures and will snap the heater switch open. The defrost switch armature being held from movement by flexible member 58 will be held against the magnet and the full magnetic force of the magnet will then hold the defrost switch closed. The bimetal will move away from the coil as it cools until the heater switch armature abuts the top of the housing and the bimetal catches up with it and again closes against the double contact. This time the defrost switch armature will be released from the magnet due to the division of flux density and the bias of spring 40 since the heater switch armature is now held against the housing. It can be seen that defrost action will continue until the bimetal has moved far enough to close the heater switch. The time of defrost action can then be regulated by controlling the time of return motion of the bimetal as explained hereinafter.

In FIGURE 5 a modified frost sensor is shown which is adaptable to a greater variety of installations at a small additional cost. The frost sensor shown in FIGURES 1 through 4 is changed by substituting flexible member 70 for rigid member 32 and mounting a termination bimetal 72 on the housing with pin 74 aligned with aperture 75 so that the pin can be projected through the housing into engagement with heater switch armature 46 to control the closing of the heater switch and consequently the time of defrost operation. The bimetal is cycled by closing the heater switch 62 to energize heater 64 and heat the bimetal which warps downward as previously described. The downward motion of the bimetal is stopped when heater switch armature 46 engages post 68 to open the heater switch and cool the bimetal. On the upward motion of the bimetal, the switch armature is stopped when it abuts the top of the housing. The double contact continues to move upward with the bimetal until the bimetal

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abuts pin 76, at which time the flux density of the magnet will be sufficient to close the heater switch.

When the sensing member contacts a predetermined amount of frost on the coil, the motion of the defrost switch armature will be stopped and the double contact will move with the bimetal until it contacts the defrost switch armature whereupon the heater switch armature will be released due to the division of the flux density of the magnet de-energizing the heater. As the bimetal cools and starts to move away from the coil, the flexible member 70 will bend slightly downward because the defroster switch is closed and the bias of spring 40 is strong enough to pull the double contact downward. When the bimetal reaches the top of its upward movement, bridge 30 will abut adjustable screw 76 preventing further upward movement of the bimetal. Since the double contact is mounted on the flexible member, it cannot engage the heater switch armature since it is pulled downward by the bias of spring 40 supporting the defrost switch armature. Defrost action will then continue indefinitely since the heater switch armature is not within the magnetic field of the magnet. Termination bimetal 72 is positioned to respond to the ambient temperature within the cooled space. When the temperature rises sufficiently to melt the amount of frost which has been sensed, the termination bimetal will warp downward until it engages the heater switch armature pushing it into contact with the double contact. The defrost switch armature will be released due to the division of magnetic force stopping defrost action and the bimetal will start another sensing movement.

By adjusting post 68, it is possible to set the frost sensor so that it is responsive to any thickness of frost. This adjustment can be made to sense as little as $\frac{1}{64}$ of an inch of frost.

Former plunger type sensing devices were confronted with an artificial buildup of frost at the point of contact of the sensor with the coil due to the capillary action of the moisture condensed thereon. That is, when the sensor contacts the coil or any frost thereon, any condensation which has accumulated in the area of contact is drawn toward the sensor. As the sensor moves away a small amount of water will be drawn out from the coil and will freeze into a frost bump on either the coil or sensor. Where a continuous checking system is used as disclosed herein, this can create a build up of frost which will prematurely initiate defrost action since it will prevent the full movement of the sensor. By wrapping screen 78 on the surface of the coil the moisture will be dissipated throughout the screen by the capillary action of screen and thus prevent the build up of frost at the point of contact. A Teflon plunger may be used to further reduce the possibility of a frost build up on the sensing member because of its low affinity for water. Surface finishes under 20 R.M.S. also aid in the prevention of feeler sticking.

In FIGS. 6 and 7 two circuits are shown for the refrigeration system contemplated herein. In FIG. 6 a solenoid actuated defrost device 12 such as a shut off switch or reversing valve, is electrically connected in parallel with compressor motor 10, across line voltage L1, L2, both of which are energized when compressor motor control relay 80 and defrost switch 66 are closed. Heater 64 for the frost sensor is also connected in parallel with the compressor motor so that it operates only when the relay is closed. This insures hot gas availability during defrost action, since the control will not operate when the relay is open. This limits the operation of the control to the periods when the compressor is operating and provides a simple and inexpensive arrangement and is considered the preferred electrical arrangement for the system. With the modified defrost control connected in this circuit, defrost action will be resumed after the relay is closed if shut down during defrost operation, since the heater switch cannot be closed until the ambient is high enough to actuate the termination bimetal. The second

circuit shown in FIG. 7 provides independent operation for heater 64 and compressor motor 10. The heater is connected across line voltage L1, L2 and when defrost switch 66 is closed shunt relay 82 and defrost control 12 are energized closing shunt switch 84 so that the compressor motor continues to run during defrost operation assuring hot gas availability for the full defrost period. The shunt relay is provided simply to eliminate the situation where defrost operation would be initiated at the end of compressor motor operation so that the compressor motor continues to operate until the defrost switch is opened. On a hot gas system this provides continued flow of hot gas during the defrost operation. In FIGS. 8 through 10 circuits are shown which can be used to lengthen the time of return motion of the bimetal to increase the time of defrost operation by adding resistance elements to the bimetal heater circuit. In FIG. 8 fixed resistance 86 is connected in series with bimetal heater 64 and in parallel with heater switch 62. When the heater switch is closed, the fixed resistance is shunted thus producing normal bimetal heating. However, when the heater switch is open and bimetal cooling occurs, the heater will be in parallel with the compressor motor and a slight amount of heat release will occur in the heater due to the still remaining closed circuit provided by the additional control resistance. This release of heat will retard the cooling of the bimetal and increase the time of defrost operation and could be calibrated to give a desired cooling time in some specific defrost control ambient. In FIG. 9 the circuit is similar to the above circuit except that variable control resistance 88 is externally connected in series with the heater. This latter innovation permits the user to vary the defrost time to his particular application.

In FIGURE 10 a circuit similar to the above circuits is shown with fixed resistance 86 connected to shunt heater switch 62 and including thermistor 90 which is connected in parallel with the bimetal heater. The thermistor, if located so that it is responsive to the external control ambient will provide a temperature compensating electrical shunt across the bimetal heater. This would tend to regulate or control the amount of current through the heater during the off or cooling cycle in relation to the external ambient resulting in a far more consistent cooling cycle time or defrost time.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

I claim:

1. A defrost control for a refrigerating system comprising, a sensing member to indicate the presence of frost on the refrigerating system, bimetal means operatively engaging the sensing member, a heater for actuating the bimetal to reciprocally move the sensing member, switch means actuated by the movement of the bimetal to energize and de-energize the heater, and means for initiating defrost action when the sensing member engages a predetermined thickness of frost on the refrigerating system.

2. A defrost control for a refrigerating system comprising, a bimetal moveable through a predetermined path, a heater to heat the bimetal to move through the path, switch means actuated by the bimetal at each end of the path to control the energizing and de-energizing of the heater, sensing means operatively connected to the bimetal and moveable therewith to sense the presence of frost on the refrigerating system, and means actuated by the bimetal for initiating defrost action when the sensing means engages an accumulation of frost.

3. A defrost control for a refrigerating system comprising, a bimetal moveable over a predetermined path, means for heating the bimetal, first switch means operably

connected to the heating means and actuated by the bimetal, said switch means being closed by the movement of the bimetal at one end of the path to energize the heating means and opened at the other end of the path to de-energize the heating means so the bimetal continually cycles over the path, sensing means moveable with the bimetal to sense the presence of frost on the refrigerating system, and defroster switch means actuated by the bimetal when frost is encountered by the sensing means on the refrigerating system to initiate defrost action.

4. A defrost control for a refrigerating system comprising a plunger type sensor positioned to engage a coil in the refrigerating system, a bimetal operatively connected to the sensor, means for actuating the bimetal to reciprocally move the sensor into and out of engagement with the coil, switch means closed by the motion of the bimetal away from the coil to energize the actuating means and opened by the motion of the bimetal toward the coil to de-energize the actuating means, defrost switch means closed by the bimetal when the sensor engages an accumulation of frost on the refrigerating system to initiate defrost action, said defrost switch means being opened when the first switch means is closed.

5. A defrost control for a refrigerating system comprising, a sensor, a frost accumulating surface, a bimetal operatively engaging the sensor, means for continuously cycling the bimetal over a predetermined path to move the sensor into and out of engagement with the surface, switch means operative to reverse the movement of the bimetal when the sensor engages an accumulation of frost on the surface and to initiate defrost action, said switch means rendered inoperative when the bimetal motion is again reversed.

6. A defrost control for a refrigerating system having frost accumulating surfaces comprising, a sensor positioned to engage the surface, means for moving the sensor toward and away from the frost accumulation surface, said moving means including a bimetal, first switch means operated by the bimetal to actuate the moving means, magnetic means holding the switch means closed during the movement of the bimetal toward the surface, means for opening the switch means in the absence of any frost on the surface, and defrost switch means closed by the sensor upon contacting a predetermined thickness of frost on the surface.

7. A defrost control according to claim 6 wherein closing of the defrost switch means releases the first switch means from the magnetic means to stop the movement of the sensor toward the frost accumulating surface.

8. A defrost control for a refrigerating system including a compressor and a defrosting device, comprising, a housing, a bimetal secured to the housing, a bimetal heater mounted within the housing, means for intermittently energizing the heater to cycle the bimetal through a prescribed path, said energizing means including a heater switch armature moveable with the bimetal, a member secured to the moveable end of the bimetal and supporting a common contact and a magnet, said heater switch armature engaging the common contact to energize the heater and held closed by the magnet during movement through part of the cycle, means for releasing the heater switch armature from the influence of the magnet at the end of the movement through said part of the cycle to thereby disengage the heater switch armature from the common contact and de-energize the heater so the bimetal moves through the other part of the cycle, sensing means moveable with the bimetal to determine the presence of frost, said releasing means including a stationary post, and a defroster switch closed when the sensor engages a predetermined thickness of frost in the refrigerator to initiate a defrosting action.

9. A defrost control for a refrigerating system comprising, means for sensing the presence of frost in the

refrigerator, means for reciprocating the sensing means including a bimetal and a heater, said heater being intermittently energized by the motion of the bimetal, means for initiating defrost action and de-energizing the heater when the sensor engages a predetermined amount of frost to reverse the motion of the reciprocating means, and means for delaying the return motion of the reciprocating means to prolong defrost action.

10. A defrost control according to claim 9 wherein the delaying means includes a fixed resistance connected to the heater.

11. A defrost control according to claim 9 wherein the delaying means includes a variable resistance connected to the heater.

12. A defrost control according to claim 9 wherein the delaying means includes a thermistor connected to the heater.

13. A defrost control according to claim 9 wherein the delaying means includes a second bimetal responsive to ambient temperature to re-energize the heater and stop defrost action.

14. A defrost control for a refrigerating system comprising, a frost accumulating surface, a housing mounted adjacent the surface, a sensor mounted in the housing and moveable into engagement with the surface, a bimetal having one end secured to the housing and the other end operatively engaging the sensor, a bimetal heater mounted within the housing to heat the bimetal so that the bimetal moves the sensor toward the surface, means for intermittently energizing the heater to cycle the bimetal and sensor toward and away from the surface, means for interrupting the motion of the bimetal toward the surface when the sensor engages a predetermined amount of frost on the surface, said interrupting means including means for initiating defrosting action within the refrigerating system.

15. A defrost control according to claim 14 wherein the intermittently energizing means includes a magnet, a switch contact and a heater switch armature biased away from the magnet, said heater switch armature engaging the housing when the bimetal moves away from the surface to allow the switch contact to engage the heater switch armature, said magnet having sufficient flux density to hold the heater switch armature against the switch contact during the motion of the bimetal toward the surface thereby energizing the heater, and a stationary post to disengage the heater switch armature from the magnet and switch contact when the sensor reaches a predetermined proximity to the surface.

16. A defrost control according to claim 15 wherein the interrupting means includes a defroster switch armature biased away from the magnet and operatively engaging the sensor whereby the defroster switch armature is brought into engagement with the magnet and the switch contact when the sensor is prevented from moving due to the presence of an accumulation of frost.

17. A defrost control for a refrigerator comprising, means for sensing the presence of frost in a refrigerator, means for reciprocally actuating the sensing means including a first bimetal and a heater, means for intermittently energizing the heater to continuously reciprocate the sensing means, said energizing means including a flexible member connected to the bimetal and supporting a common contact and a magnet, a heater switch armature being moveable with the bimetal and biased away from the common contact, said magnet having only sufficient magnetic flux density to overcome the bias of the heater switch armature, means for holding the heater switch armature so the common contact moves into engagement therewith on the return motion of the bimetal to energize the heater, the magnet holding the heater switch armature in contact with the switch contact during the sensing motion of the bimetal, means for

interrupting the sensing motion of the bimetal when the sensing means engages a predetermined accumulation of frost to initiate defrosting action, said interrupting means including a defrost switch armature moveable with the bimetal and biased away therefrom and operatively engaging the sensor so the switch contact moves into engagement with the defrost switch armature and the magnet, the heater switch armature disengaging the switch contact due to the reduction in magnetic flux density of the magnet and thereby de-energizing the heater and reversing the motion of the bimetal, the defrost action continuing during return motion of the bimetal, and means for prolonging the defrost action, said prolonging means including means for preventing the return motion of the bimetal, the flexible member supporting the switch contact being bent away from the heater switch armature due to the bias of the defrost switch armature, and a termination bimetal operatively engaging the heater switch armature and being responsive to ambient temperature to move the heater switch armature into engagement with the switch contact thereby releasing the defrost switch armature and stopping defrost action.

18. A defrost control for a refrigerating system having frost accumulating surfaces comprising a sensor positioned to engage the surface, means for moving the sensor toward and away from the surface, first switch means mounted on the moving means, magnetic means holding the first switch means closed during the movement of the sensor toward the surface, means for opening the first switch means if the sensor engages the surface, and second switch means mounted on the moving means, said second switch being closed by the sensor when frost is engaged on the surface and being held closed by the magnetic means during movement away from the surface.

19. A defrost control according to claim 18, wherein closing of the second switch means releases the first switch means from the magnetic means.

20. A defrost control for a refrigerating system comprising, a sensing member to indicate the presence of frost on the refrigerating system, bimetal means operatively engaging the sensing member, a heater for actuating the bimetal to move the sensing member, switch means to energize and de-energize the heater, and means for initiating defrost action when the sensing member engages a predetermined thickness of frost on the refrigerating system.

21. A frost sensor comprising, a frost accumulating surface, a sensor movable toward the surface to sense the frost and from the surface to allow frost build-up, electrically energized heat motor means for moving the sensor in one direction, switch means operated upon completion of the sensing motion of said sensor to change the state of electrical energization of the moving means, whereby the direction of the sensor motion is changed, a defrost circuit including second switch means closed in response to engagement of the sensor with a predetermined thickness of frost on said surface.

22. A frost sensor according to claim 21 including means responsive to ambient temperature for opening the second switch to terminate defrost action.

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