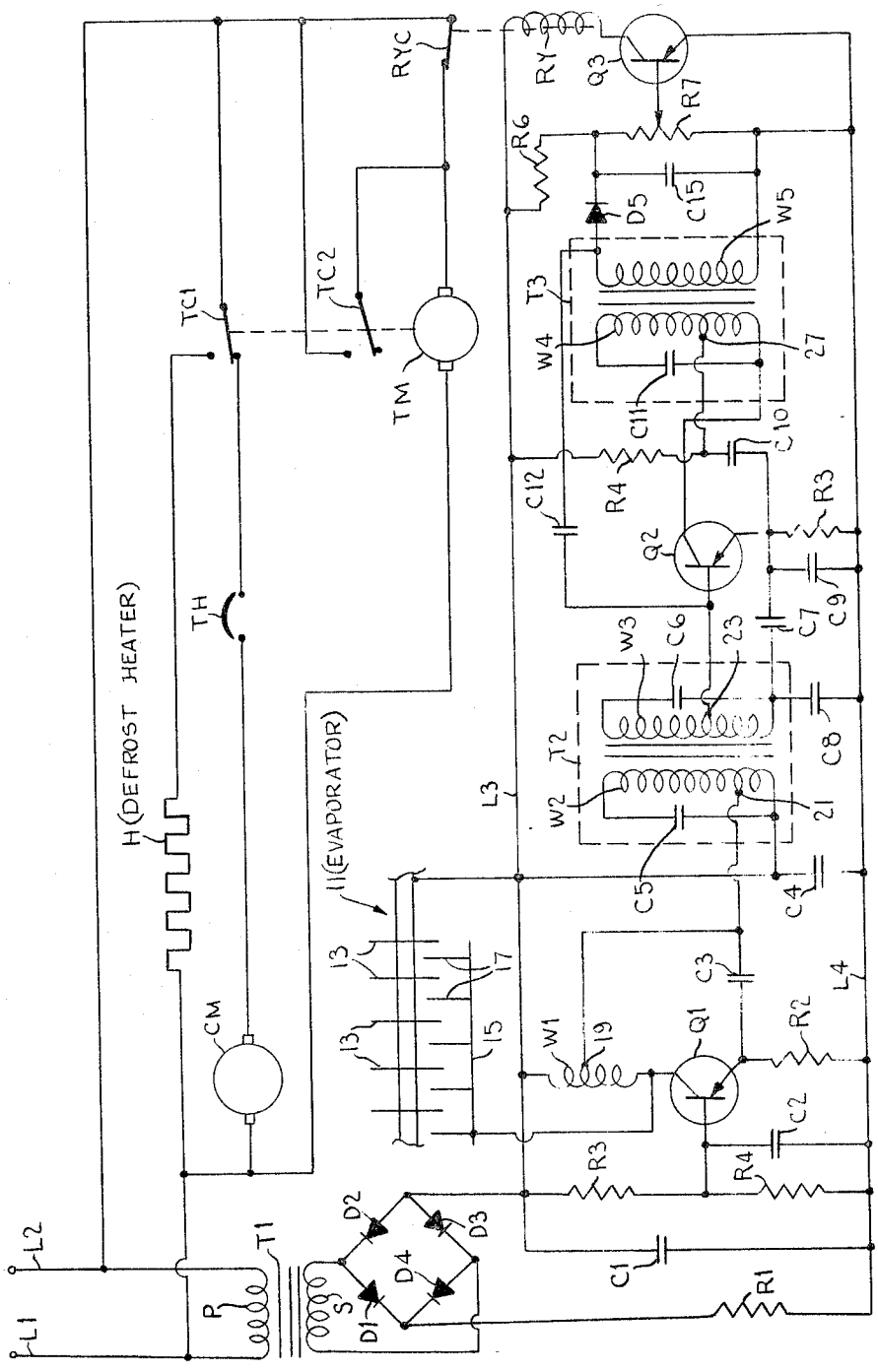
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DEFROSTER CONTROL FOR REFRIGERATION APPARATUS

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DEFROSTER CONTROL FOR REFRIGERATION APPARATUS

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This invention relates to controls for refrigeration apparatus and more particularly to methods and apparatus for sensing and controlling frost buildup in refrigeration apparatus.

In typical refrigeration system installations, frost must be periodically removed from the evaporator or other cooling element employed to absorb heat from the refrigerated zone. Various arrangements have been heretofore devised to initiate a defrosting operation. For example, timers have been employed to provide a defrost operation after the passage of a preselected time interval and counters have been used on refrigerators to initiate defrosting after the door has been opened a preselected number of times. However, it is highly desirable for reasons of efficiency and for obtaining a close control that the buildup of frost be sensed directly rather than indirectly and that the defrosting operation be initiated in response to the actual buildup of frost beyond a preselected level.

Among the several objects of this invention may be noted the provision of an electronic control for controlling the buildup of frost in refrigeration apparatus; the provision of such a control which senses the actual frost buildup on a cooling element; the provision of such a control which responds to the buildup of frost beyond a preselected level for initiating a defrosting operation for removing the buildup; the provision of such a control which is efficient and reliable; and the provision of a novel method of sensing the buildup of frost on a cooling element. Other objects and features will be in part apparent and in part pointed out hereinafter.

In one aspect of the invention the control includes an electrode adapted to be positioned adjacent and spaced from a cooling means to constitute therewith a capacitor. The capacitance exhibited between the electrode and the cooling means will depend upon the dielectric constant of any material within the space between the electrode means and the cooling means and will thus vary with the buildup of frost on the cooling means. An A.C. current is applied to the capacitor, e.g., by an oscillator, to provide an A.C. signal which varies with frost buildup. There are also provided means, responsive to these variations in the A.C. signal, for initiating a defrosting operation. Thus, when frost builds up on the cooling means beyond a preselected level, the defrost means is automatically energized to remove the frost.

The invention accordingly comprises the apparatus and methods hereinafter described, the scope of the invention being indicated in the following claims.

In the accompanying drawing in which one of various possible embodiments of the invention is illustrated, there is shown a schematic circuit diagram of a control for automatic defrosting in cooperation with the diagrammatically illustrated components of a conventional refrigeration apparatus.

Referring now to the drawing, electric power is supplied to the apparatus therein illustrated through a pair of conductors L1 and L2 which are connected to a conventional 117 volt A.C. source (not shown). A compressor motor CM, which constitutes one of the components of a conventional refrigeration apparatus to which the present control is applied, is connected across lines L1, L2 through a circuit which includes a conventional thermostat TH and the normally closed side of a set of timer contacts TC1. Compressor motor CM pumps an appropriate refrigerant through a refrigeration cycle including passage through an evaporator 11. Evaporator 11 is provided with a plurality of side-by-side heat exchange plates 13 which aid the evaporator in absorbing heat from a refrigerated zone. Thermostat TH is positioned within the refrigerated zone and energizes compressor motor CM whenever the temperature within the zone rises above a preselected level. Accordingly, when power is available to the compressor motor circuit through contacts TC1, the temperature within the zone is maintained substantially at the preselected level within the inherent temperature differential provided by thermostat TH.

In typical installations, evaporator 11 with its associated heat exchange plates 13 will be subject to frost buildup and it will be necessary to periodically remove this frost so that the heat exchange efficiency of the evaporator is not seriously impaired thereby. For this purpose, the refrigeration apparatus is provided with a heater H which when energized removes frost from the evaporator. Heater H is connected for energization to lines L1 and L2 by a circuit which includes the normally open side of contacts TC1 so that either, but not both, of heater H and compressor motor CM may be energized at one time.

Contacts TC1 are operated by a timer motor TM which also operates a set of single-pole, normally open contacts TC2. Timer motor can be energized from the lines L1 and L2 either through contacts TC2 or through a set of relay contacts RYC. Contacts RYC are operated by a relay coil RY and are closed when the relay coil is not energized. However, by control means described hereinafter, coil RY is energized and contacts RYC are held open during normal cooling operation, that is, between defrosting operations.

To initiate a defrosting operation, the contacts RYC are closed to start timer motor TM. Timer motor TM operates contacts TC1 so that power is removed from the compressor motor circuit and is applied to heater H for a preselected interval sufficient to defrost evaporator 11. Simultaneously with the operation of contacts TC1, contacts TC2 are operated to establish a holding circuit for the timer motor TM so that the heater H will be energized for the preselected interval even though contacts RYC are opened in the meantime. At the end of the timed interval, the contacts TC1 and TC2 revert to their positions shown in the drawing so that power is restored to the compressor motor circuit and the timer motor holding circuit is broken. Thus, assuming that contacts RYC are then open, the apparatus returns to normal cooling operation under the control of thermostat TH. It can thus be seen that closing contacts RYC initiates a complete defrosting operation.

The control which initiates the defrosting operation includes semiconductor circuitry. Low voltage power appropriate for such circuitry is obtained from the line L1 and L2 through a stepdown transformer T1 having a primary winding P which is connected across lines L1 and L2 and a low voltage secondary winding S. The low voltage A.C. power provided by winding S is rectified in a full wave bridge circuit including diodes D1—D4. The pulsating D.C. thereby obtained is filtered by resistor R1 and capacitor C1 to obtain substantially pure D.C. between a pair of lines L3 and L4.

Positioned adjacent evaporator 11 is an electrode 15 which includes a plurality of plates 17 interleaved with the heat exchange plates 13 of evaporator 11 to constitute therewith a capacitor. The capacitance of this capacitor will vary with the quantity and dielectric constant of any material interposed between evaporator 11 and electrode

15, e.g., frost. Evaporator 11 is connected to line L3 and electrode 15 is connected to the collector of a transistor Q1. Transistor Q1 is connected in a Hartley oscillator circuit for applying high frequency alternating current to the capacitor constituted by evaporator 11 and electrode 15. The collector terminal of transistor Q1 is also connected to line L3 through an inductor winding W1 having an intermediate tap 19. The effective capacitance between electrode 15 and evaporator 11 and the winding W1 are thus connected in parallel thereby constituting a resonant tank circuit.

The emitter terminal of transistor Q1 is connected to line L4 through a current limiting resistor R2. A forward bias is applied to the base of transistor Q1 by a voltage divider constituted by a pair of resistors R3 and R4 and connected across lines L3 and L4. A.C. currents are shunted from the base terminal of transistor Q1 by a capacitor C2.

Regeneration, sufficient to provide oscillation in the transistor Q1 circuit, is provided by a capacitor C3 which connects the tap 19 of winding W1 to the emitter. As will be understood by those skilled in the art, the frequency of oscillation will be determined by the resonant frequency of the oscillator tank circuit and hence the frequency will also depend upon and vary with the capacitance between electrode 15 and evaporator 11.

An A.C. signal is taken from the tuned oscillator circuit by means of the tap 19 and is applied to a tap 21 on the primary winding W2 of a double-tuned transformer T2. One end of winding W2 is connected to line L3, high frequency signals at this point being shunted between lines L3 and L4 by a capacitor C4. Transformer T2 may, for example, be a readily available I.F. transformer and, as illustrated, also comprises a secondary winding W3 having an intermediate output tap 23. Windings W2 and W3 are separately resonated to the same frequency by capacitors C5 and C6 respectively. A.C. signals passed by transformer T2 are applied to the base-emitter circuit of a transistor Q2 by direct connection of tap 23 to the base and connection of the lower end of winding W3, through a capacitor C7, to the emitter. The lower end of winding W3 and the emitter of transistor Q2 are separately by-passed for A.C. signals by capacitors C8 and C9 respectively. The emitter of transistor Q2 is also connected to line L4 through a current limiting resistor R3.

The emitter-collector circuit of transistor Q2 is coupled to the primary winding W4 of an output transformer T3 by means of direct connection of the collector to one end of winding W4 and connection of the emitter, through a D.C. blocking capacitor C10, to an intermediate tap 27 on winding W4. A resistor R4 connects tap 27 to line L3 for providing direct current to the collector of transistor Q2. Primary winding W4 of transformer T3 is resonated to the same frequency as transformer T2 by a capacitor C11. Transformer T3 also includes a secondary winding W5 one end of which is connected to line L4. A capacitor C12 connecting the other end of secondary winding W5 to the base terminal of transistor Q2 provides regeneration which increases the gain of transistor Q2 for signals of the selected frequency. As will be understood by those skilled in the art, the transformers T2 and T3 and the transistor Q2 circuitry constitute a tuned or frequency selective amplifier which will greatly amplify signals of a frequency within its bandpass but which will substantially reject or discriminate against signals outside the bandpass.

A transistor Q3 is operated as a direct current amplifier to selectively energize relay coil RY. The emitter of transistor Q3 is connected directly to line L4 and the collector terminal is connected, through coil RY, to line L3. A fixed resistor R6 and a potentiometer R7 are connected in series across lines L3 and L4. The movable tap of potentiometer R7 is connected to the base of transistor Q3 to normally forward bias the transistor into conduction thereby energizing relay coil RY to hold open contacts RYC. The amount of bias can be varied by adjusting potentiometer R7.

Amplified A.C. signals passed by the frequency selective amplifier to output winding W5 are rectified by a diode D5 and filtered by a capacitor C15. The direct current thereby obtained is applied across the potentiometer R7 in opposition to the bias current normally flowing from the lines L3 and L4 through resistor R6. Accordingly, the state of conduction of transistor Q3 will depend upon the relative magnitudes of the normal bias current and the amplified D.C. signals passed by the frequency selective amplifier.

The operation of this control is as follows, it being assumed initially that the evaporator 13 is free from frost. The value of inductor winding W1 is chosen or adjusted so that the characteristic frequency of the tuned circuit which includes the capacitance between electrode 15 and evaporator 11 is substantially above the bandpass frequency of the frequency selective amplifier which includes transistor Q2. As will be understood from the following explanation, the difference between the frequency of oscillation and the amplifier bandpass frequency determines the amount of frost which must accumulate before a defrosting operation is initiated. Being of a frequency outside the amplifier bandpass, the A.C. signal provided by the oscillator will not be substantially amplified and thus there will be insufficient signal strength at the output of the frequency selective amplifier to overcome the normal forward bias applied to transistor Q3. Accordingly, coil RY is energized and contacts RYC are held open. This is the normal or cooling mode of operation and under these conditions, the compressor motor has A.C. power available to it through the normally closed side of contacts TC1 and will be operated under the sole control of the thermostat TH so as to maintain the temperature in the refrigerated zone at a predetermined level as explained previously.

However, as frost builds up on the evaporator 11, the capacitance exhibited between the electrode 15 and evaporator 11 will increase due to the presence of the frost which has a substantially higher dielectric constant than air. As this capacitance increases, the characteristic frequency of the tuned circuit and of the A.C. output signal will decrease and approach the bandpass of the frequency selective amplifier.

As the frequency of the A.C. provided by the oscillator comes within the bandpass of the amplifier, the amplitude of the A.C. output signal provided at secondary winding W5 will increase sharply and diode D5 will then provide a sufficient direct current flow through potentiometer R7 to reverse bias transistor Q3 and thereby deenergize relay coil RY.

The deenergization of coil RY permits contacts RYC to close thereby applying power to timer motor TM and initiating a timed defrosting operation as described previously. The timed interval over which heater H is energized is chosen to provide a sufficient period of operation for the heater H to completely remove that accumulation of frost which is sufficient to initiate operation of the defrost control. Thus, in typical operation, the frost will be melted and the coil RY will be reenergized before the end of the timer cycle. Accordingly, when the cycle ends, the contacts RYC will already be open so that power will be restored to the compressor motor circuit and operation of the compressor under control of the thermostat TH will be resumed.

It will be noted that the defrost heater H will not be again energized until sufficient frost has accumulated on the evaporator 11 to bring the characteristic frequency of the oscillator within the bandpass of the frequency selective amplifier. Thus, if conditions are such that frost accumulates slowly, the heater will be energized infrequently whereas, if conditions should become such that frost accumulates rapidly, the heater will be energized as

frequently as is needed to keep the accumulation of frost below that level preselected for initiating operation of the control circuitry. The level of frost accumulation which is tolerated before a defrosting operation is initiated, can be conveniently and easily adjusted by varying the difference in frequency between the bandpass of the frequency selective amplifier and the characteristic frequency of the tuned oscillator circuit in the absence of frost buildup.

While a particular oscillator has been shown for applying alternating current to the capacitor constituted by the electrode 15 and evaporator 11, it will be apparent to those skilled in the art that other types of oscillators or other sources of A.C. may be employed or that current of the supply line or other fixed frequency could be applied to produce an A.C. signal the magnitude of which varies with frost buildup. Various other means of detecting the changes in the A.C. signal may also be used and different means of executing and initiating the defrost cycle may be employed. For example, if a relay is used at all, it may be normally deenergized rather than energized.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above apparatus and methods without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A control for refrigeration apparatus having cooling means for absorbing heat from a refrigerated zone, said cooling means being subject to frost buildup, and defrost means adapted when energized to remove frost from said cooling means, said control comprising:

electrode means adapted to be positioned adjacent said cooling means to constitute therewith a capacitor having a capacitance which varies with frost buildup;

means interconnected with said capacitor and forming therewith a tuned circuit;

an oscillator circuit incorporating said tuned circuit for providing an A.C. signal the frequency of which is controlled by said tuned circuit and varies with frost buildup; and

means, responsive to such variations in said A.C. signal beyond a preselected limit, for energizing said defrost means whereby, when frost builds up on said cooling means beyond a preselected level, said defrost means is automatically energized to remove the frost.

2. A control as set forth in claim 1 in which the means for energizing said defrost means includes frequency responsive means for discriminating between signals of different frequencies.

3. A control as set forth in claim 1 in which said means for energizing said defrost means includes a relay and a frequency selective amplifier for operating said relay when said A.C. signal reaches a preselected frequency.

4. A control as set forth in claim 3 including means responsive to the operation of said relay for energizing said defrost means for a preselected interval.

5. A control for refrigeration apparatus having cooling means for absorbing heat from a refrigerated zone, said cooling means being subject to frost buildup, and defrost means adapted when energized to remove frost from said cooling means, said control comprising:

electrode means adapted to be positioned adjacent said cooling means to constitute therewith a capacitor having a capacitance which varies with frost buildup;

an oscillator for applying a high frequency alternating current to said capacitor thereby to provide an A.C. signal the frequency of which varies with frost buildup;

a frequency selective amplifier for amplifying said A.C. signal when said signal reaches a preselected frequency; and

means, connected to said amplifier and responsive to an amplified A.C. signal of magnitude greater than a preselected level, for energizing said defrost means whereby, when frost builds up on said cooling means beyond a preselected level, said defrost means is automatically energized to remove the frost.

6. A control as set forth in claim 5 in which said means for energizing said defrost means includes:

a D.C. relay;

a D.C. amplifier; and

means for rectifying the amplified A.C. signal provided by said frequency selective amplifier for biasing said D.C. amplifier to operate said relay.

7. Refrigeration apparatus comprising:

cooling means far absorbing heat from a refrigerated zone, said cooling means being subject to frost buildup;

defrost means adapted when energized to remove frost from said cooling means;

electrode means positioned adjacent said cooling means and constituting therewith a capacitor having a capacitance which varies with frost buildup;

means interconnected with said capacitor and forming therewith a tuned circuit;

an oscillator circuit incorporating said tuned circuit for providing an A.C. signal the frequency of which is controlled by said tuned circuit and varies with frost buildup; and

means, responsive to such variations in said A.C. signal beyond a preselected limit, for energizing said defrost means whereby, when frost builds up on said cooling means beyond a preselected level, said defrost means is automatically energized to remove the frost.

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