

[54] REFRIGERATOR CONTROL APPARATUS	2,812,642	11/1957	Jacobs	62/155
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[52] U.S. Cl. 62/80; 62/155; 62/158; 62/186

[51] Int. Cl.² F25D 21/00

[58] Field of Search 62/80, 155, 158, 186

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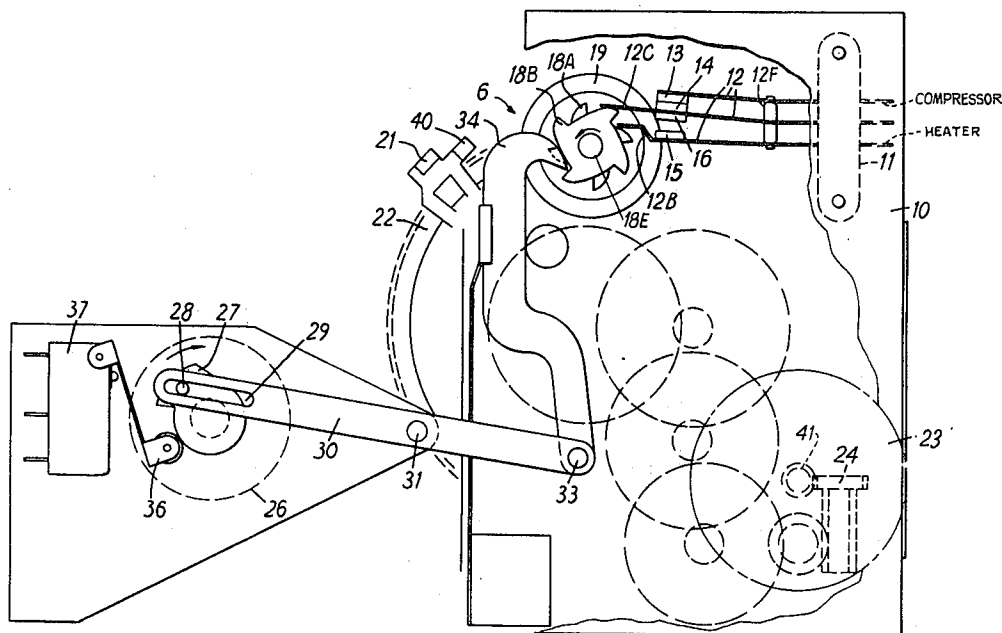
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[57]

ABSTRACT

Apparatus for automatic defrosting of refrigerators in which defrosting is commenced on a predetermined time basis and return to refrigeration is initiated on reaching a predetermined temperature. The highest desired defrosting temperature is sensed and circuit means responds thereto to disconnect the defrosting heater and start the compressor. The fan is started after a desired refrigeration temperature is reached.

15 Claims, 10 Drawing Figures



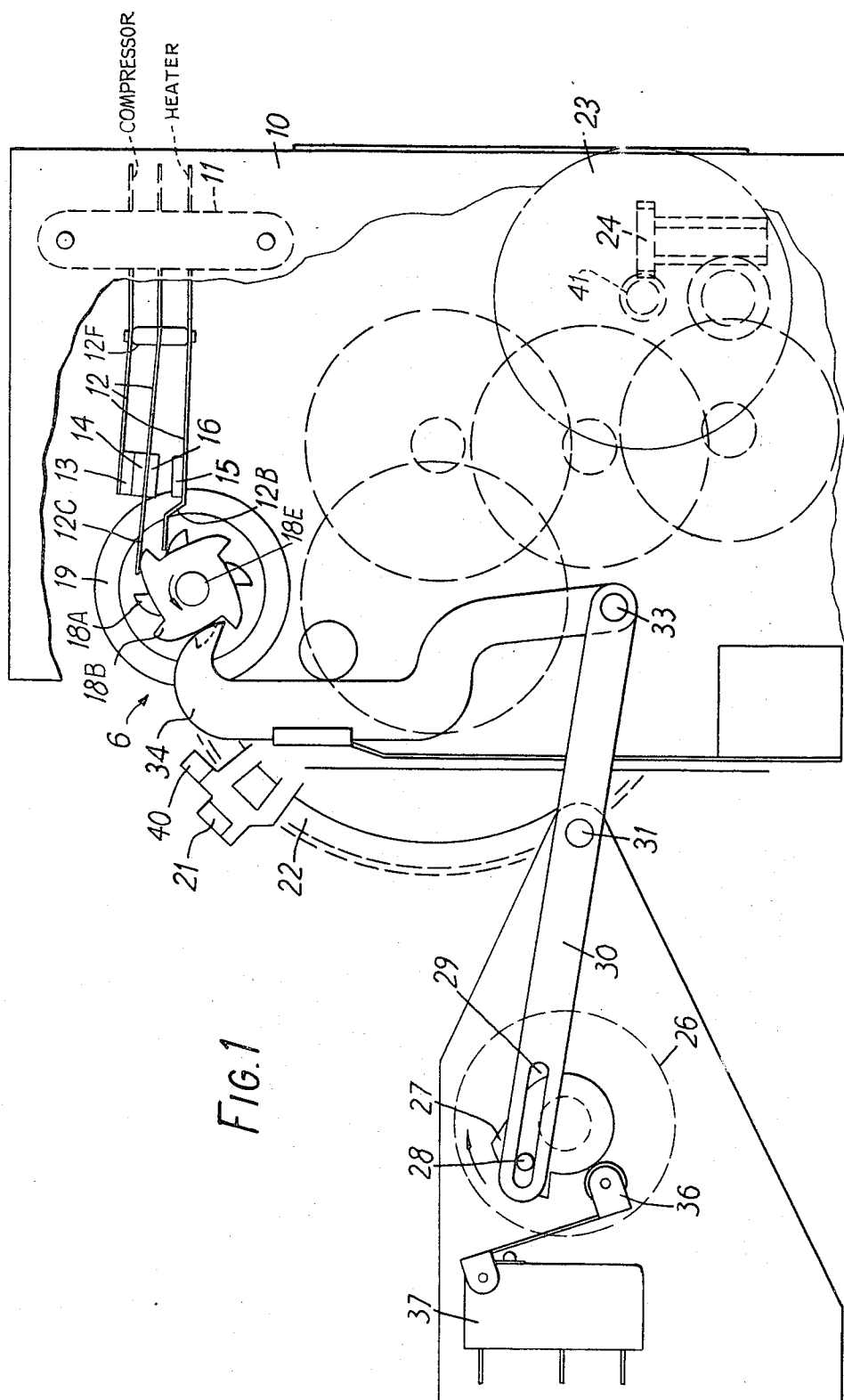


FIG. 2

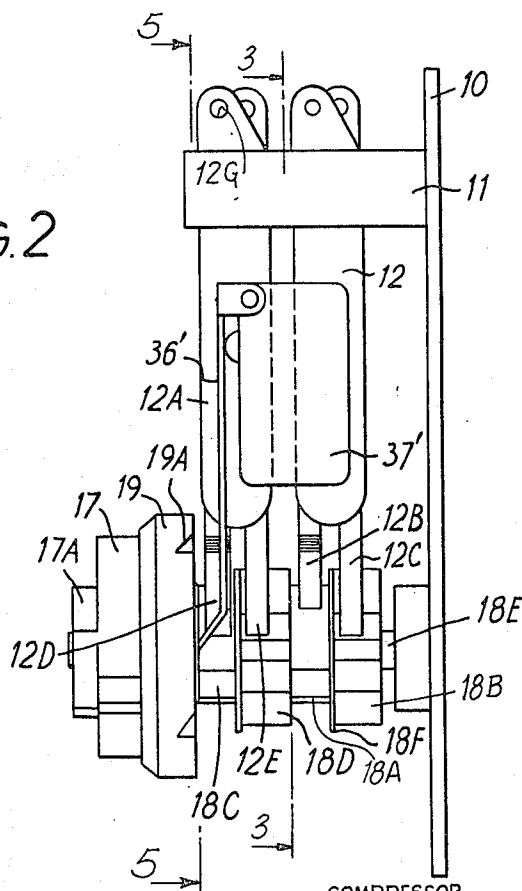
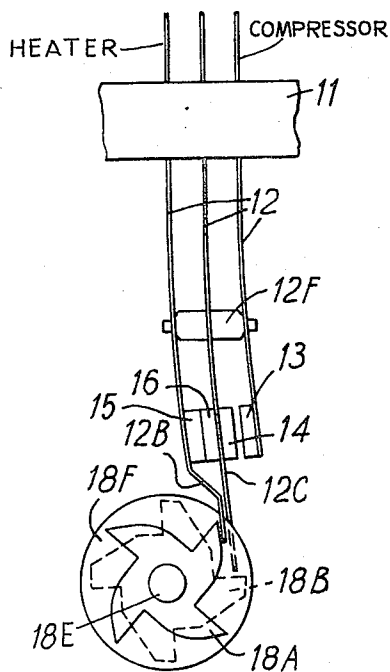
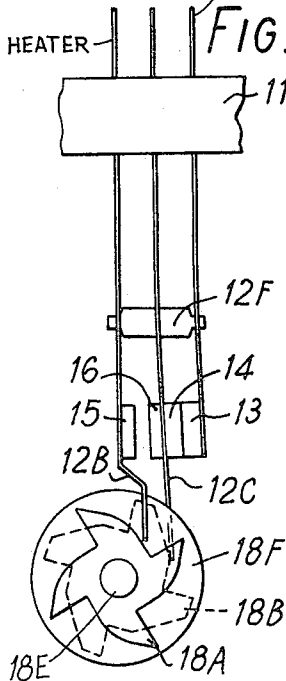


FIG. 3



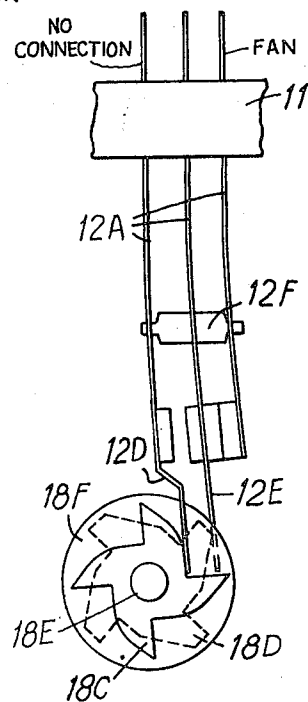
COMPRESSOR

FIG. 4



NO CONNECTION

FIG. 5



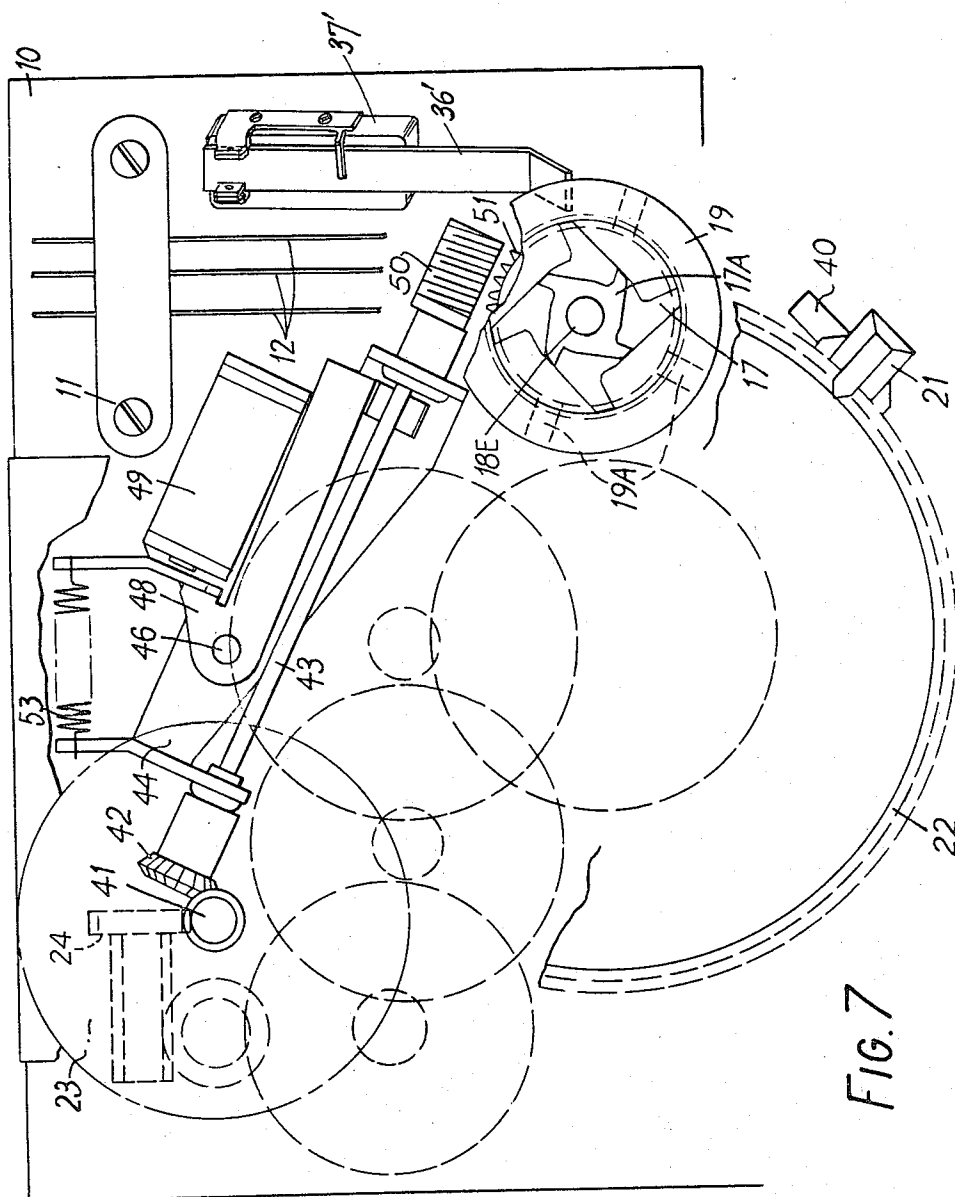


FIG. 7

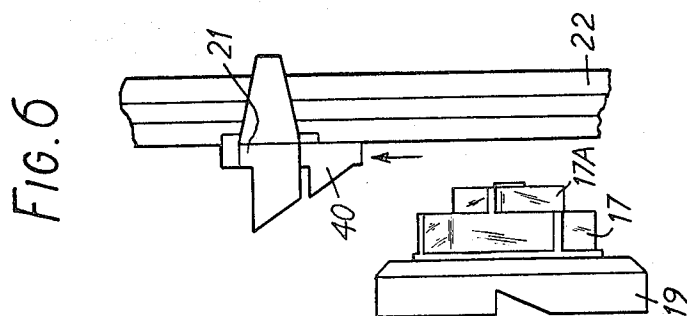


FIG. 6

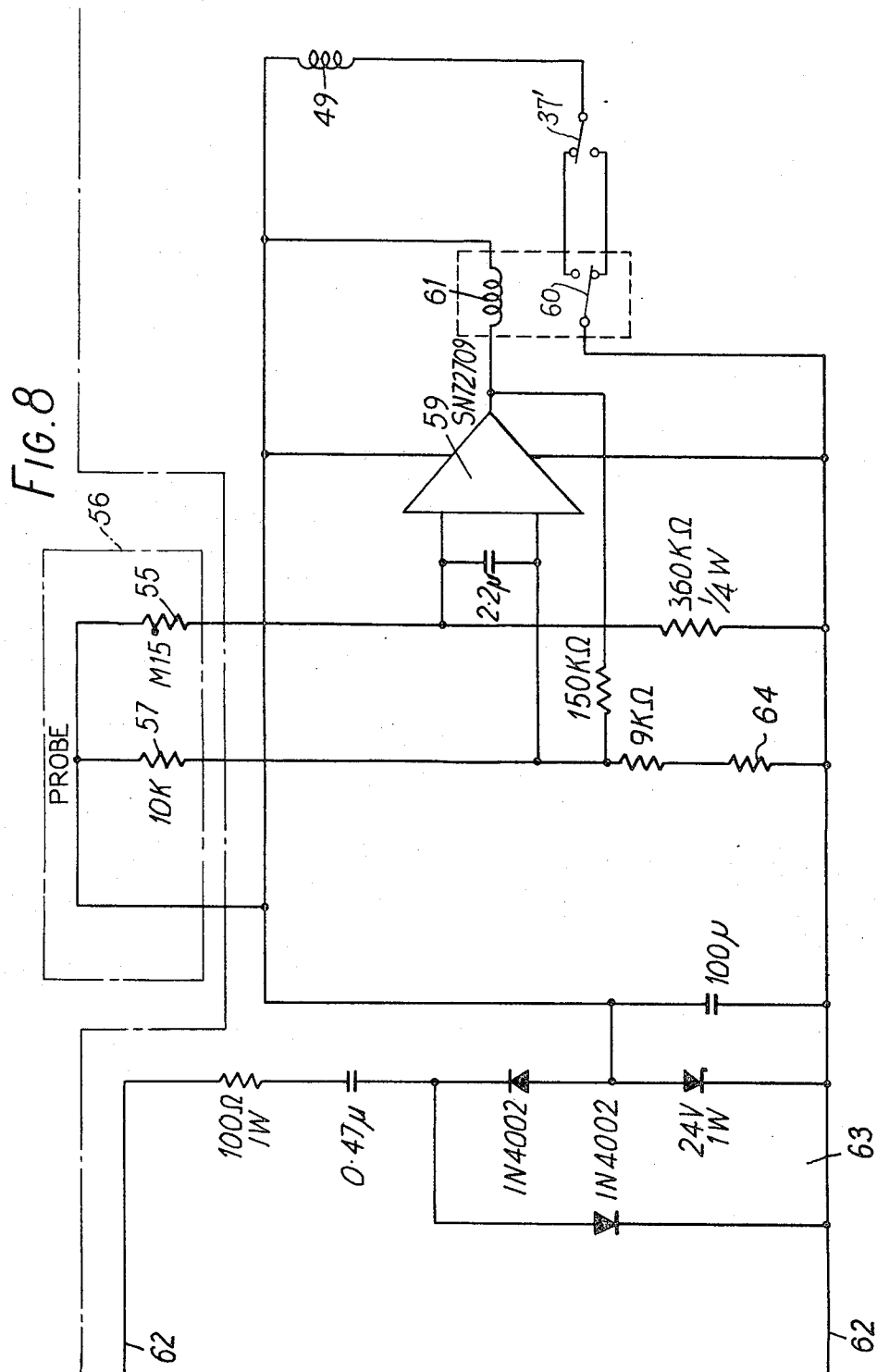


FIG. 9

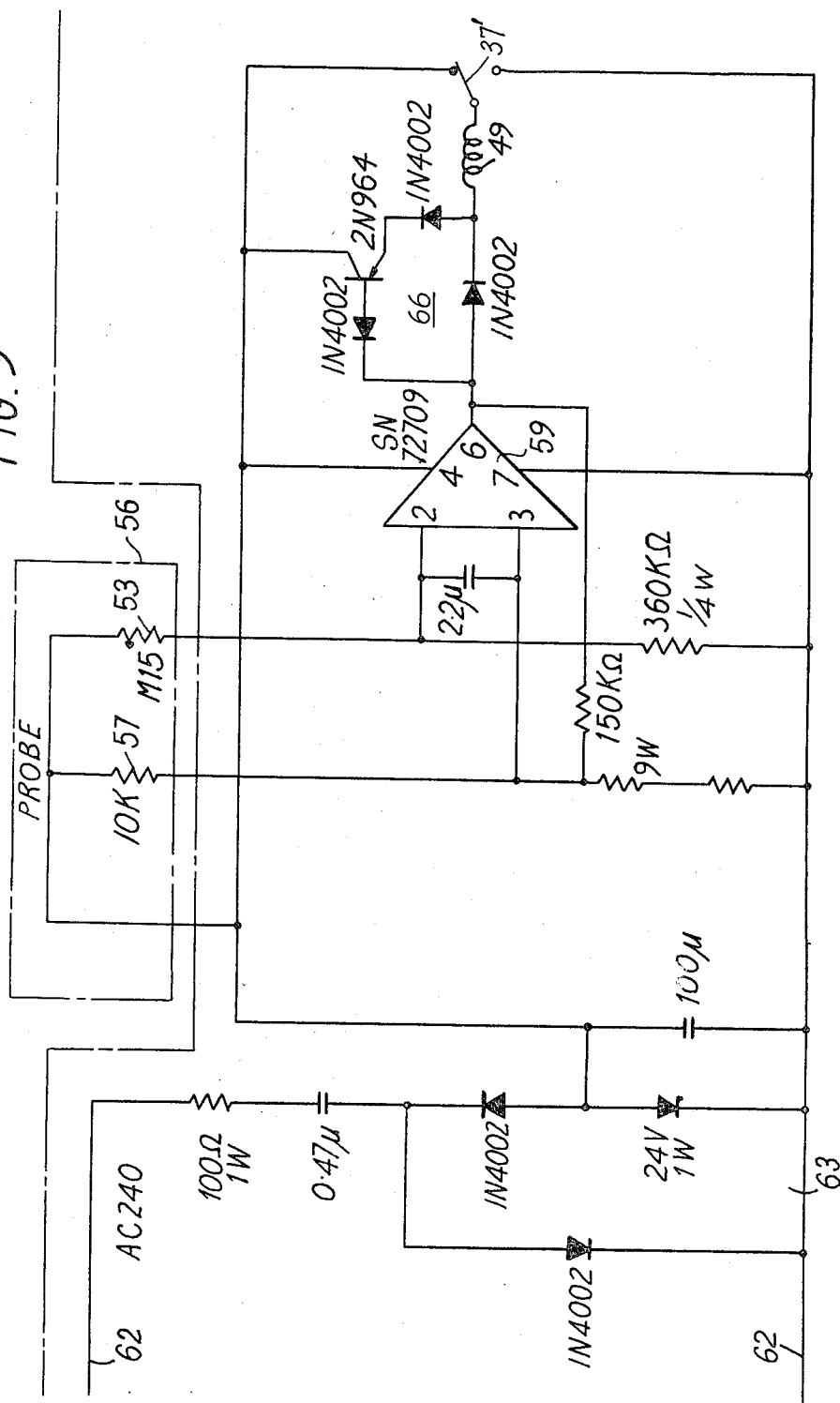
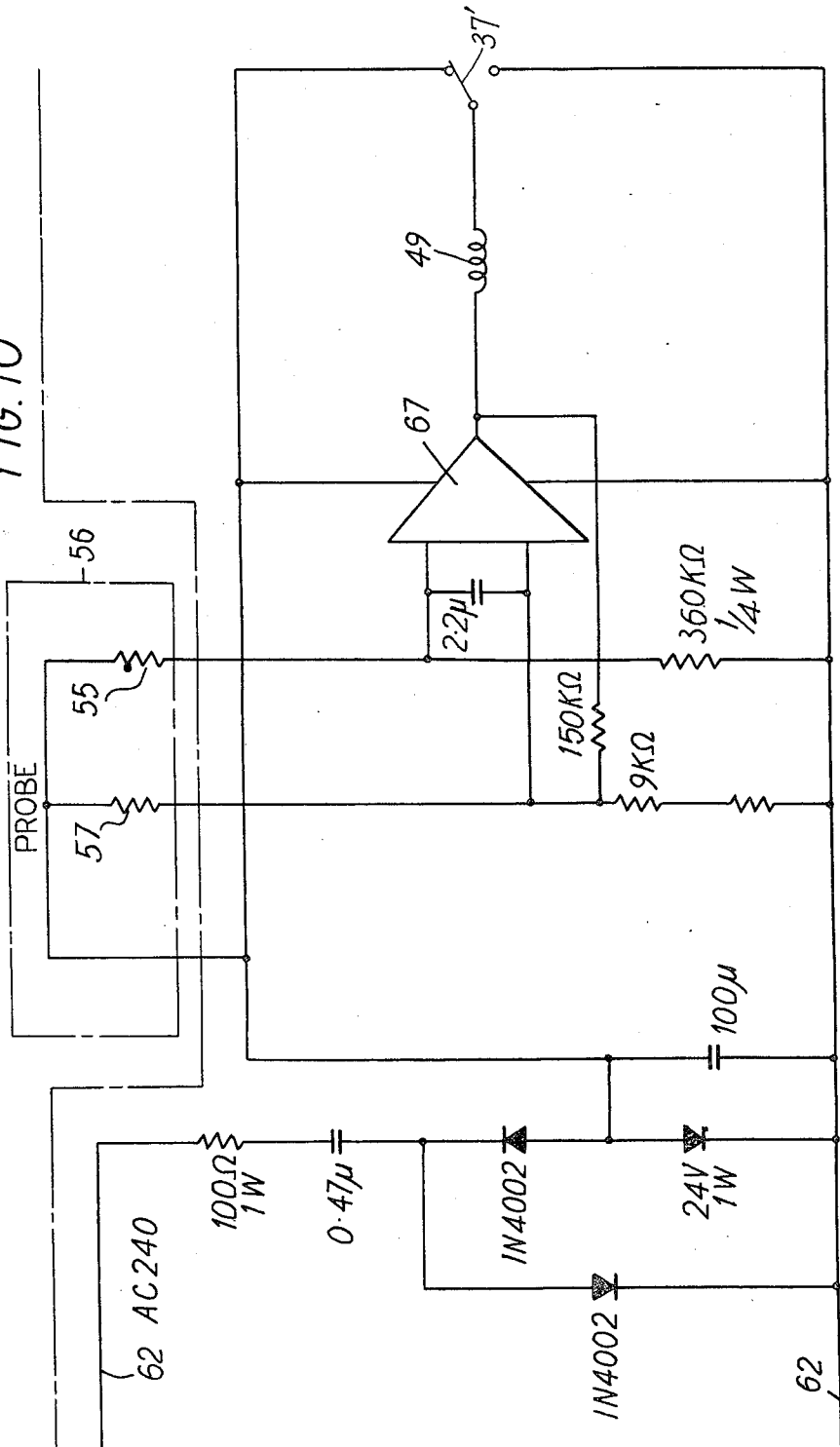


FIG. 10



REFRIGERATOR CONTROL APPARATUS

This invention relates to apparatus for effecting automatic defrosting of refrigerators, which as usual, are provided with a heater, compressor and fan to be switched on or off to control defrosting. The apparatus is suitable for use with large refrigeration chambers.

It is known to provide such apparatus in which defrosting is initiated at predetermined times and defrosting is stopped by means depending on detection of a predetermined temperature. Such means are unduly complicated and provide a somewhat coarse temperature control.

The main object of the invention is to provide apparatus of simple construction which reliably effects defrosting initially according to time and restoring normal refrigeration conditions according to a predetermined temperature.

A further object is to provide a time controlled override to operate the system in the event of temperature control failure.

A more specific object is to provide such apparatus which is capable of effecting control within narrow temperature limits e.g. $\pm 1^\circ\text{C}$ or even less.

According to the present invention the apparatus comprises switch means for switching off the refrigerator compressor and fan and switching on the heater, switch actuating means for actuating said switch means, a time clock operating the switch actuating means to switch off the refrigerator compressor and fan and switch on the heater, a thermometer in the form of a thermistor for detecting a predetermined maximum temperature of a part of the refrigerator, an electronic amplifying circuit controlled by said thermometer, a control device energized by said circuit when the thermometer indicates said predetermined maximum temperature, and motor driven means which also actuate the same switch actuating means and made operative by the control device when energized by the circuit when the thermometer reaches said predetermined maximum temperature to cause the switch means to switch the heater off and the compressor on at maximum temperature, and said control means being again operative to switch on the fan at a predetermined minimum temperature. The control device may for example be a switch device (e.g., a relay switch) and an electromagnetic device (such as an electric motor or solenoid) controlled by the switch device.

Two motors may be used, one for driving the time clock and the second being said electromagnetic device and driving said switch actuating means, the second motor being switched off after the compressor has been switched on and being switched on again when the thermometer registers a predetermined minimum temperature whereupon the motor again actuates the switch actuating means to switch on the fan, the motor then being again switched off by the switch means.

In an alternative construction the second motor is omitted and the electromagnetic device is a solenoid which serves to make and break a mechanical driving connection between the time clock motor and the switch actuating means.

Constructional forms of the invention will now be described by way of example with reference to the accompanying drawings wherein:

FIG. 1 is a plan view of an apparatus made in accordance with the invention incorporating a time drive motor and a temperature controlled motor;

FIG. 2 is an elevational view incorporating part of FIGS. 1 and 7;

FIGS. 3, 4 and 5 are plan views showing various switch blades in different positions during a defrost cycle of operation;

FIG. 6 is a simplified illustration of the time dial and tappet thereon which initiates operation of switch actuator means;

FIG. 7 is a view of an alternative embodiment in which the temperature controlled motor of FIG. 1 is omitted and the time drive motor is utilized for actuating the switch means according to temperature control;

FIG. 8 is a diagram of an electrical temperature sensing-switching circuit for use with the apparatus of FIG. 1 or FIG. 7 utilizing a thermistor as the temperature sensor or thermometer;

FIG. 9 is a view of a similar circuit but using a transistor switching circuit in place of the reed relay of FIG. 8; and

FIG. 10 is a view of a similar circuit but using a high power integrated circuit, thus dispensing with the reed relay and the transistor switching circuit.

In the construction of the apparatus illustrated in FIGS. 1 to 6 a plate 10 carries a mounting block 11 on which are mounted flexible switch arms 12 that carry contacts 13, 14 and 15, 16, as well as others to be described. Contacting of contacts 13, 14 switches on the compressor and contacting of contacts 15, 16 switches on the heater. A similar set of switch blades 12A and similar contacts controls the switching on and off of the fan, as illustrated in FIG. 5, although a second set of contacts similar to 15, 16 are not used in the fan control circuit of the present system. Two of the blades 12 have extensions 12B, 12C and two of the blades 12A have extensions 12D, 12E.

The switch blades are operated by switch operating means comprising four cam members 18A, 18B, 18C, 18D by engagement of the latter with the switch blade extensions 12B, 12C, 12D, 12E respectively. The blades 12 that carry contacts 15 and 13 are linked together by a link 12F which causes them to move together as a unit except for a slight amount of relative displacement which permits the contacts to make and break. The blades 12 have small holes 12G at their far ends beyond mounting block 11 to facilitate attachment of electric conductor wires connected to the compressor, heater and fan.

Cams 18 are separated from each other by discs 18F. Cam members 18A, 18B, 18C and 18D are mounted on a spindle 18E carried by the plate 10. This spindle also carries cams 19, 17 and 17A to be referred to. Cam 19 is, however, not used in the operation of the system of FIG. 1 but is used in the alternative embodiment of FIG. 7. Cam members 18A, 18B, 18C, 18D, (referred to hereafter as cam members 18) have teeth which serve as cams and as ratchet teeth. The cam members are rotated in unison one step by a tappet 21 on each rotation of the dial 22 of a clock driven by a motor 23 through a train of worms and gears 24. The tappet 21 is mounted on the dial 22 and engages the cam 17 to rotate it and the cam members 18. The location of tappet 21 can be adjusted on dial 22 to actuate the cams to the defrost position at any predetermined time during 24 hours. Another view of the tappet 21 and cams 17, 17A

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and 19 is shown in FIG. 6 which is a view looking in the direction of the arrow 6 on FIG. 1.

FIG. 1 shows the positions of switch blade extensions 12B and 12C on their respective cams 18A and 18B during the refrigerating portion of a cycle. As illustrated, contacts 13 and 14 are engaged to energize the compressor.

FIG. 3 shows the position of cams 18A, 18B and the switch blades 12B, 12C at the commencement of the defrost portion of the operating cycle in which contact 15, 16 are in engagement to energize the heater. FIG. 4 shows the positions of the same cams and switch blades after further rotation which causes contact 15 to disengage from contact 16 and contacts 13, 14 are in engagement, thereby switching the heater off and switching the compressor on. The movement to the FIG. 4 position is initiated by the sensing of a predetermined highest defrosting temperature, as will be further described. FIG. 5 represents further movement of the cams and illustrates cams 18C, 18D and switch blades 12D, 12E at positions where the longer contact blade extension 12D has dropped off cam 18C to switch on the fan after the thermometer has sensed a lower desired refrigeration temperature.

Considering the switch blades 12D and 12E and their respective positions for the corresponding degree of cam rotation illustrated in FIG. 3 (defrosting cycle just commenced), the blades will be in their closest proximity so that the fan is not energized. Switch blades 12D and 12E will remain in that same position for the further degree of cam rotation corresponding to FIG. 4 (defrosting heater just turned off). This results from the fact that the blade extension 12B, which is connected to the heater, is shorter than the blade extension 12D which switches the fan circuit. Therefore, switch extension 12B drops off its corresponding cam 18A before switch extension 12D drops off its corresponding cam 18C. As illustrated in FIG. 2, cams 18A and 18C are in angular registration, and cams 18B and 18D are in angular registration with each other, but at a different angular orientation than cams 18A, 18C. Thus on start of defrosting the switch blade extensions 12B, 12D are raised and blades 12C, 12E drop off, as shown in FIG. 3. On reaching the maximum defrosting temperature the blade extensions 12C and 12E are raised and extension 12B drops off (because it is shorter than 12D) to bring the compressor on. Subsequently, after the temperature falls to a desired refrigeration temperature, the cams rotate further and switch blade 12D drops off to start the fan.

The normal refrigeration condition is restored upon the refrigerator reaching a predetermined lower temperature which is detected by a thermometer (to be described) which acts through an amplifying circuit and relay to switch on an electromagnetic device in the form of an electric motor 26, FIG. 1, the spindle of which carries a cam 27 and an eccentric pin 28. The pin 28 is engaged in a slot 29 in a lever 30 that is pivotally mounted at 31 and is pivotally connected at 33 to a spring biased pawl 34 which engages one of the ratchet teeth of the cam members 18. When the motor 26 operates, the cam members 18 are pulled round one step by pawl 34 to switch the heater off and the compressor on. The cam 27 then acts on the switch arm 36 of a microswitch 37 to switch off the motor 26. When the amplifier current is sufficiently reduced as a result of a reduction in temperature, the control circuit responds by again switching on the motor 26 which drives the cam

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members 18 a further step to switch on the fan. The cam 27 then again actuates the switch arm 36 to switch off the motor 26.

In case of electrical fault in the temperature sensing control circuit an extension 40 of the tappet 21 will act on the cam 17A (which is integral with cam 17) 40 minutes after initiation of the defrost cycle to effect the restoration of the normal conditions in two steps i.e., the heater is switched off and the compressor is switched on and then after a certain delay the fan is switched on. Normally the extension 40 will pass the cams without operating them.

FIG. 7 is a view of an alternative and closely related embodiment similar to FIG. 1 but looking at the opposite side of the apparatus. With the exception of motor 26 and pawl 34 with its linking mechanism, the parts shown in FIGS. 2 to 6 are also applicable to this alternative construction. In this construction the timing motor 23 also serves to effect the switching operations according to temperature. For this purpose, the motor spindle carries a worm gear 41 driving a bevel gear 42 on a spindle 43 that is mounted in bearings on a bracket 44. The bracket 44 carries a movable armature 48 of an electromagnetic device in the form of a solenoid 49. Armature 48 pivots about post 46. Spindle 43 carries a worm gear 50 which can move into and out of engagement with a wormwheel 51 that is pivoted on spindle 18E for rotation with the cam members 18.

The tappet 21, as before, switches the cam members 18 via cam 17 through one step to initiate defrosting. When the maximum desired defrosting temperature, e.g. 2°C, is reached the thermometer-relay circuit, or temperature sensing-switching circuit, energizes the solenoid to swing the armature 48 and spindle 43 about the pivot 46 to bring the worm gear 50 into mesh with the wormwheel 51 and drive the cam members 18 through one further step to switch off the heater and switch on the compressor. Simultaneously, a cam shaped part 19A of the cam 19 actuates the switch arm 36' to deenergize the solenoid 49. Spring 53 now acts on the armature 48 to swing the worm 50 out of mesh with the wormwheel 51. When the temperature falls to the desired refrigeration temperature, e.g., -2°C, the thermometer-relay circuit again energizes solenoid 49 and the worm 50 again drives the cam members 18 through a further step to switch on the fan, whereupon the switch 37' again switches off the current to the solenoid 49 and the worm 50 is swung out of engagement with the worm-wheel 51.

FIG. 8 shows the electrical circuit for controlling the apparatus illustrated in FIG. 7. It comprises a thermistor 55 which is encased in an electrically insulating envelope 56 of synthetic plastics material together with a resistor 57 in circuit therewith. This constitutes an electrical thermometer probe and can be placed between the fins of the refrigerator heat exchanger. An amplifier 59 is connected across the probe leads and serves to energize a relay coil 61 that controls a switch device in the form of a relay reed switch device 60 connected with the solenoid 49 through microswitch 37'. As an example, amplifier 59 may be a semiconductor operational amplifier type SN 72709 which is commercially available from a number of manufacturers. Reed relay switch 60 and microswitch 37 each provide single pole double throw switching and each may be any of various commercially available switches of those types.

The temperature sensing switching circuit is connected to mains supply at 62 (e.g., A.C. 240 volts) and

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has a rectifier circuit 63 deriving a 24 volt D.C. supply which is connected to the probe, amplifier 59 and coil 61 through appropriate resistors, suitable values of which are indicated by way of example. The value of resistor 64 will be selected to suit the thermistor 55.

From the above discussion it is believed that the operation of the circuit of FIG. 8 is obvious. That is, after the heater has been turned on by tappet 21 actuating cam 17 and the compressor has been turned off as a result of the cam and switch arrangement illustrated in FIG. 3, the temperature in the refrigerator will rise and the resistance of thermistor 55 will decrease. Correspondingly, the output of amplifier 59 will increase. At a predetermined maximum defrosting temperature the output of amplifier 59 will energize winding 61 sufficiently to actuate reed relay 60 so that the movable contact engages the upper fixed contact. Solenoid winding 49 now is energized through microswitch 37' to attract its armature 48, FIG. 7. This causes rotating wormgear 50 to engage with pinion gear 51, thus causing cams 18 to commence rotating. After the cams 18 reach the positions illustrated in FIG. 4 contacts 15 and 16 open to disconnect the heater while contacts 13 and 14 make to switch on the compressor.

At substantially the same time switch arm 36' of switch 37' is actuated by cam surface 19A of cam 19 to transfer switch 37', FIG. 8, to its bottom position, thus deenergizing relay coil 49 and disengaging wormgear 50 from pinion gear 51.

Meanwhile, the temperature in the refrigerator still is high but beginning to fall. Consequently, the output of amplifier 59 still is high to hold reed relay 60 closed on its upper contact. When the refrigerator temperature falls to a desired refrigerating temperature, the resistance of thermistor 55 will have increased and the output of amplifier 59 will fall to a level to allow reed relay 60 to return to its bottom position. Because microswitch 37' had previously switched to its bottom position, solenoid coil 49 again is energized. In the same manner as described above wormgear 50 engages pinion gear 51 to again rotate cams 18 to the position illustrated in FIG. 5, thereby turning on the fan. Rotation of cams 18 at this time again causes switch arm 36' to be actuated by cam surface 19' to return the contact of microswitch 37' to the position illustrated in FIG. 8. This deenergizes solenoid 49, disengages wormgear 50 and concludes the defrost cycle.

In the circuit of FIG. 8, the temperature sensing thermistor 55 and operational amplifier provide precise temperature control within narrow limits.

FIG. 9 shows a circuit similar to that of FIG. 8 but in which the reed relay 60, 61 is replaced by a transistor switching circuit 66.

FIG. 10 shows a similar circuit in which a high power integrated circuit device 67 enables the reed relay and the transistor switching circuit to be dispensed with, but incorporates in effect a similar switch device in its circuitry.

For controlling the construction shown in FIG. 1 a similar circuit is used in which the motor 26 replaces solenoid 49.

What is claimed is:

1. In apparatus for controlling the defrosting of a refrigeration system which includes a compressor, fan, and heater, the combination comprising control means for independently and selectively controlling said compressor, fan and heater,

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actuating means for selectively actuating said control means,

means for initiating operation of said actuating means upon occurrence of an event, thereby to initiate a defrosting cycle of said refrigeration system, said actuating means and said control means being constructed and arranged to turn off said compressor and fan and turn on said heater upon a first actuation by the initiating means in a defrosting cycle of operation, to turn on said compressor and turn off said heater at a second actuation, and to turn on said fan at a later third actuation thereof,

a temperature sensing-switching circuit for sensing temperature in a part of said refrigeration system and for providing a first switching function when a predetermined maximum defrosting temperature is sensed and for providing a second switching function when a predetermined lower temperature is sensed,

motor means selectively operable in response to said temperature sensing-switching circuit for operating said actuating means, and

means for further selectively operating the motor means only during the existence of said first switching function to provide only said second actuation to the actuating means and for selectively operating the motor means only during the existence of said second switching function to provide only said third actuation to the actuating means.

2. The apparatus claimed in claim 1 wherein said temperature sensing-switching circuit includes

first switch means providing a single pole double throw switch function and which is operated to a first condition upon the sensing of said maximum temperature and which is operated to a second condition upon the sensing of said lower temperature, and wherein

the means for further selectively operating the motor means comprises second switch means providing a single pole double throw switch function,

said means for further selectively operating the motor means including means responsive to the operation of said motor means for operating the second switch means from a first to a second switch condition after the heater is turned off and for operating the second switch means from its second to its first switch condition after said fan is turned on.

3. The apparatus claimed in claim 2 wherein said second named means responsive to the operation of the motor means comprises

cam means rotatable by said motor means when the motor means operates the actuating means and a cam follower for operating the second switch means.

4. The apparatus claimed in claim 3 wherein said motor means includes an independent motive source coupled to a source of electrical supply through said first and second switch means.

5. The apparatus claimed in claim 4 wherein said first and second switch means each is comprised of first and second stationary contacts and a movable contact,

the first and second stationary contacts of said two switch means being, respectively, connected together and the movable contact of one switch means being connected to one side of a source of electrical supply and the movable contact of the other switch means being connected through said

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motive source to the other side of said source of electrical supply.

6. The apparatus claimed in claim 3 wherein said means for initiating operation of said actuating means upon occurrence of an event is a timing motor having positionable tappets associated therewith, and wherein

1 said motor means includes coupling means driven by said timing motor and selectively engageable with said actuating means for operating the actuating means when so engaged,
10 said motor means further including means responsive to the output of said temperature sensing-switching circuit for causing selective engagement of the coupling means with said actuating means.

7. In apparatus for controlling the defrosting of a refrigeration system which includes a compressor, fan and heater, the combination comprising

control means for independently and selectively controlling said compressor, fan and heater,
20 actuating means for selectively actuating said control means,

means for initiating operation of said actuating means upon occurrence of an event, thereby to initiate a defrosting cycle of said refrigeration system,
25 said actuating means and said control means being constructed and arranged to turn off said compressor and fan and turn on said heater upon a first actuation by the initiating means, to turn on said compressor and turn off said heater upon a second actuation, and to turn on said fan upon a third actuation thereof,

temperature sensing means for sensing a predetermined maximum temperature in a part of the refrigeration system,

circuit means responsive to said sensing means for producing an output signal of given characteristic when said maximum temperature is sensed,

motor means operable in response to said output signal of given characteristic to operate said actuating means to turn off the heater and turn on the compressor,

switching means for further controlling the operation of said motor means,

means operable in response to said motor means for actuating the switching means to interrupt operation of the actuating means by said motor means after the compressor is again turned on,

said sensing means and said circuit means being operable to sense a predetermined temperature lower than said maximum temperature and upon sensing said lower temperature operating with said switching means to reactivate operation of the actuating means by the motor means to turn on said fan,

said means operable in response to the motor means being responsive to said reactivation of the motor means to operate said switching means to again turn off the motor means after the fan is turned on.

8. In apparatus for controlling the defrosting of a refrigeration system which includes a compressor, fan and heater, the combination comprising

switch means for independently and selectively controlling said compressor, fan and heater,
switch actuating means for selectively actuating said switch means,

timing means for initiating operation of said switch actuating means thereby to initiate a defrosting cycle of said refrigeration system,

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said switch actuating means and said switch means being constructed and arranged to switch off said compressor and fan and switch on said heater upon a first actuation by the timing means in a defrosting cycle of operation, to switch on said compressor and switch off said heater at a subsequent actuation, and to switch on said fan at a still later actuation thereof,

temperature sensing means for sensing a predetermined maximum temperature in a part of the refrigeration system,

circuit means responsive to said sensing means for producing an output signal of given characteristic when said maximum temperature is sensed,

motor means operable in response to said output signal of given characteristic to operate said switch actuating means to switch off the heater and switch on the compressor,

second switching means for further controlling the operation of said motor means,

means operable in response to said motor means for actuating the second switching means to stop the operation of said motor means after the compressor is again turned on,

said sensing means and said circuit means being operable to sense a predetermined temperature lower than said maximum temperature and upon sensing said lower temperature operating with said second switching means to reactivate said motor means to operate the switch actuating means to turn on said fan,

said means operable in response to the motor means being responsive to said reactivation of the motor means to operate said second switching means to again switch off the motor means after the fan is switched on.

9. The combination claimed in claim 8 wherein said motor means includes an independent motive means whose energization from a source is controlled through said first and second switching means connected in series.

10. The combination claimed in claim 8 wherein said timing means includes a clock motor, and wherein

said motor means includes coupling means driven by said clock motor and selectively engageable with said switch actuating means for operating said switch actuating means when so engaged,

said motor means further including means responsive to said circuit means for causing selective engagement of the coupling means with said switch actuating means.

11. The combination claimed in claim 8 wherein said switch means includes switch arms carrying one or more contacts thereon and said switch actuating means comprises rotatable cam members engaged with said switch arms for selectively moving said arms to selectively make and break contacts upon predetermined rotation of said cams.

12. The combination claimed in claim 11 wherein said means operable in response to said motor means is a second cam means and a switch arm of said second switching means, said second cam being rotatable with said first mentioned cam means.

13. The combination claimed in claim 11 wherein said switch actuating means include ratchet teeth, and wherein said motor means includes

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a pivoted pawl engageable with said ratchet teeth for rotating said cams,
 said motor means further including an electric motor and linkage means coupled to said pawl,
 said electric motor being responsive to the output of said circuit means to actuate said pawl when the sensing means senses said predetermined temperature and said lower temperature.

14. In a method of controlling the defrosting of a refrigeration system having a compressor, fan and heater which are independently and selectively connectable to a source of electrical supply through respective switches, and wherein the opening and closing of said switches is controlled by respective rotatable cams which are rotated together by motor means, the steps comprising
 positioning the cams and switches to connect the compressor and fan to said source and to disconnect the heater therefrom,
 rotating said cams upon occurrence of a predetermined event and disconnecting the compressor and fan from the source and connecting the heater to said source,
 sensing the temperature in a given part of said refrigeration system,

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actuating said motor means and turning said cams when the sensed temperature reaches a predetermined maximum temperature,
 disconnecting said heater and reconnecting said compressor to said source upon turning of the cams through a given angle in response to the sensing of said maximum temperature,
 interrupting the operation of said motor means and the turning of said cams after the heater is disconnected,
 reactuating said motor means and again turning the cams when the temperature in said part of the system falls to a predetermined lower temperature,
 reconnecting the fan to said source upon further turning of the cams through some angle, and
 again interrupting the operation of the motor means and the turning of the cams after the fan has been connected.

15. The method claimed in claim 14 wherein the steps of interrupting the operation of the motor means includes the steps of
 actuating a second switching means in the control circuit of the motor means in response to a predetermined angular rotation of a cam means which turns in response to operation of the motor means.

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