United States Patent [19]

Schulze-Berge et al.

[11] 3,854,915

[45] Dec. 17, 1974

[54] DEMAND DEFROST CONTROL SYSTEM

[75] Inventors: **Karl J. Schulze-Berge**, Manitowoc; **John Joseph Allard**, Mishicot, both of Wis.

[73] Assignee: **AMF Incorporated**, White Plains, N.Y.

[22] Filed: **Apr. 10, 1973**

[21] Appl. No.: **349,690**

[52] **U.S. Cl.** **62/155**, 62/156, 62/157, 62/176, 62/234

[51] **Int. Cl.** **F25d 21/06**

[58] **Field of Search** 62/151, 155, 156, 157, 62/176, 234

[56] **References Cited**

UNITED STATES PATENTS

3,277,662	10/1966	Winters	62/155
3,460,352	8/1969	Lorenz	62/176
3,728,867	4/1973	Jarrett	62/155
3,759,049	9/1973	Bell	62/176

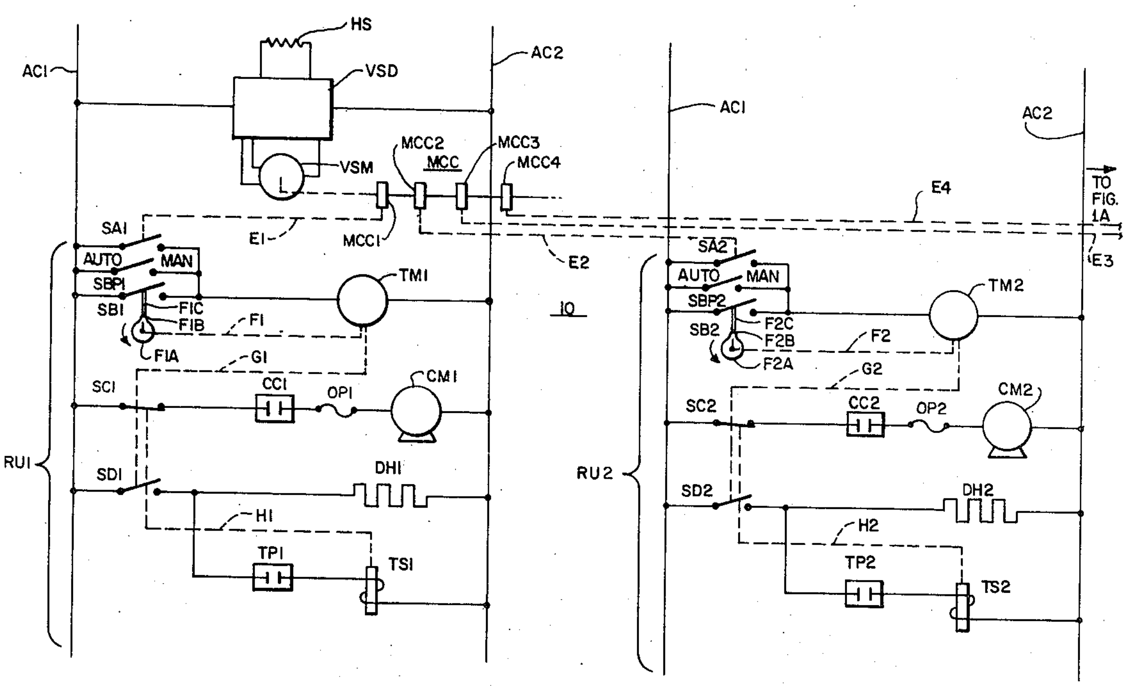
Primary Examiner—Meyer Perlin

Attorney, Agent, or Firm—George W. Price; John H. Gallagher

[57] **ABSTRACT**

A demand defrost system is provided in which a periodic switch device is driven at variable speed in response to relative humidity values ambient to one or more refrigeration units. The periodic switch device initiates defrost cycles in the refrigeration units at variable periodic intervals under the demand constraint of relative humidity. The refrigeration units are controlled by individual constant speed timers which control the maximum period of a given defrost cycle and terminate the cycle early if defrost criterion is satisfied prior to the end of the maximum interval. These timers slave themselves to the periodic switch device to readily receive defrost initiation commands therefrom and include by-pass means to selectively permit real time control of the defrost cycles.

48 Claims, 10 Drawing Figures



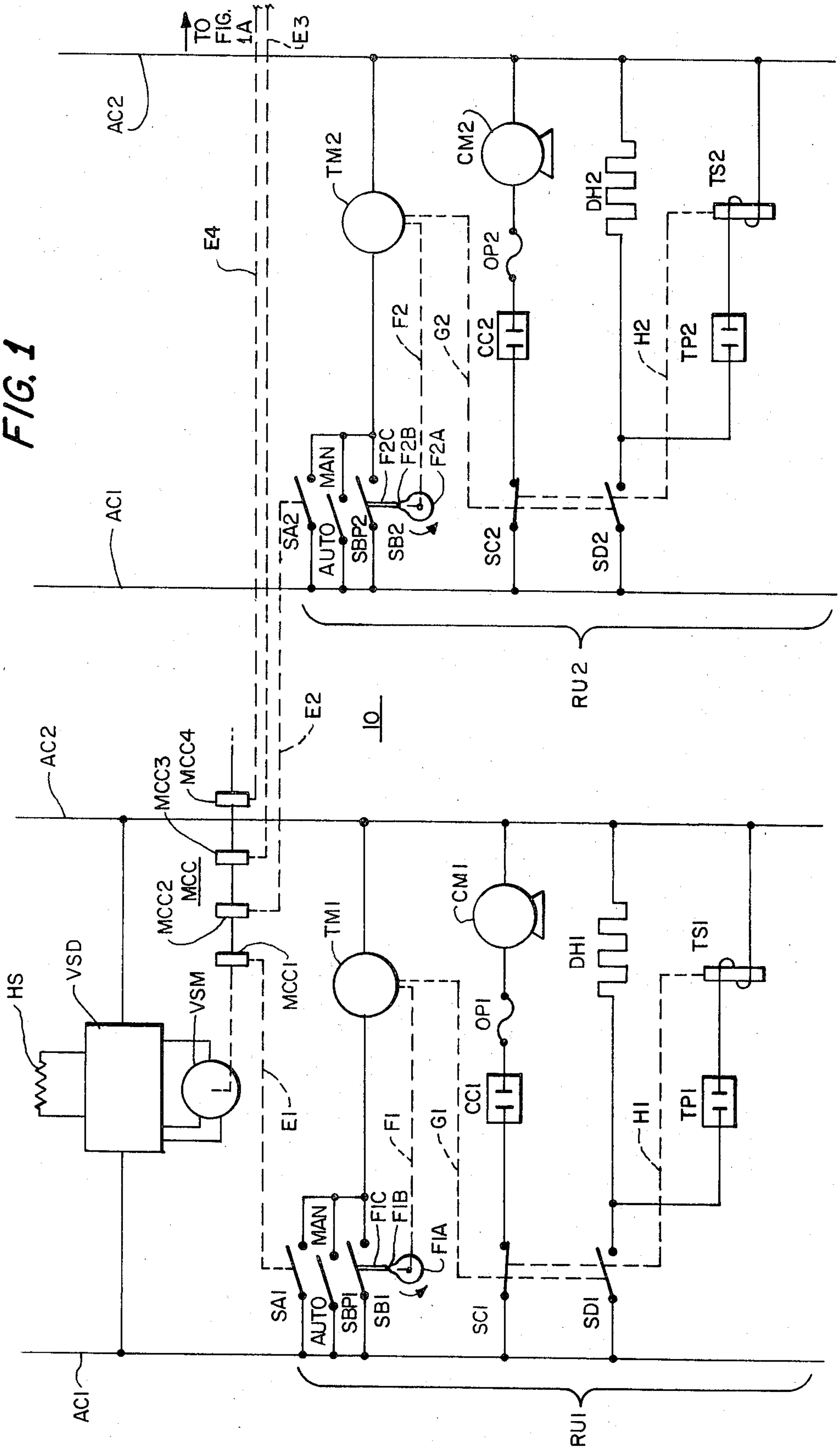

TO FIG. 1A
E3
E4
AC2
AC1
TM2
CM2
DH2
TS2
OP2
CC2
F2
G2
H2
TP2
F2C
F2B
F2A
MAN
AUTO
SA2
SBP2
SB2
SC2
SD2
RU2
E2
10
MCC4
MCC3
MCC
MCC2
MCC1
HS
VSD
VSM
TM1
CM1
DH1
TS1
OP1
CC1
E1
F1
G1
H1
TP1
F1C
F1B
F1A
SA1
SBP1
SB1
SC1
SD1
RU1

FIG. 1

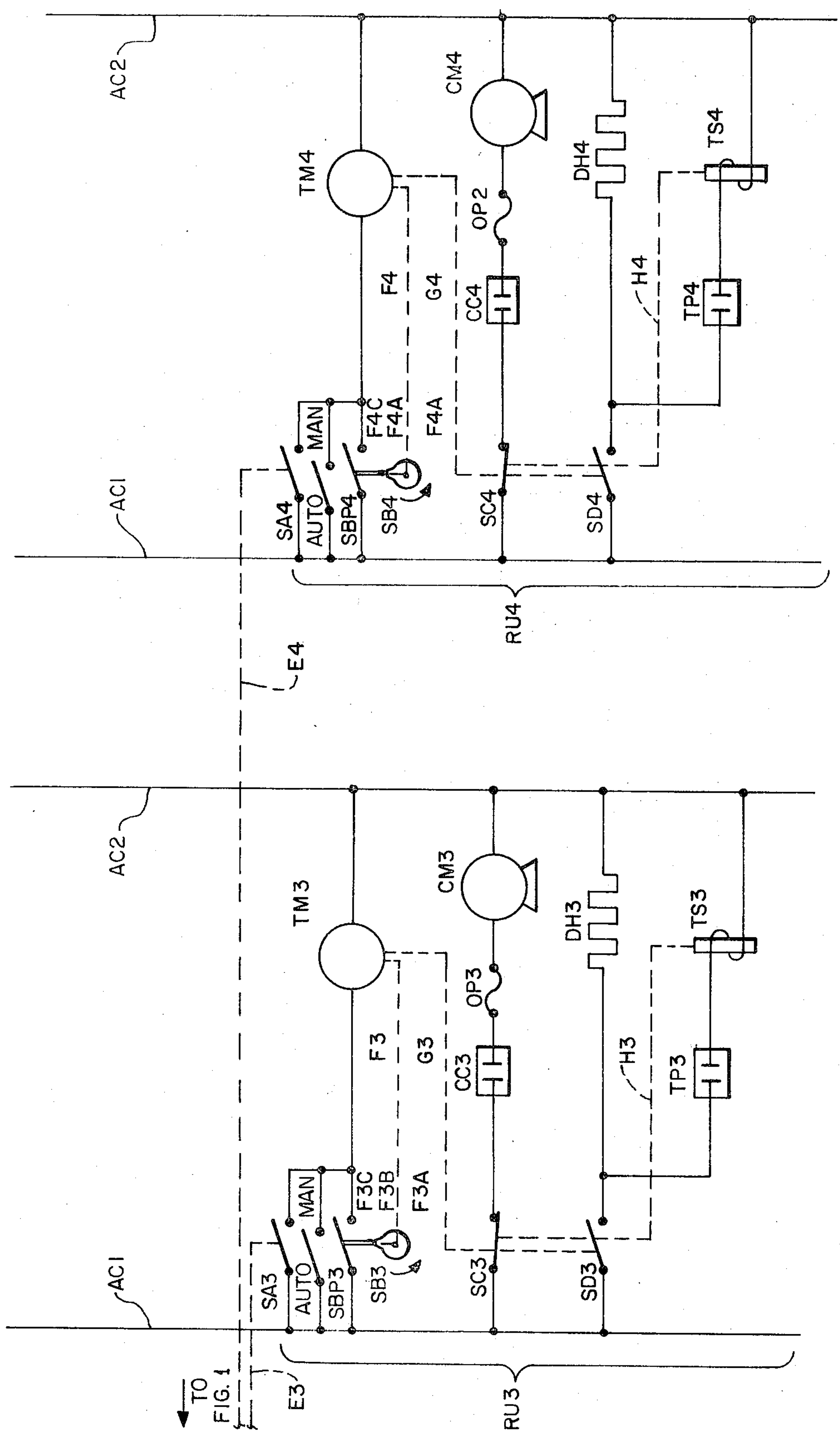

AC2
AC1
TM4
CM4
DH4
TS4
OP2
F4
G4
CC4
H4
TP4
MAN
AUTO
SA4
SBP4
SB4
F4C
F4A
SC4
SD4
RU4
E4
AC2
AC1
TM3
CM3
DH3
TS3
OP3
F3
G3
CC3
H3
TP3
MAN
AUTO
SA3
SBP3
SB3
F3C
F3B
F3A
SC3
SD3
RU3
E3
TO FIG. 1

FIG. 1A

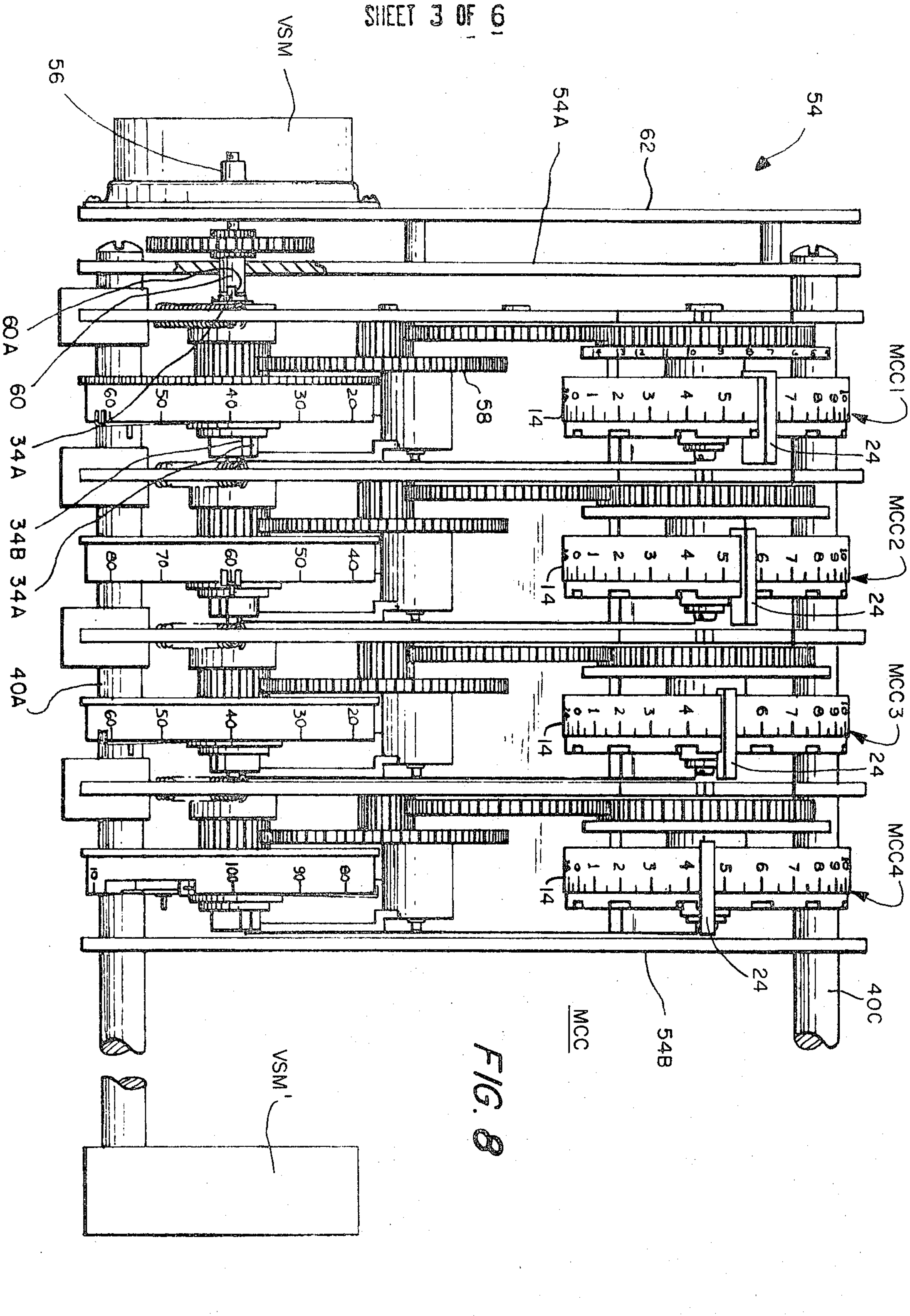

VSM
56
54A
62
54
60A
60
34A
34B
34A
40A
58
MCC1
MCC2
MCC3
MCC4
14
24
54B
40C
MCC
VSM'

FIG. 8

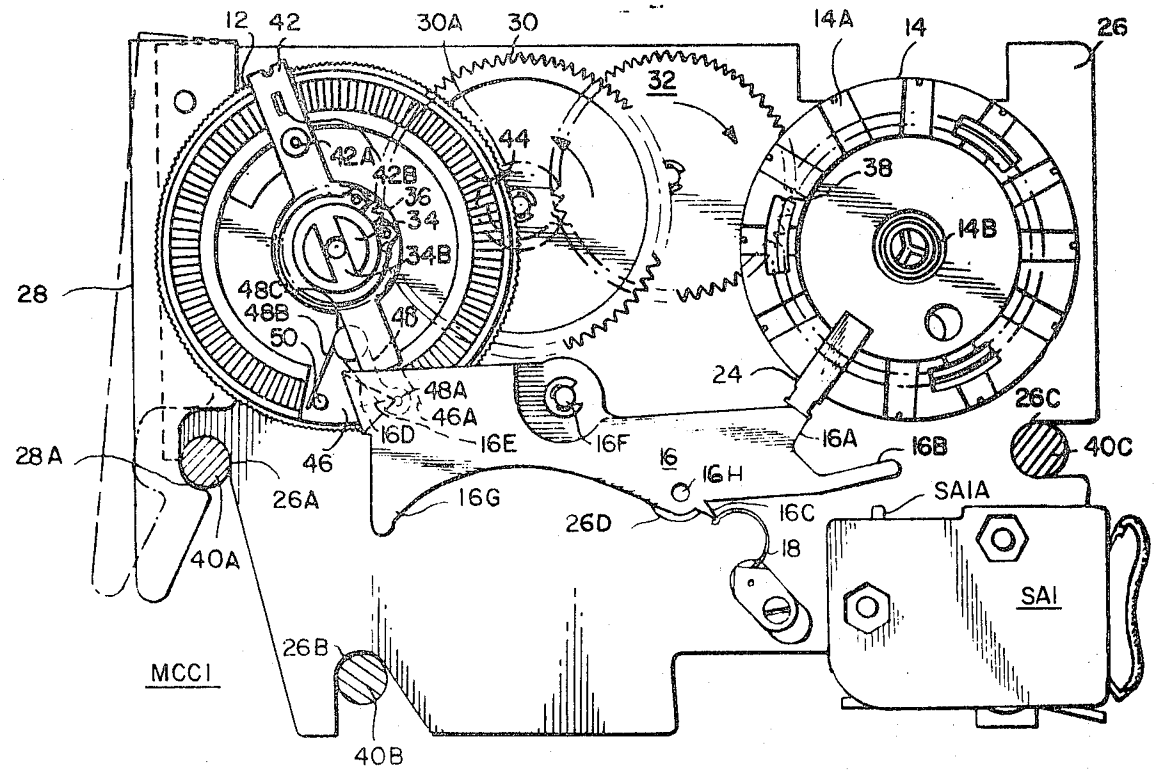

12
42
30A
30
14A
14
26
32
44
42A
42B
36
34
34B
38
14B
28
48C
48B
50
46
48A
46A
24
28A
26A
16D
16E
16F
16A
16B
26C
40C
16
16H
SAIA
16G
26D
16C
18
40A
SAI
26B
MCCI
40B

FIG. 2

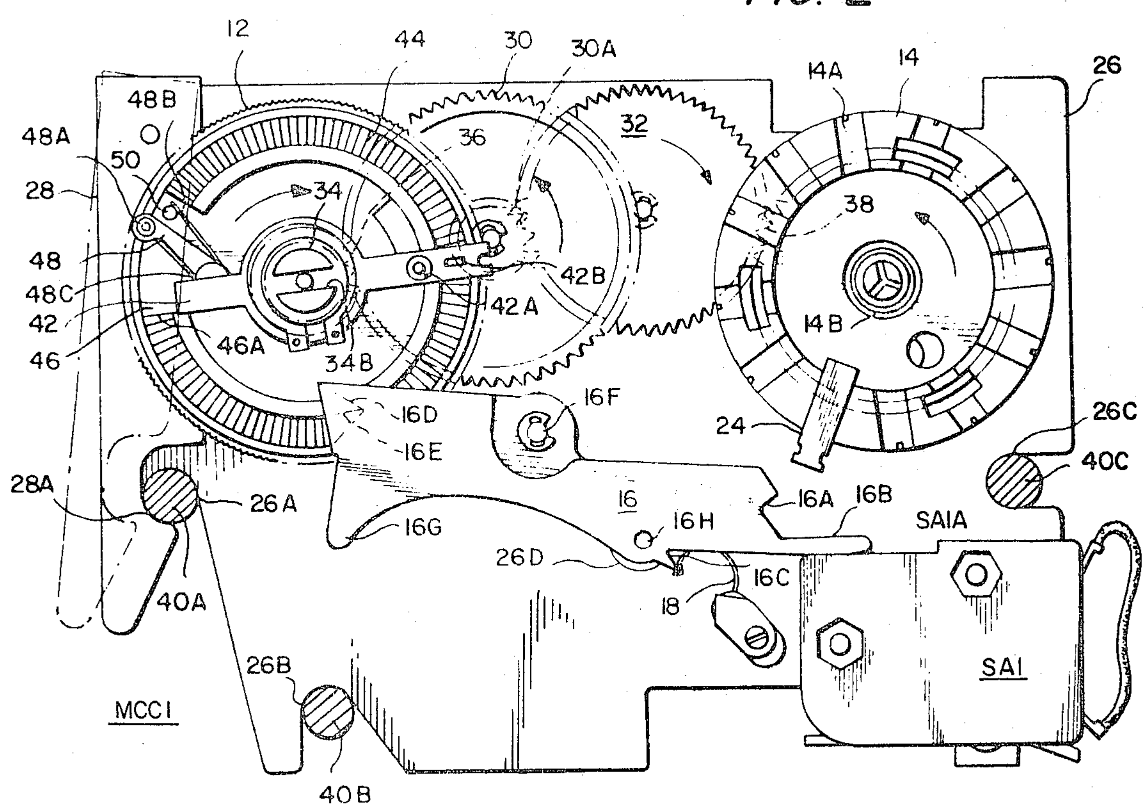

12
44
30
30A
14A
14
26
48B
48A
50
28
36
32
34
38
48
48C
42
46
42B
42A
14B
46A
34B
16D
16E
16F
24
26C
40C
28A
26A
16A
16B
SAIA
16
16H
16G
26D
16C
18
40A
26B
SAI
MCCI
40B

FIG. 3

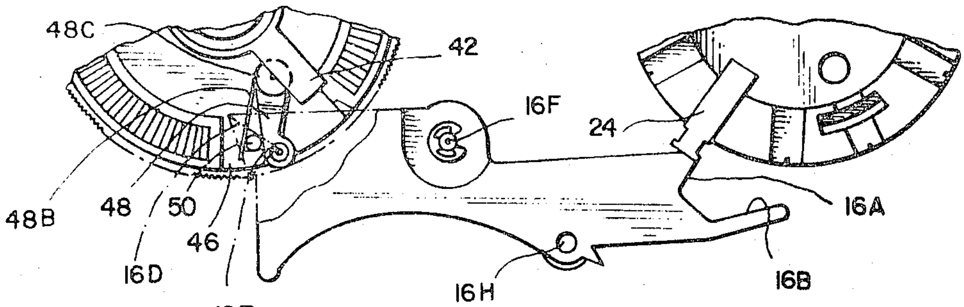


FIG. 4

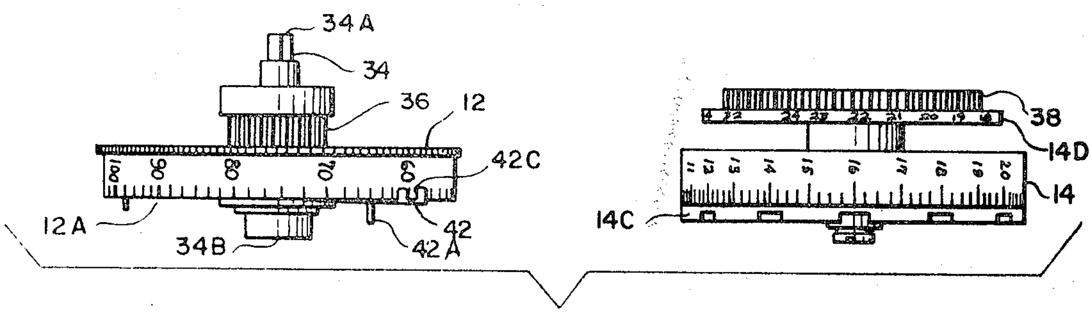


FIG. 5

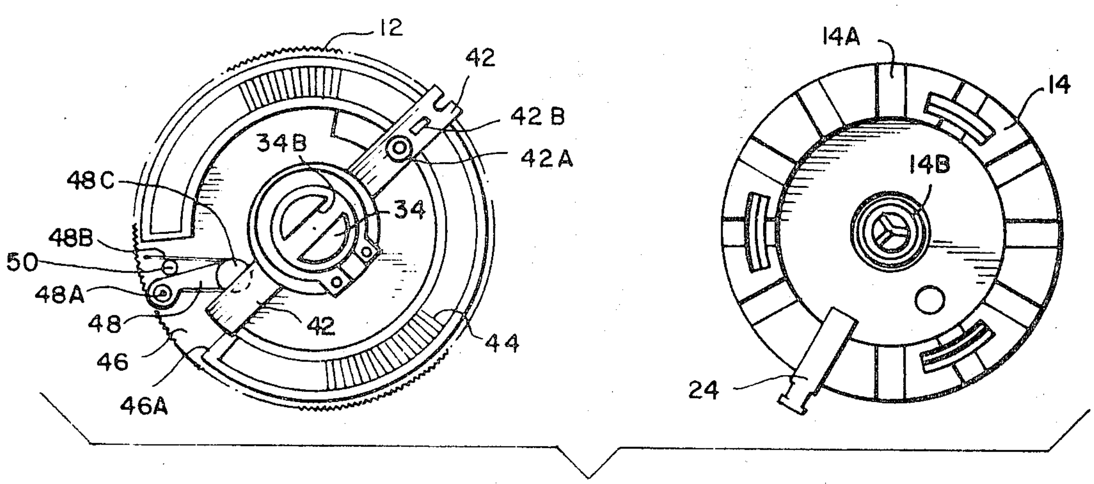
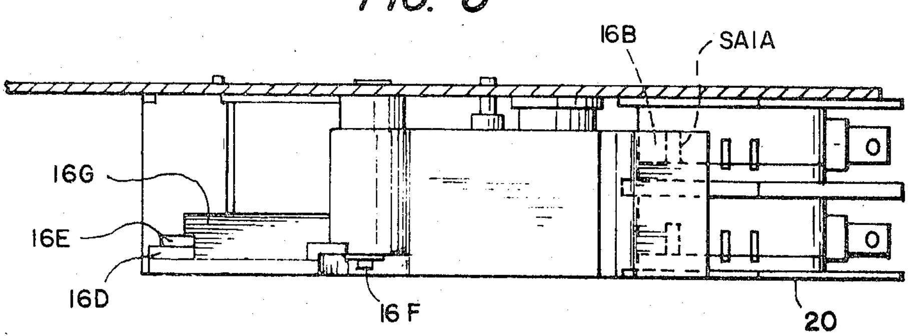


FIG. 6

FIG. 7



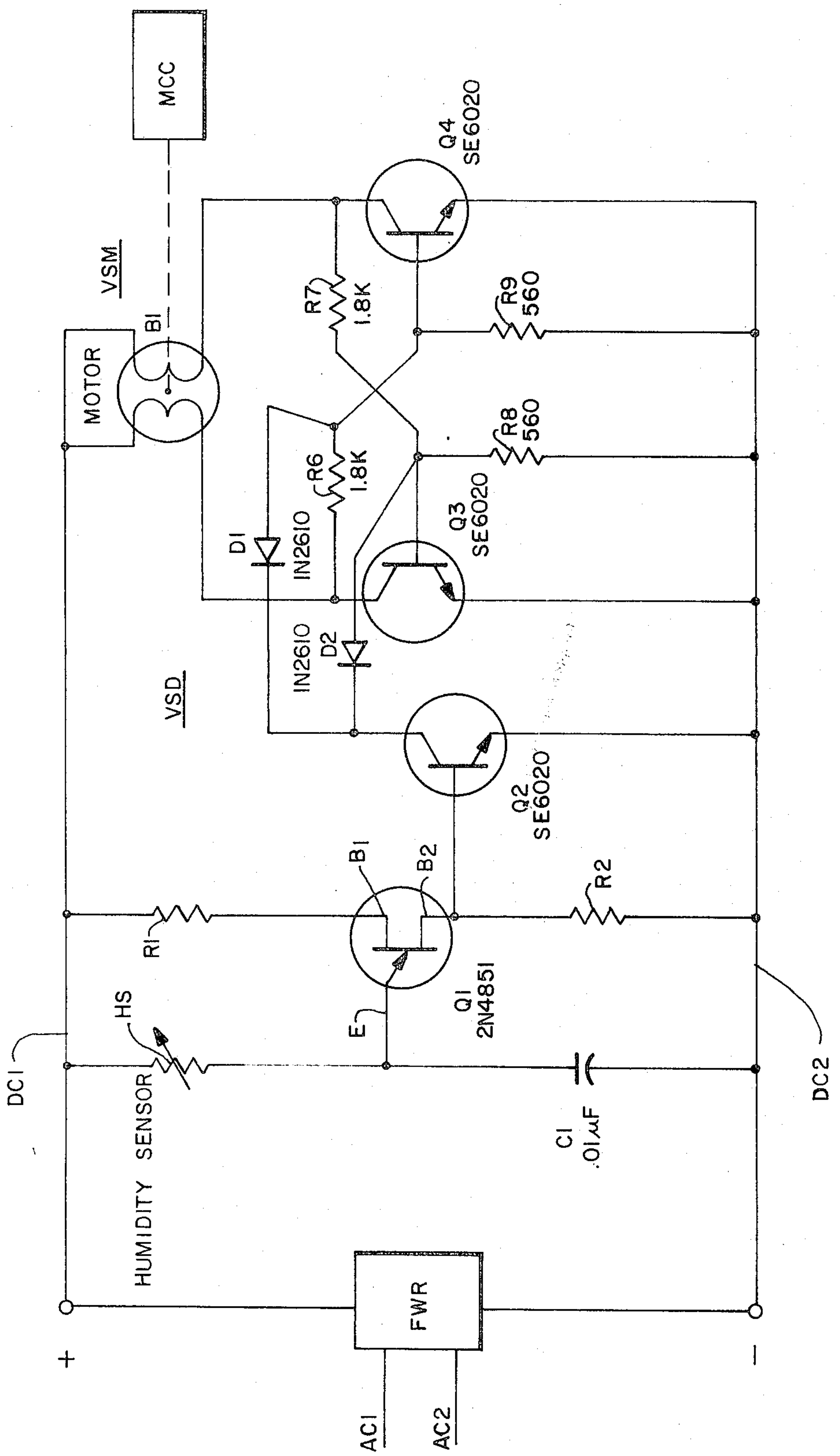

MCC
Q4
SE6020
VSM
MOTOR
B1
R7
1.8K
R9
560
R8
560
R6
1.8K
Q3
SE6020
D1
IN2610
D2
IN2610
VSD
Q2
SE6020
B1
B2
R2
R1
Q1
2N4851
E
HS
DC1
DC2
HUMIDITY SENSOR
C1
.01μF
FWR
+
−
AC1
AC2

FIG. 9

DEMAND DEFROST CONTROL SYSTEM

This invention relates to defrost cycle controllers for one or a plurality of refrigeration units and more particularly to a demand type defrost controller responsive to an ambient parameter common to one or more such units.

BACKGROUND OF THE INVENTION

Defrost controllers for one or a plurality of refrigeration units are known in the art for defrosting at regular timed intervals or on demand based upon the sensing of frost accumulation on the refrigeration coils of the refrigeration unit or units being controlled.

The timed initiation of defrost cycles with the use of thermal tripping to terminate those cycles and a maximum time interval of termination are also known.

Time controlled defrost cycles can be damaging to food and other perishables in the refrigeration units by initiating defrost cycles unnecessarily. Furthermore, such unnecessary initiation of defrost cycles results in increases in cost of power or energy to drive defrost heaters and re-initiate refrigeration cycles unnecessarily.

Prior art demand systems using the sensing of frost build-up as the controlling parameter for initiation of defrost cycles lack versatility in that in the control of large numbers of refrigeration units at common locations, power overloads can readily occur by the concurrent initiation or overlap of a number of defrost cycles requiring power in excess of proper rated loads for the power systems servicing those units.

The problem is further complicated by the fact that the designs of various refrigeration units result in varying individual defrost cycle requirements, thereby necessitating individual defrost controllers, either time or demand, for each freezer and further, necessitating that for each multiple installation of timed defrost units an empirical timing chart for that installation must be prepared and utilized to set the various individual controllers to preclude undue concurrent initiation and/or overlap of multiple defrost cycles.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide new and novel defrost control means for one or a plurality of refrigeration units which correlates the frequency of defrost initiation to the value of an ambient parameter common to said units.

Another object of the present invention is to provide new and novel demand defrost control means for one or a plurality of refrigeration units responsive to relative humidity to vary the rate of initiation of defrost cycles in said units.

Still another object of the present invention is to provide a new and novel demand defrost control system having a variable rate common controller for a plurality of refrigeration units.

Still another object of the present invention is to provide a new and novel demand defrost control system having a variable rate common controller for a plurality of refrigeration units and an individual defrost cycle timing and control means at each said refrigeration unit selectively controlled by said common controller to initiate a defrost cycle therethrough in response to a common ambient characteristic of said units.

Yet another object of the present invention is to provide a new and novel demand defrost control system for a plurality of refrigeration units which substantially precludes concurrent initiation and undue overlap of individual defrost cycles.

These and other objects of the present invention will become more fully apparent with reference to the following specification and drawings which relate to a preferred embodiment of the invention.

SUMMARY OF THE INVENTION

A central controller is provided comprising a multi-circuit cam switch means driven by a variable speed motor having its speed proportional to relative humidity. Each circuit cam controls the initiation of the defrost cycle of a separate refrigeration unit, each of the latter having a defrost control timer which is started by the respective cam switch.

Each defrost control timer is capable of terminating the initiated defrost cycle after the expiration of a fixed interval or upon the achievement of a given temperature or pressure limit as is known in the refrigeration art.

Each cam of the multi-circuit cam switch is programmed separately for a given refrigeration unit by placing an appropriate number of trippers on the cam. Although these cams are being driven at variable speed (as a function of relative humidity) and not as a function of time of day, the relative time of defrost initiation for each refrigeration units can be staggered or offset from that of the others by staggering the positions of the various cam trippers on the individual cams.

The trippers constrain the actuation of the corresponding defrost timers at the refrigeration units which timers initiate the defrost cycle for that unit. While the defrost cycle may terminate in response to sensed temperature or pressure conditions, the defrost timer will continue to run for a fixed interval to slave itself into a ready position for receipt of the next "initiate defrost cycle" command from the corresponding cam in the multi-circuit controller.

Thus, the variable speed multi-circuit controller determines the time between defrost cycle initiations and the localized defrost timers determine the length of the respective defrost cycles.

By-pass switch means are provided at the local defrost timers to preclude the effect of the multi-circuit timer and permit a defrost by time of day operating mode at any given refrigeration unit.

In the drawings:

The objects of the invention will become more fully apparent by reference to the following description of the drawings wherein like numerals refer to like parts and wherein:

FIGS. 1 and 1A, taken together, comprise is a schematic diagram of a demand defrost control system of the present invention controlling a group of refrigeration units;

FIG. 2 is a side elevational view of a variable speed control module of the present invention illustrating the pivot lever in the up position just prior to actuation thereof;

FIG. 3 is a side elevational view of the control module of FIG. 2 with the pivot lever in the down position just prior to deactivation thereof;

FIG. 4 is a partial view of the control module of FIG. 2 illustrating the ready position immediately proceeding the activation of the pivot lever;

FIG. 5 is a top plan view illustrating the details of the primary and secondary timing dials of the control modules of the present invention;

FIG. 6 is a side plan view illustrating further details of the dials of FIG. 5;

FIG. 7 is a partial sectional view of FIG. 2;

FIG. 8 illustrates a system including a plurality of juxtaposed timing modules of the present invention and a mounting frame therefor; and

FIG. 9 is a schematic of a variable speed drive control circuit of the present invention.

THE DEMAND DEFROST SYSTEM

Referring in detail to the drawings and with particular reference to FIGS. 1 and 1A, the demand defrost system 10 of the present invention is shown for controlling four refrigeration units RU1, RU2, RU3 and RU4 as an example of a multi-circuit application thereof.

Assuming a common situs for the refrigeration units RU1 --- RU4, such that substantially uniform conditions of relative humidity exist for the said units, a humidity sensor HS is shown as the input constraint for a variable speed drive means VSD (to be more fully described hereinafter) which drives a variable speed motor VSM at speeds proportional to the relative humidity of the situs of the refrigeration units RU1 --- RU4 as sensed by the humidity sensor HS.

The variable speed motor VSM drives a multi-circuit controller MCC having control cam means MCC1 --- MCC4 thereon for controlling, respectively, the initiation of defrost cycles for the refrigeration units RU1 --- RU4.

The variable speed drive means VSD is connected across alternating current leads AC1 and AC2 which are common to all the refrigeration units RU1 --- RU4.

The refrigeration unit RU1 has defrost and refrigeration controls typical of the other units RU2 --- RU4 and all like elements of the several units RU1 --- RU4 bear like designations with the appropriate suffices 1, 2, 3 and 4 designating the respective units RU1 --- RU4 to which they belong.

The refrigeration unit RU1 includes a defrost initiate switch SA1, a by-pass mode selection switch SBP1 and a slaving switch SB1 all connected in parallel from the alternating current power lead AC1 to one side of the defrost timer motor TM1. The opposite side of the timer motor TM1 is connected to the other power lead AC2.

A compressor control switch SC1 is connected from the power lead AC1 through a cold control thermostat CC1 or the like and an overload protection device OP1 to one side of a compressor drive motor CM1, the other side of the latter being connected to the other power lead AC2.

A defrost heater control switch SD1 is connected from the power lead AC1 to one side of a defrost heater DH1, the other side of the latter being connected to the other power lead AC2.

Connected across the defrost heater DH1 is a temperature or pressure responsive defrost termination switch TP1 in series with a defrost termination solenoid winding TS1. Thus, the switch TP1 and solenoid winding TS1 are in series with the defrost heater control switch SD1.

The first control cam MCC1 on the multi-circuit controller MCC drives the normally open defrost cycle initiation switch SA1 into closed position one or more times per given revolution by the control connection E1 schematically shown in broken lines.

The closing of the defrost initiate switch SA1 completes a circuit through the timing motor TM1 for a time at least sufficient for the said timing motor TM1 to close its sustaining and slave switch SB1 via the control connection F1 shown schematically in broken lines, which switch SB1 maintains the said timing motor running for a predetermined timed interval. The timing motor TM1 is a synchronous motor locked into the line frequency across the power leads AC1 and AC2.

Substantially simultaneously with the closing of the sustaining and slave switch SB1, the timing motor TM1, through control connection G1, shown schematically in broken lines, opens the normally closed compressor control switch SC1 and closes the normally open defrost heater control switch SD1. This initiates the defrost cycle in the first refrigeration unit RU1 by completing a circuit through the defrost heater DH1.

While the timing motor TM1 continues to run, the energization of the defrost heater DH1 causes the temperature to rise in the refrigeration unit RU1 until such time as the normally open temperature or pressure sensitive switch TP1 senses that sufficient defrost has been achieved.

At this point in time the switch TP1 closes, completing a circuit through the defrost heater switch SD1, and the termination solenoid winding TS1, thereby energizing the latter.

Energization of the termination solenoid coil TS1 actuates the control connection H1, schematically shown in broken lines, to open the defrost heater switch SD1 and close the compressor control switch SC1, thereby terminating the defrost cycle and initiating the cooling cycle in the refrigeration unit RU1.

In the meantime, because of the closure of the sustaining and slave switch SB1, the timing motor continues to run for a predetermined maximum interval until, via the control connection F1, it re-opens the slave switch SB1. This breaks the circuit to the timing motor TM1 and causes it to stop.

The control connection F1 by means of cams or other suitable timing means known in the art, is adjusted to open the sustaining and slave switch SB1 and thus stop the timing motor TM1 in a ready position for substantially immediate resumption of the defrost cycle and reclosure of the sustaining and slave switch SB1 upon the next closure of the defrost initiate switch SA1. Closure of the latter, as previously described, completes a circuit through the timing motor TM1 around the then open sustaining and slave switch SB1, causing the timing motor TM1 to start and reclose the said sustaining and slave switch SB1 via the control connection F1 for another period of time until the ready position previously described has been achieved and the sustaining and slave switch SB1 has been reopened.

A second predetermined maximum time interval for the defrost cycle is effected by the control connection G1, the latter acting to maintain the defrost heater switch SD1 closed and the compressor control switch SC1 open for that second interval in the event that the temperature or pressure sensitive switch TP1 does not cause the termination solenoid TS1 and its control connection H1 to override the control connection G1 and cause the said switches SC1 and SD1 to reverse the initial state constrained upon them by the control connection G1.

In further explanation of the operation, the control connection F1 is shown as including a timing cam F1A having a short duration rise and dwell portion F1B which cooperates with a cam follower F1C engaging the sustaining and slave switch SB1. Accordingly, when the timer motor TM1 is energized by the closure of the defrost initiate switch SA1 in the automatic mode (demand defrost) or by the by-pass switch SBP1 if the motor TM1 is to be driven in a timed defrost mode, the initial rotation of the cam F1A causes the follower F1C to drop off the rise F1B and close the sustaining and slave switch SB1.

When in the automatic mode, the defrost initiate switch SA1 is opened after a short period of time by the multi-circuit controller MCC (control cam MCC1) and thus, as the control cam F1A completes a full cycle via the connection F1 and timer motor TM1, the rise F1B engages the follower F1C and opens the sustaining and slave switch S1B, thereby stopping the timer motor TM1 in a ready position to resume another defrost cycle as constrained by the defrost initiate switch SA1 in the demand mode or the by-pass switch SBP1 if a timed defrost mode is desired.

The balance of the defrost timing control at the refrigeration unit RU1, namely, the timer motor TM1, control connection G1, compressor control switch SC1, defrost heater switch SD1 control linkage H1 and defrost termination solenoid TS1 are all embodied in commercially available defrost timers such as the 8140 Series of Paragon Electric Company, Inc., Two Rivers, Wis., described in Bulletin No. 374; 10 – 68, of that company. Such timers provide control interconnections for the cold control switch CC1, overload protection device OP1, compressor motor CM1, temperature or pressure switch TP1 and defrost heater DH1 as described with reference to FIG. 1.

As previously stated for other elements in FIG. 1 the control cam F1A, rise and dwell F1B and follower F1C are included in the refrigeration units RU2 – – – RU4 by proper suffix correlation and function in the same manner described in connection with the refrigeration unit RU1.

THE MULTI-CIRCUIT CONTROLLER

A multi-circuit controller MCC suitable for the present invention comprises a plurality of timing modules MCC1 – – – MCCN, each module including in combination: a rotary primary timing dial; a rotary secondary timing dial; drive shaft means coupled to said secondary dial for rotating the same; reduction gear train means for coupling said secondary dial to said primary dial; actuator means selectively disposed on each of said dials for initiating and terminating a timing cycle; a spring biased pivot lever having cam surfaces thereon for engaging said actuator means at selected time intervals; and switch means adapted for engagement with said pivot lever means in response to actuation thereof by said actuator means, said switch means initiating or terminating a timing cycle.

Each of said timing modules MCC1 – – – MCCN includes a support plate which may be removably snapped into place in a modular support frame. The respective modules are disposed side by side in said support frame and the drive shafts of the respective modules are releasably coupled together. The timing modules are interchangeable so that when one inoperative module is removed for repair, a replacement can be immediately installed.

Means are provided for programming the multiple module unit MCC so that only one timing module MCC1 – – – MCCN will initiate a timing cycle at any given time. This prevents the occurrence of an overload in the refrigeration defrost circuits being controlled.

The timer of the present invention is provided with a drive means comprising the variable speed electric motor VSM disposed on multiple timer module frame.

The timing modules MCC1 – – – MCCN described herein each initiate a defrost cycle in one freezer of a bank of freezers at predetermined relative times and include means for terminating this defrost initiation after a predetermined rotary displacement of the timing dials.

Referring in detail to FIGS. 2 to 7 there is shown a typical timing module MCC1 including a main support plate **26**. Support plate **26** is provided with notches **26A**, **26B**, **26C** for receiving module support bars **40A**, **40B** and **40C**, respectively, of a support frame to be more fully described hereinafter with respect to FIG. **8**. A spring biased lever **28** is pivotally mounted on support plate **26** and is provided with a notch **28A** for receiving support bar **40A** and latching plate **26** thereto. Lever **28** is spring biased toward the position shown so that when module MCC1 is placed on the respective support bars, bar **40A** will snap into the opening defined by notches **26A** and **28A** and will be retained therein by spring biased lever **28**.

The operative components of the timing module MCC1 generally include a secondary timing dial **12** mounted on a main drive shaft **34** journaled in plate **26**, a primary timing dial **14** mounted on shaft **14B** journaled in plate **26**, a micro-switch SA1 for initiating a defrost cycle, and a spring biased pivot lever **16** having cam surfaces thereon for constraining lever **16** to actuate microswitch SA1 in response to the engagement of the cam surfaces with actuator means disposed on the respective timing dials.

Timing dials **12** and **14** are coupled together by a reduction gear train including: pinion gear **36** affixed to drive shaft **34**; a first reduction gear **30** coupled to pinion gear **36** and having a pinion gear **30A** affixed thereto; a second reduction gear **32** coupled to pinion gear **30A**; and pinion gear **38** affixed to shaft **14B** of primary timing dial **14**. The variable speed motor means VSM is coupled to drive shaft **34** and energization of variable speed motor means VSM facilitates the simultaneous rotation of both secondary dial **12** and primary dial **14**. The reduction gear train is so designed that secondary dial **12** makes 12 revolutions for each revolution of primary dial **14**.

Primary dial **14** is provided with slots **14A** for selectively receiving substantially U-shaped loading actuator means **24**. For reasons that will become more fully apparent hereinafter with reference to FIG. **8**, slots **14A** may be spaced at positions corresponding to twelve equal intervals. Of course slots **14A** can be spaced at any other equally spaced intervals as required for various application. U-shaped actuator means **24** may be selectively inserted into any desired slot or slots **14A**. The operation of loading actuator **24** will be described hereinafter.

Secondary dial **12** mounted on drive shaft **34** includes a defrost-initiate-on actuating arm **48** and an end-defrost initiate actuating arm **42**. Arms **48** and **42** are provided with actuating pins **48A** and **42A**, respectively, for engaging cam surfaces **16E** and **16D** of pivot lever **16** in a manner to be more fully described hereinafter.

As shown most clearly in FIG. **6** defrost-initiate-on actuating arm **48** is pivotally mounted about a pin **48C** on the surface of dial **12** for movement in slot **46** defining a sector of the surface of circular dial **12**. A torsion spring **48B** is provided on pin **48C** and has a linear portion which extends into abutment with a post **50**. The arrangement of spring **48B** on pin **48C** is such that arm **48** is normally biased against post **50** but when placed under stress, arm **48** will move across slot **46** and engage boss **46A**. With arm **48** held against boss **46A** actuating pin **48A** is rigidly supported for engagement with cam surface **16E** of pivot lever **16**. As dial **12** rotates in a clock-wise direction pin **48A** will clear cam surface **16E** and snap back against post **50**. This snap action of arm **48** prevents pin **48A** from hanging up on cam surface **16E**.

As shown most clearly in FIG. **6** end-defrost-initiate actuating arm **42** is mounted for rotation on shaft **34** with respect to the surface of dial **12**. Dial **12** is provided with an annular ring of grooves **44** spaced at one minute increments. Arm **42** has a spring detent portion **42B** formed therein which may be selectively snapped into any selected groove **44** by rotating arm **42** about shaft **34**. By these means substantially any initiate-defrost time period may be selected in the range between zero and 2 hours, i.e., the duration of closure of the defrost initiate switch **SA1**. In actual practice this time is preselected to insure an initiation signal of sufficient length (i.e. interval of closure of SA1 – – – SA4) to permit the slave switches SB1 – – – SB4 of the corresponding refrigeration unit RU1 – – – RU4 to close under all conditions of relative humidity and thus dial speeds produced by the latter.

Actuating arm **42** is further provided with an actuating pin **42A** which is operatively associated with pivot lever **16** to engage cam surface **16E**, as dial **12** is rotated clock-wise to constrain lever **16** out of engagement with the defrost initiate micro-switch **SA1** to thereby terminate the defrost-initiate cycle.

Pivot lever **16** is mounted for rotation on a pivot pin **16F**, which is journaled in support plate **26**. A hole **26D** is provided in plate **26** and is operatively associated with a pin **16H** which extends from lever **16** into hole **26D** to limit the range of rotation of lever **16** about pivot pin **16F**. Stated another way the edges of hole **26D** function as stop means for lever **16** as it is rotated in either direction. Lever **16** is provided at the bottom thereof with a shoulder portion **16C** which rests in a groove in an over center C-spring **18**. C-spring **18** is so disposed that it will snap over center as lever **16** is rotated in a clock-wise direction to hold end portion **16B** of lever **16** in engagement with actuator buttons **SA1A** of micro-switch **SA1**.

Lever **16** is provided with a plurality of cam surfaces **16A**, **16D** and **16E** which are adapted to engage actuator means on dials **12** and **14**. Cam surface **16A** is adapted to engage actuators **24** as dial **14** is rotated in a counter-clockwise direction. The engagement of cam surface **16A** with actuators **24** constrains lever **16** to rotate clockwise to a ready position, as shown in FIG. **4**, which flexes C-spring **18** to approximately the center position thereof. Cam surface **16E** is adapted to engage actuating pin **48A** as dial **12** is rotated clockwise, which flexes C-spring **18** over center and pivots lever **16** in a clock-wise direction to thereby move end portion **16B** of lever **16** into engagement with buttons **SA1A** of defrost-initiate micro-switch **SA1**. Cam surface **16D** is adapted to engage actuating pin **42A** as dial **12** rotates in a clockwise direction. The engagement of pin **42A** with cam surface **16D** constrains lever **16** to rotate counter-clockwise, whereby C-spring **18** snaps back over center and **16B** rises from engagement with buttons **SA1A** of the defrost-initiate micro-switch **SA1**.

Referring to FIG. **5** there is shown a top plan view of dials **12** and **14** illustrating calibration marks and indicia thereon. Dial **12** is provided with marks and indicia comprising a scale **12A** thereon the increments of which correspond to settings of the defrost-initiate cycle on the dial. Arm **42** has a V-shaped notch **42C** therein to facilitate reading of the indicia corresponding to each selected setting. Dial **14** is provided with two scales **14C** and **14D**. Scale **14C** is provided adjacent notches **14A** to designate the time of day on a 24 hour clock to which each notch **14A** corresponds. The corresponding calibration marks on scales **14C** and **14D** are approximately 210° out of phase to allow for the distance between the top of dial **14** and the portion of dial **14** adjacent cam surface **16A**.

If driven by a synchronous motor at constant timed speed instead of by the variable speed drive motor VSM and the foregoing time intervals will be in absolute units of time. As previously disclosed, however, these intervals are relative intervals to the total intervals on the several dials. The time of day indicia on the dials provides a familiar relative reference for the user in setting up the multi-circuit controller MCC to effect a staggering of defrost cycle initiation in a multiplicity of refrigeration units RU1 – – – RUN.

Referring in detail to FIG. **8** there is shown a modular system including a plurality of timing modules MCC1 – – – MCCN mounted in a common support frame **54** including side plates **54A** and **54B** connected together by a plurality of transverse support bars **40A**, **40B** and **40C**.

The variable speed drive motor VSM is secured to the outside of a vertical plate **62** by screws or any other suitable means and is connected to a main drive shaft **56** journaled in plate **62**. A gear train **58** is coupled to drive shaft **56** and is housed in a space provided between side plate **54A** and vertical plate **62**. Gear train **58** has a stub **60** journaled in plate **54A** and is provided with a slot **60A** therein for receiving a stub **34A** on the drive shaft **34** of a first timing module **MCC1**.

An auxiliary variable speed drive motor VSM′ may be mounted on plate **54B** and may be energized simultaneously with variable speed motor VSM to drive the timing modules MCC1 – – – MCCN. Therefore, if either motor VSM or VSM′ should fail, the other motor will continue to drive timing modules MCC1 – – – MCCN without interruption. In the alternative variable speed motor VSM only could be initially energized and control means could be provided for energizing the auxiliary motor VSM′ upon failure of motor VSM.

As illustrated in FIG. 8 a plurality of timing modules MCC1 – – – MCC4 are disposed side by side in support frame 54 on support bars 40A, 40B and 40C. The drive shafts 34 of each respective timing module MCC1 – – – MCC4 are coupled together by the respective stubs 34A and slots 34B. The modular construction of FIG. 8 has the advantage that if one module must be removed for repair and no replacement is immediately available, then the modules can be shifted to fill the void without substantially interrupting the defrost-initiate timing cycles of the other modules.

In a preferred embodiment the spaced slots 14A of primary timing dial 14 of the adjacent timing modules are staggered so that no two timing modules can be set to trigger a defrost-initiate cycle at the same time. As shown in FIG. 8 from left to right, four timing modules are illustrated having slots provided which are staggered by 7½° of angular rotation from each other. The timing modules illustrated in FIG. 8 have U-shaped operators 24 inserted therein to facilitate the initiation of defrost cycles that are one-half hour apart if the primary dial 14 is turning one revolution per 24 hours representing the worse anticipated case of 60 percent relative humidity or 1½ hours apart if said primary dial 14 is turning one revolution per 72 hours representing the lowest anticipated relative humidity of 20 percent.

The purpose for staggering the slots 14A, as shown in FIG. 8, is to prevent more than one defrost heater DH1 – – – DH4 from turning on at any given time. If more than one heater could possibly turn on at a given time a fuze could blow out or a circuit breaker might be tripped, causing a power failure to the freezers RU1 – – – RU4 and resulting in the spoiling of frozen foods disposed in the freezers RU1 – – – RU4. In a large supermarket this could be a very costly accident. With the timing module system of FIG. 8, it is impossible for an operator to accidently set any two timing modules for the same defrost-initiate time, since no two timing modules are provided with spaced slots 14A at the same time settings. Therefore, the possibility of a power failure caused by more than one defrost heater DH1 – – – DH4 turning on at a given time is virtually eliminated.

The timing dials may of course be calibrated in smaller or larger increments and the slots 14A staggered in other relationships without departing from the spirit and scope of this invention. It should also be understood that although four timing modules MCC1 – MCC4 are illustrated in FIG. 8, any number of timing modules MCC1 – MCCN may be used commensurate with the number of freezers RU1 – – – RUN which need to be controlled.

For example, the support frames 54 of FIG. 8 could be constructed to hold four to eight individual timing modules and as many as three to eight frames 54 could be ganged together for controlling a plurality of freezers in a large supermarket. In this type of application it may be possible with slots staggered at 7½° angular intervals for more than one timer to turn on simultaneously. However, the number of timing cycles which may be simultaneously initiated is kept to a minimum. This can be minimized even further by staggering spaced slots 14A at smaller intervals, such as three and three quarter degree intervals or any other intervals which will give the desired result for the particular number of load devices being controlled.

The timing modules MCC1 – – – MCC4 may easily be inserted into support frame 54 by sliding slots 26C of plate 26 onto support bar 40C and pivoting plate 26 until slot 26B receives support bar 40B and spring biased lever 28 is snapped into place around support bar 40A. Modules MCC1 – MCC4 may be removed by lifting lever 28 to the position shown in dotted lines in FIGS. 2 and 3 and by pivoting support plate 26 in the opposite direction. This modular construction enables an operator to quickly replace or add a timing module to the system in a minimum amount of time with minimum effort.

DESCRIPTION OF OPERATION

The relative point in time at which a defrost cycle is to begin is chosen by inserting one or more U-shaped operators 24 into selected slots 14A in primary timing dial 14. The period of duration of the defrost-initiate cycle is then chosen by positioning end-defrost-initiate actuating arm 42 at a selected position on the secondary dial 12. Any defrost-initiate period (i.e., period of closure of the defrost-initiate switches SA1 – – – SA4), within the range of the secondary dial 12 may be selected.

A timing cycle then begins by energizing the variable speed drive motor VSM which causes drive shaft 34 coupled to secondary timing dial 12 to rotate in a clockwise direction. The rotary force of timing dial 12 is transferred to primary timing dial 14 by way of the reduction gear train including gears 36, 30, 30A, 32, 38 and causes timing dial 14 to rotate in a counterclockwise direction. Dial 14 rotates at one-twelfth the speed of dial 12. Stated another way dial 12 makes 12 complete revolutions for every single revolution of the primary dial 14.

As timing dial 14 rotates operator 24 will come into contact with cam surface 16A of pivot lever 16, as shown in FIG. 4. This position may be designated the ready position, because as operator 24 pushes against cam surface 16A, lever 16 begins to pivot in a clockwise direction until C-spring 18 is displaced approximately to the center position thereof where it is ready to be pushed over center by actuating pin 48A. At substantially the same time actuating pin 48A of spring biased pivot arm 48 comes into contact with cam surface 16E on bottom surface of the tab extending from the rear of pivot lever 16.

As dial 12 continues to rotate arm 48 traverses slot 46 in the surface of dial 12 until it rigidly abuts boss 46A, as shown in FIG. 2. When this occurs pin 48A pulls upwardly on cam surface 16E causing spring 18 to snap over center, thereby rotating lever 16 clockwise against push buttons SA1A of the defrost-initiate switch SA1 as illustrated in FIG. 3. Micro-Switch SA1 is connected in circuit with the timer motor TM1 as previously described with reference to FIG. 1.

As spring 18 snaps over center and pivot lever 16 moves into engagement with defrost-initiate micro-switch SA1, spring biased arm 48 snaps clear of pivot lever 16 to a position against post 50.

Lever 16 will remain in the position shown in FIG. 3 until actuating pin 42A on end-defrost-initiate actuating arm 42 rotates into engagement with the upper surface 16D of the tab extending from the rear of lever 16. As pin 42A engages surface 16D it constrains lever 16 to rotate counter clockwise, thereby lifting lever 16 from engagement with defrost-initiate switch SA1 and terminating the defrost-initiate cycle. The timing dials 12 and 14 continue to rotate until the next cycle is initiated in a like manner.

If it is desired to control the defrost cycles of a plurality of freezers such as in a supermarket or warehouse, a plurality of timing modules MCC1 – – – MCC4 are provided in a common support frame 54, as shown in FIG. 8, and the respective microswitches SA1 – – – SA4 are connected to the separate defrost circuits (at RU1 – – – RU4). All of the timing modules are driven by the common variable speed motor VSM.

In programming a multi-circuit defrost timer of the type shown in FIG. 8 it is important to assure that only one defrost cycle is initiated at any given time. Therefore, as stated with respect to the description of FIG. 8, the slots 14A of the adjacent timing modules MCC1 – – – MCC4 are staggered to prevent an erroneous setting of the modules by an operator. With the slots provided as shown in FIG. 8, it is impossible to set any two timing modules for the initiation of a defrost cycle at the same time.

Referring to the operation of FIG. 8 an operator may select the defrost cycles for the respective modules and freezers being controlled by selectively inserting operators 24 into slots 14A on primary timing dials 14. The duration of each defrost-initiate cycle is then set by positioning arm 42. The arms 42 of the respective timing modules may be set at selected positions to effect defrost-initiate cycles of compatible length with the energization of the respective timing motors TM1 – – – TM4 as controlled by the sustaining and slave switches SB1 – – – SB4. As drive shaft 56 rotates each respective module goes through a timing cycle as described above.

THE VARIABLE SPEED DRIVE

Referring to FIG. 9 there is illustrated a variable speed drive circuit generally indicated VSD for a variable speed A.C. hysteresis motor VSM, which is adapted to drive multi-circuit timer MCC. The function of control circuit VSB is to vary the speed of motor VSM as a function of changes in ambient relative humidity sensed by humidity sensor HS.

A D.C. bias voltage is provided for variable speed drive VSD through A.C. supply lines AC1, AC2, and full wave rectifier FWR to D.C. supply lines DC1 and DC2.

Motor VSM is provided with a bifilar wound coil B1 having two parallel branches each consisting of one half the turns of coil B1 for driving motor VSM. D.C. power is supplied to coil B1 from line DC1. The parallel branches of coil B1 are connected in circuit with the collectors of transistors Q3 and Q4, respectively.

Transistors Q3 and Q4 are connected for alternate conduction in a conventional bistable multivibrator configuration wherein the collector of transistor Q3 is coupled to the base of transistor Q4 through resistor R6 and the collector of transistor Q4 is coupled to the base of transistor Q3 through resistor R7. The bases of transistors Q3 and Q4 are coupled to a common emitter junction at DC2 through resistors R8 and R9, respectively.

Because of the coil inductance of B1 in the collector circuits of transistors Q3 and Q4, the multivibrator will free run as an RL multivibrator to drive motor VSM. The multivibrator can be triggered by momentarily connecting both bases of transistors Q3 and Q4 to their emitters through diodes D1, D2 and buffer amplifier transistor Q2.

The multivibrator circuit will free run as a function of the back EMF of the transformer action of the motor coil B1 which acts as a transformer. This transformer action only permits a gradual build-up of motor coil current compared to the apparent impedance of the coil itself.

The transformer action of the coil B1 acts as a memory for the multivibrator to enable the multivibrator to recall which of the transistors Q3 and Q4 was "on" and which transistor was "off." As motor drive current flows through one branch of the coil B1 it acts as a transformer primary and the other branch acts as a transformer secondary. The secondary furnishes an exponential base drive current to the "on" transistor. During the latter part of the exponential current drive pulse, the following value of di/dt causes the "on" transistor to come out of saturation and start towards cut-off. The collector current of the "on" transistor changes at a slower pace due to the motor inductance. The motor current is then diverted from the "on" transistor collector to the "off" transistor base, thus turning it "on." This transistor is regenerative and ends with the formerly "on" transistor cut off and the "off" transistor saturated.

The multivibrator including transistors Q3 and Q4 can be driven synchronously by pulses furnished through transistor Q2 by a unijunction relaxation oscillator Q1 to be described hereinafter. The pulses are supplied by the unijunction at rate which varies with the ambient relative humidity sensed by humidity sensor HS.

Transistor Q2 is provided with the base thereof connected in circuit with base B2 of a unijunction transistor Q1. Transistor Q1 is connected in a relaxation oscillator configuration including: a variable resistor HS connected between DC1 and the emitter or gate E of unijunction Q1; a timing capacitor C1 connected between the emitter E and DC2; a biasing resistor R1 connected between DC1 and base B1; and biasing resistor R2 connected between base B2 and DC2. Humidity sensor resistor HS and capacitor C1 determine the RC time constant and frequency of the oscillator. Therefore, the frequency of the unijunction oscillator will vary with changes in ambient relative humidity. Base B2 of unijunction transistor Q1 is connected to the base of transistor Q2 to turn Q2 on and off at a rate determined by the frequency of the oscillator.

Although transistors Q2, Q3 and Q4 are disclosed as NPN transistors it should be understood that PNP transistors could be used in the alternative by reversing the polarity of the D.C. supply without departing from the spirit and scope of this invention.

In operation motor VSM and multi-circuit timer MCC are driven at a rate determined by the alternate conduction of transistors Q3 and Q4 which are driven in synchronism with the frequency of pulses supplied by unijunction transistor Q1 through transistor Q2 and diodes D1, D2. Since the frequency of the unijunction transistor oscillator Q1 varies with changes in relative humidity sensed by resistor HS, the speed of motor VSM and the drive shaft of multi-circuit timer MCC will also vary with changes in relative humidity. Therefore, the rate of occurrence of defrost cycles can be varied as a function of changes in the relative humidity of the air surrounding the freezers to be controlled.

SUMMARY OF OPERATION

If actual time of day on the multi-circuit controller MCC and its modules MCC1 - - - MCC4 etc., is chosen to represent the worst conditions of relative humidity and temperature ambient to refrigeration units RU1 - - - RU4 etc., to be controlled by the demand defrost system **10**, then better conditions of relative humidity and temperature will result in a slower drive speed of the variable speed motor VSM as constrained by the humidity sensor HS and the variable speed drive circuit VSD. This will result in a lesser number of defrost cycle initiations over a given 24 hour period and a more efficient operation of the refrigeration units RU1 - - - RU4.

Accordingly, if the primary dial **14** on each control module MCC1 - - - MCC4 is provided with six trippers **24**, appropriately staggered between modules to preclude simultaneous defrost initiation as previously described, the minimum interval between defrost cycle initiations would be 4 hours.

Accordingly, under these assumptions, the timer motors TM1 - - - TM4 in the refrigeration units RU1 - - - RU4, by appropriate drive ratios to the control cams F1A - - - F4A, can be constrained to maximum energization cycles of 4 hours (i.e., one revolution of the said cams F1A - - - F4A for 4 hours subsequent to closure of the defrost initiate switches SA1 - - - SA4 by the pivot levers **16** of the respective control modules MCC1 - - - MCC4), which interval will place the timer motors TM1 - - - TM4 and their respective sustaining and slave switches SB1 - - - SB4 in the ready position for all anticipated defrost initiation constraints from the multi-circuit controller MCC.

Thus, upon the receipt of a defrost initiation command, i.e. closure of a defrost-initiate switch SA1 - - - SA4, the respectively associated timer motor TM1 - - - TM4 will run for 4 hours, then stop and wait for the next defrost initiation signal from the appropriate control module MCC1 - - - MCC4.

The actual defrost cycle in a given refrigeration unit RU1 - - - RU4 is not 4 hours, but is controlled either by the termination solenoids TS1 - - - TS4 and the control connections H1 - - - H4 (and their related temperature or pressure sensitive switches TP1 - - - TP4) or by the maximum defrost interval set on the defrost control switch SD1 - - - SD4 via the respective control connections G1 - - - G4 as is known in the art for commercially available defrost control timers.

Thus, the variable speed motor VSM and the multi-circuit controller MCC controls the time between the initiation of the respective defrost cycles and the constant speed time motors TM1 - - - TM4 determine the length of the defrost period for the refrigeration units RU1 - - - RU4 subject to earlier termination by the termination solenoids TS1 - - - TS4.

If a non-demand (regularly timed) defrost mode is desired for any given one of the refrigeration units RU1 - - - RU4 is desired, then the appropriate by-pass switch SBP1 - - - SBP4 is shifted from the open (AUTO) position to the closed or manual (MAN) position to remove the constraint of the multi-circuit controller MCC from that particular refrigeration unit RU1 - - - RU4 by shunting the defrost-initiate switches SA1 - - - SA4 and the sustaining and slave switches SB1 - - - SB4. This permits the appropriate one of the timer motors TM1 - - - TM4 to run continuously, synchronized to actual time of day and control the defrost cycles of its associated refrigeration unit RU1 - - - RU4 according to actual time between defrost cycles.

What is claimed is:

1. Means controlling defrost cycles of at least one refrigeration unit having defrost and refrigeration means in response to the demand constraint of an ambient parameter, comprising:

transducer means sensing said ambient parameter and providing a variable speed drive output as a function thereof;

control means driven by said drive output;

constant speed drive means;

first means responsive to said control means energizing said constant speed drive means for a first predetermined interval;

second means responsive to said constant speed drive means maintaining the latter energized for a second predetermined interval; and

third means responsive to said constant speed drive means actuating said defrost means and precluding actuation of said refrigeration means for a third predetermined interval.

2. The invention defined in claim **1**, wherein said ambient parameter comprises relative humidity.

3. The invention defined in claim **1**, wherein said transducer means includes ambient parameter sensing means, variable frequency oscillator means providing a variable frequency output as a function of said ambient parameter, and variable speed motor means responsive to said variable frequency output comprising said variable speed drive output.

4. The invention defined in claim **3**, wherein said ambient parameter comprises relative humidity;

and said ambient parameter sensing means comprises variable impedance means responsive to changes in relative humidity.

5. The invention defined in claim **1**, wherein said control means comprises periodic switch actuating means;

said first means comprises first switch means;

said second means comprises second switch means in parallel with said first switch means and cam means contrlling same, said cam means being driven by said constant speed drive means; and

said third means comprises third and fourth complimentary switch means energizing and de-energizing, respectively, said defrost means and said refrigeration means and vice-versa.

6. The invention defined in claim **5**, wherein said ambient parameter comprises relative humidity.

7. The invention defined in claim **5**, wherein said transducer means includes ambient parameter sensing means, variable frequency oscillator means providing a variable frequency output as a function of said ambient parameter, and variable speed motor means responsive to said variable frequency output comprising said variable speed drive output.

8. The invention defined in claim **7**, wherein said ambient parameter comprises relative humidity;

and said ambient parameter sensing means comprises variable impedance means responsive to changes in relative humidity.

9. The invention defined in claim **1**, wherein said defrost controlling means further includes:

override means responsive to an internal parameter of a said refrigeration unit constraining said third means to deactuate said defrost means and actuate said refrigeration means prior to the expiration of said third predetermined interval in response to a predetermined value of said internal parameter.

10. The invention defined in claim **9**, wherein said ambient parameter comprises relative humidity.

11. The invention defined in claim **9**, wherein said transducer means includes ambient parameter sensing means, variable frequency oscillator means providing a variable frequency output as a function of said ambient parameter, and variable speed motor means responsive to said variable frequency output comprising said variable speed drive output.

12. The invention defined in claim **11**, wherein said ambient parameter comprises relative humidity;

and said ambient parameter sensing means comprises variable impedance means responsive to changes in relative humidity.

13. The invention defined in claim **9**, wherein said control means comprises periodic switch actuating means;

said first means comprises first switch means;

said second means comprises second switch means in parallel with said first switch means and cam means controlling same, said cam means being driven by said constant speed drive means; and

said third means comprises third and fourth complimentary switch means energizing and de-energizing, respectively, said defrost means and said refrigeration means and vice-versa.

14. The invention defined in claim **13**, wherein said ambient parameter comprises relative humidity.

15. The invention defined in claim **13**, wherein said transducer means includes ambient parameter sensing means, variable frequency oscillator means providing a variable frequency output as a function of said ambient parameter, and variable speed motor means responsive to said variable frequency output comprising said variable speed drive output.

16. The invention defined in claim **15**, wherein said ambient parameter comprises relative humidity;

and said ambient parameter sensing means comprises variable impedance means responsive to changes in relative humidity.

17. Means controlling defrost cycles of at least one refrigeration unit having defrost and refrigeration means in response to the demand constraint of an ambient parameter, comprising:

variable speed motor means having means for providing a defrost initiation constraint at periodic intervals varied as a function of the value of said ambient parameter;

constant speed motor means responsive to said defrost initiation constraint initiating actuation of said defrost means to the exclusion of said refrigeration means for a predetermined maximum interval; and

said defrost means including override means for deactuating and actuating said refrigeration means prior to the expiration of said predetermined interval in response to an internal parameter of said refrigeration unit.

18. The invention defined in claim **17**, wherein said constant speed means includes sustaining and slave means indexing same to a ready condition for response to said defrost initiation constraint prior to the end of the current one of said periodic intervals.

19. The invention defined in claim **17**, wherein said ambient parameter comprises relative humidity.

20. The invention defined in claim **18**, wherein said ambient parameter comprises relative humidity.

21. Means controlling defrost initiation cycles of a plurality of refrigeration units, each such unit having refrigeration and defrost means, in response to the demand constraint of an ambient parameter common to said units, comprising:

variable speed motor means including means for providing defrost initiation constraints for each of said units at staggered periodic intervals to substantially preclude simultaneous initiation of defrost cycles in two or more of said units, said periodic intervals being varied as a function of the value of said ambient parameter;

constant speed motor means in each of said units responsive to respective defrost initiation constraints from said variable speed means initiating actuation of said defrost means to the exclusion of said refrigeration means in each of said units for a predetermined maximum interval; and

override means in each of said units for deactuating said defrost means and actuating said refrigeration means in a said unit prior to the expiration of said predetermined interval in response to an internal parameter of the corresponding said unit.

22. The invention defined in claim **21**, wherein each said constant speed means includes sustaining and slave means indexing same to a ready condition for response to the corresponding ones of said defrost initiation constraints prior to the end of each corresponding current one of said periodic intervals.

23. The invention defined in claim **21**, wherein said ambient parameter comprises relative humidity.

24. The invention defined in claim **22**, wherein said ambient parameter comprises relative humidity.

25. Means controlling defrost cycles of a plurality of refrigeration units, each such unit having refrigeration and defrost means, in response to the demand constraint of an ambient parameter common to said units, comprising:

transducer means common to said units sensing said ambient parameter and providing a variable speed drive output as a function thereof;

control means common to said units driven by said drive output and providing defrost initiation constraints for each of said units at staggered periodic intervals to substantially preclude simultaneous initiation of defrost cycles in two or more of said units, said periodic intervals being varied as a function of the value of said ambient parameter;

constant speed drive means in each of said units;

first means in each of said units, responsive to correlated ones of said periodic defrost initiation constraints, energizing the correlated one of said constant speed drive means for a first predetermined interval;

second means in each of said units responsive to the correlated one of said constant speed drive means maintaining the latter energized for a second predetermined interval; and

third means in each of said units responsive to the correlated one of said constant speed drive means actuating the correlated one of said defrost means and precluding actuation of the correlated one of said refrigeration means for a third predetermined interval.

26. The invention defined in claim **25,** wherein said ambient parameter comprises relative humidity.

27. The invention defined in claim **25,** wherein said transducer means includes ambient parameter sensing means, variable frequency oscillator means providing a variable frequency output as a function of said ambient parameter, and variable speed motor means responsive to said variable frequency output comprising said variable speed drive output.

28. The invention defined in claim **27,** wherein said ambient parameter comprises relative humidity;

and said ambient parameter sensing means comprises variable impedance means responsive to changes in relative humidity.

29. The invention defined in claim **25,** wherein said control means comprises a plurality of periodic switch actuating means corresponding one to each said refrigeration unit;

said first means comprises first switch means;

said second means comprises second switch means in parallel with said first switch means and cam means controlling same, said cam means being driven by the correlated one of said constant speed drive means; and

said third means comprises third and fourth complimentary switch means energizing and deenergizing, respectively, the correlated ones of said defrost and refrigeration means and vice-versa.

30. The invention defined in claim **29,** wherein said ambient parameter comprises relative humidity.

31. The invention defined in claim **29,** wherein said transducer means includes ambient parameter sensing means, variable frequency oscillator means providing a variable frequency output as a function of said ambient parameter, and variable speed motor means responsive to said variable frequency output comprising said variable speed drive output.

32. The invention defined in claim **31,** wherein said ambient parameter comprises relative humidity;

and said ambient parameter sensing means comprises variable impedance means responsive to changes in relative humidity.

33. The invention defined in claim **25,** wherein said defrost controlling means further includes, in each said unit:

override means responsive to an internal parameter of the correlated one of said units constraining the correlated one of said third means to deactuate and actuate, respectively, the correlated ones of said defrost and refrigeration means prior to the expiration of said third predetermined interval in response to a predetermined value of said internal parameters.

34. The invention defined in claim **33,** wherein said ambient parameter comprises relative humidity.

35. The invention defined in claim **33,** wherein said transducer means includes ambient parameter sensing means, variable frequency oscillator means providing a variable frequency output as a function of said ambient parameter, and variable speed motor means responsive to said variable frequency output comprising said variable speed drive output.

36. The invention defined in claim **35,** wherein said ambient parameter comprises relative humidity;

and said ambient parameter sensing means comprises variable impedance means responsive to changes in relative humidity.

37. The invention defined in claim **33,** wherein said control means comprises a plurality of periodic switch actuating means corresponding one to each said refrigeration unit;

said first means comprises first switch means;

said second means comprises second switch means in parallel with said first switch means and cam means cntrolling same, said cam means being driven by the correlated one of said constant speed drive means; and

said third means comprises third and fourth complimentary switch means energizing and deenergizing, respectively, the correlated ones of said defrost and refrigeration means and vice-versa.

38. The invention defined in claim **37,** wherein said ambient parameter comprises relative humidity.

39. The invention defined in claim **38,** wherein said transducer means includes ambient parameter sensing means, variable frequency oscillator means providing a variable frequency output proportional to said ambient parameter, and variable speed motor means responsive to said variable frequency output comprising said variable speed drive output.

40. The invention defined in claim **39,** wherein said ambient parameter comprises relative humidity;

and said ambient parameter sensing means comprises variable impedance means responsive to changes in relative humidity.

41. Means controlling defrost cycles of at least one refrigeration unit having defrost and refrigeration means in response to the demand constraint of an ambient parameter, comprising:

transducer means sensing said ambient parameter and providing a variable speed drive output as a function thereof;

control means driven by said drive output;

constant speed drive means;

first means responsive to said control means energizing said constant speed drive means for a first predetermined interval;

second means responsive to said constant speed drive means maintaining the latter energized for a second predetermined interval; and

third means responsive to said constant speed drive means actuating said defrost means and precluding actuation of said refrigeration means for a third predetermined interval; and

by-pass means selectively disabling said first and second means, constraining said constant speed means to drive continuously and control said defrost and refrigeration means as a function of time and said third means.

42. The invention defined in claim **41,** wherein said defrost controlling means further includes:

override means responsive to an internal parameter of a said refrigeration unit constraining said third means to deactuate said defrost means and actuate said refrigeration means prior to the expiration of said third predetermined interval in response to a predetermined value of said internal parameter.

43. Means controlling defrost cycles of a plurality of refrigeration units, each such unit having refrigeration and defrost means, in response to the demand constraint of an ambient parameter common to said units, comprising:

transducer means common to said units sensing said ambient parameter and providing a variable speed drive output as a function thereof;

control means common to said units driven by said drive output and providing defrost initiation constraints for each of said units at staggered periodic intervals to substantially preclude simultaneous initiation of defrost cycles in two or more of said units, said periodic intervals being varied as a function of the value of said ambient parameter;

constant speed drive means in each of said units;

first means in each of said units, responsive to correlated ones of said periodic defrost initiation constraints, energizing the correlated one of said constant speed drive means for a first predetermined interval;

second means in each of said units responsive to the correlated one of said constant speed drive means maintaining the latter energized for a second predetermined interval;

third means in each of said units responsive to the correlated one of said constant speed drive means actuating the correlated one of said defrost means and precluding actuation of the correlated one of said refrigeration means for a third predetermined interval; and

by-pass means in each of said units selectively disabling correlated ones of said first and second means, constraining the correlated one of said constant speed means to drive continuously and control the correlated ones of said defrost and refrigeration means as a function of time and said third means.

44. The invention defined in claim **43,** wherein said defrost controlling means further includes, in each said unit:

override means responsive to an internal parameter of the correlated one of said units constraining the correlated one of said third means to deactuate and actuate, respectively, the correlated ones of said defrost and refrigeration means prior to the expiration of said third predetermined interval in response to a predetermined value of said internal parameters.

45. Means controlling defrost initiation cycles of a plurality of refrigeration units, each such unit having refrigeration and defrost means, in response to the demand constraint of an ambient parameter common to said units, comprising:

variable speed means providing defrost initiation constraints for each of said units at staggered periodic intervals to substantially preclude simultaneous initiation of defrost cycles in two or more of said units, said periodic intervals being varied as a function of the value of said ambient parameter; and

constant speed means in each of said units responsive to respective defrost initiation constraints from said variable speed means initiating actuation of said defrost means to the exclusion of said refrigeration means in each of said units for a predetermined maximum interval.

46. The invention defined in claim **45,** wherein said constant speed means includes sustaining and slave means indexing same to a ready condition for response to said defrost initiation constraint prior to the end of the current one of said periodic intervals.

47. The invention defined in claim **46,** wherein said ambient parameter comprises relative humidity.

48. The invention defined in claim **45,** wherein said ambient parameter comprises relative humidity.

* * * * *