

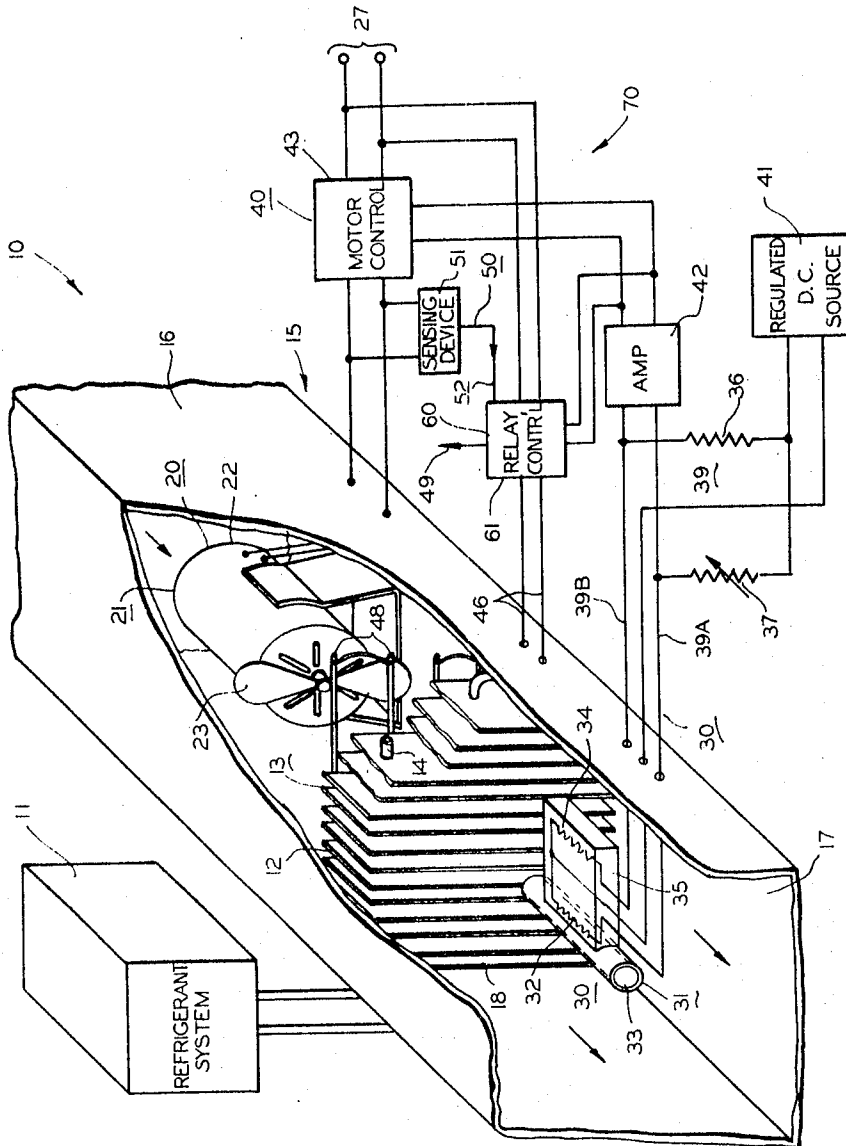
Sept. 2, 1969

S. V. SWANSON

3,464,224

MEANS AND METHOD FOR CONTROLLING A REFRIGERATION SYSTEM

Filed Dec. 22, 1967



INVENTOR

SVEN V. SWANSON

BY

R J Falbowski

ATTORNEY

1

3,464,224

MEANS AND METHOD FOR CONTROLLING A REFRIGERATION SYSTEM

Sven V. Swanson, Niles, Mich., assignor to Clark Equipment Company, a corporation of Michigan
Filed Dec. 22, 1967, Ser. No. 692,868

Int. Cl. F25d 17/06, 21/02

U.S. Cl. 62—80

12 Claims

ABSTRACT OF THE DISCLOSURE

A refrigeration system comprises duct structure for carrying refrigerated air through cooling coils cooled by a refrigerant system. A motor driven fan is located within the duct to circulate air from a refrigeration storage portion of the refrigeration system through the refrigerating coils. The fan speed is controlled to maintain a minimum velocity through the cooling coils as frost builds up on the coils. When the coils become covered with frost to a degree that the maximum operable speed of the fan cannot maintain the required velocity through the coils, the system is defrosted.

This invention relates to a means for controlling refrigeration systems, particularly to controlling means that sense the amount of frost accumulation in a refrigeration system and defrost the system when the accumulation of frost reaches a level where the system is unable to maintain the desired refrigeration temperatures.

One of the significant problems in operating refrigeration systems is the determining of the time to defrost the system to remove accumulated frost. Most practical systems require periodic defrost and many different approaches are utilized to determine when this frost should be removed. Most of these approaches do not operate in response to frost accumulation, but are related to time or the counted occurrences of repetitive events. Since it is desirable to defrost the system as seldom as possible, the preferred way to achieve this is by defrosting only when it is physically necessary.

With this invention, defrosting occurs only when required to provide an interval between defrosts that is as great as possible for the existing operating conditions. This is accomplished generally by changing the heat transfer characteristics of the cooling system as frost accumulates by maintaining a minimum, or increasing, air velocity through the refrigeration coils to maintain the desired heat transfer characteristics. When the frost has accumulated to the point where even the maximum design air velocity is unable to maintain the necessary heat transfer rate to maintain the desired temperatures, the system automatically defrosts.

The drawing is a simplified schematic of a duct portion of a refrigeration system that supplies refrigerated air to a portion of the system that has material to be refrigerated, and a control system that is utilized to control the operation of the defrosting refrigeration cycle in accordance with this invention.

Referring to the figure, a duct portion 15 of a refrigeration system 10 receives air from a refrigerating box (not shown), or other structure that stores material to be refrigerated, at an inlet 16, circulates the air through duct portion 15 over a cooling means 12 contained therein, and discharges the air through an outlet 17 back to the refrigerating box. The duct portion shown, or variations thereof, can be used with most refrigerating systems by adjusting the form or shape for a particular installation.

Refrigeration system 10 contains air cooling means 12, a means for circulating air 20, a means for sensing air velocity 30, a means for controlling the means for circulating

2

air 40, a means for sensing the force level of the means for circulating air 50, and a means for defrosting the refrigeration system 60.

Air cooling means 12 comprises a refrigerant circulating system 11, shown as a box exemplifying any type of refrigerant system known in the art, that provides refrigerant to a heat transfer device, such as a refrigeration coil 13, having tubes 14 and fins 18, constructed to operate with the refrigerant circulating system to cool the air passing through the refrigeration coil.

Means for circulating air 20 comprises duct structure 15, that may be of any required shape and size for any particular application, an air circulating device or assembly 21, such as an electric motor 22 and a fan 23, mounted within duct structure 15 to move the air from inlet 16 to outlet 17. Motor 22 is of a type that has a variable speed controlled by varying the electrical energy received from an electrical source 27.

Means for circulating air 20 supplies pressurized air at a desired force level to refrigeration coils 13. In a typical motor and fan installation this is accomplished by increasing the speed of rotation of the fan to provide air at a desired force or pressure level.

Means for sensing air velocity 30 operates to measure the velocity of the air passing through refrigeration coil 13, and comprises a thermistor air velocity sensing assembly 31 mounted to duct structure 15. Sensing assembly 31 includes a thermistor 32 connected as part of an electrical resistance bridge 39 and mounted in a tube 33 that exposes it to the air moving through refrigeration coil 13, and a thermistor 34 mounted within a case 35 made of plastic or other suitable material in any manner known in the art. In addition to thermistors 31 and 33, bridge circuit 39 also comprises a resistor 36 and a variable resistor 37 for balancing the bridge at the desired air temperature and air velocity in the refrigeration system. Electrical energy for thermistor bridge circuit 39 is supplied from a regulated direct current source 41 that can be of any suitable type known in the art. The output signal, typically a voltage signal, of the thermistor bridge is taken between conductors 39A and 39B and applied to an amplifier 42 that may be of any suitable type able to amplify the output signal from the thermistor bridge to the level and with the linearity necessary to successfully operate the subsequent circuitry in a control system 70.

The amplified output signal from amplifier 42 is applied to means for controlling the means for circulating air 40 which comprises a motor control 43 which may be of any type known in the art that varies the electrical energy delivered to the motor in response to an input control signal, such as a varying input voltage. In this embodiment, motor control 43 increases the speed of motor 22 as the output of amplifier 42 increases in signal level.

In this embodiment, a means for sensing the force level of the circulated air is a sensing device 51 connected to motor control 43 that senses the power produced by motor 22 by sensing the amount of electrical energy delivered to motor 22 to produce a control signal when motor 22 reaches a preselected maximum speed of rotation. The sensing control signal is applied to a relay control, as illustrated by line 52, to control a means for defrosting 60. This function is not necessary but may be used in some applications.

Means for defrosting the system 60 comprises relay control 61, of any type known in the art that responds to a signal, or voltage level, to energize or deenergize selected electrical circuits. In this embodiment, relay control 61 energizes and deenergizes heating elements 48 through conductors 46. Heating elements 48 are placed adjacent refrigeration coil 13 and are turned on by relay control 61 during the defrosting period. Relay control

61 also controls refrigerant system 11, as schematically illustrated by line 49, in any known manner. When the output signal from amplifier 42 reaches a preselected level, relay control 61 turns off the refrigerant system and turns on the heaters. If desired, relay control 61 may operate to defrost only when the amplifier output signal is above a selected level and the sensing device signal, along line 52, indicates the motor is operating at the selected maximum speed.

In the operation of this system, assuming starting of operation with the refrigeration system and coil free of frost, the system is energized with motor 22 from source 27 through motor control 43 to turn on at a minimum force level, or speed of rotation. The air from the refrigeration box is drawn into duct portion 15 through inlet 16, through refrigeration coil 13, and out through outlet 17 with a portion of the air passing through tube 33 of thermistor sensing block 31 to cool thermistor 32. Thermistor bridge 39 is adjusted to provide the desired relationship between signal to amplifier 42 and the air velocity, but typically the system is balanced by adjusting resistor 37 with the designed operating temperatures and without any frost deposits in the system to provide a zero output signal to amplifier 42. As the velocity through the refrigeration coil decreases from the accumulation of frost, thermistor 32, assuming a positive coefficient of resistance relative to temperature, increases in resistance as the temperature of thermistor 32 increases. The increase in resistance unbalances the bridge and provides a voltage signal along conductors 39A and 39B to amplifier 42. As the voltage signal increases above a selected level, motor control 43 responds to this increase to increase the fan rotation speed to increase the cooling effect on thermistor 32 to tend to balance the bridge and thereby maintain the desired air velocity.

The air velocity through refrigeration coil 13 will be relatively constant, or the system can be designed so that the air velocity increases, as thermistor 32 responds substantially immediately and continuously to a change in air velocity to produce an output signal that increases the speed of motor 22 through motor control 43. When motor 22 has reached its designed maximum speed, the air velocity will continue to drop as the frost accumulation increases. This decreased velocity will produce an increasing unbalancing of thermistor bridge circuit 39 which will produce a continuously increasing output signal level or voltage. The relay control is selected, for example, to respond to a preselected maximum voltage from amplifier 42 by turning on heaters 48 and turning off refrigerant system 11.

While with a system as here described, motor 22 continues operation at the high speed until the frost starts to diminish, at which time it slows down, other systems could contain time delay or similar circuits that would maintain a high velocity for a given period of time during a defrosting cycle to circulate the heated air as rapidly as possible over the refrigeration coils. After a selected time delay for the defrost cycle, determined by the expected defrosting characteristics, the time delay circuit would operate to again turn on the refrigerant system, turn off the heating system, and release motor control 43 to operate from the amplifier output. Motor control 43 would again respond to the amplifier output to rotate the fan at the minimum design speed.

The method for operating the refrigeration system according to this invention comprises operating the air circulating means at a selected force level to maintain the selected air velocity through the air cooling means upon initial startup when there is no frost accumulation. A continuous sensing of the air velocity through the air cooling means is maintained and the force level of the air circulating means is increased in response to a decrease in the air velocity resulting from frost accumulation in the flow path. This maintains a selected minimum air velocity through the air cooling means. The

system is defrosted when the maximum force level of the fan speed, that is, the speed of rotation, has increased to the selected maximum design level resulting in a drop of the actual air velocity through the air cooling means below a selected minimum level. The defrosting cycle can be shortened significantly by heating the air during the defrost time.

While this specification contains a written description of the invention and the manner and process of making and using it and sets forth the best mode contemplated by me of carrying out my invention, there are many variations, combinations, alterations and modifications of the invention that can be made within the spirit of the invention and the scope of the appended claims.

I claim:

1. A method of operating a refrigeration system tending to accumulate frost in its cooling air flow path during operation having air cooling means, and having circulating means for circulating air through the air cooling means comprising:

operating the circulating means at a selected force level to maintain a selected air velocity through the air cooling means when the refrigeration system is substantially free of frost accumulation,

sensing the air velocity through the air cooling means and increasing the force level of the air moving means in response to a decrease in said air velocity resulting from frost accumulation in the air flow path to maintain a selected minimum air velocity through said air cooling means, and

defrosting the system when the circulating means force level has increased to a selected maximum level and the air velocity has dropped below a selected minimum level.

2. A method according to claim 1 also comprising heating the air during defrosting of the system.

3. A means for controlling a refrigeration system having an air cooling means, said means for controlling comprising:

circulating means for circulating air at a selected force level through the cooling means,

means responsive to the air velocity through the air cooling means for sensing a decrease in said air velocity to increase the circulating means force level and maintain a preselected air velocity through the air cooling means, and

means responsive to the circulating means force level and to the air velocity through the air cooling means for defrosting the system when said circulating means force has reached a preselected maximum level and said air velocity has dropped below a preselected minimum level.

4. A system according to claim 3 wherein said air cooling means comprises refrigeration coils and means for providing refrigerant to the coils.

5. A system according to claim 3 wherein said circulating means comprises an electrical motor driven fan and said circulating means force level is increased by increasing the speed of rotation of the fan.

6. A system according to claim 5 wherein said air cooling means comprises a refrigeration coil and means for providing refrigerant to the coil.

7. A system according to claim 3 wherein said means for sensing comprises a thermistor bridge circuit with one thermistor of the bridge circuit located in the air stream to change its resistance characteristics in response to the air velocity.

8. A system according to claim 7 wherein said air cooling means comprises a refrigeration coil and means for providing refrigerant to the coil.

9. A system according to claim 3 wherein said means for sensing is also responsive to the force level of the circulating means to increase the preselected air velocity as said force level increases.

10. A refrigeration system having refrigeration coils and defrosting means for removing frost accumulation from said coils and system, said system comprising:

first means for circulating air through the refrigeration coils at a controllable force level,

second means for measuring the air velocity through the coils, said second means responsive to a change in said air velocity resulting from frost accumulation on the coils to provide a signal varying as a function of said velocity change,

third means responsive to the signal to control the first means to increase the force level to maintain a minimum selected air velocity through the coils, and fourth means responsive to the signal for defrosting the refrigeration system when said signal indicates an air velocity drop below a minimum selected level and the first means force level has attained a pre-selected maximum.

11. A method of operating a refrigeration system tending to accumulate frost in its cooling air flow path during operation having air cooling means and an electrical motor driven fan adapted to circulate air through the air cooling means, said method comprising:

operating the motor driven fan at a selected speed of rotation to maintain a selected air velocity through the air cooling means when the refrigeration system is substantially free of frost accumulation,

sensing the air velocity through the air cooling means and increasing the speed of rotation of the motor driven fan in response to a decrease in said air velocity resulting from frost accumulation in the air flow path to maintain a selected minimum air velocity through said air cooling means, and

defrosting the system when the speed of rotation of the motor driven fan has increased to a selected maximum level and the air velocity through the air

cooling means has dropped below a selected minimum level.

12. A method of operating a refrigeration system tending to accumulate frost in its cooling air flow path during operation, having air cooling means, and having circulating means for circulating air through the air cooling means, said method comprising:

operating the circulating means at a selected force level to maintain a selected air velocity through the cooling means when the refrigeration system air flow path is substantially free of frost accumulation, sensing the air velocity through the air cooling means and increasing the force level of the circulating means in response to a decrease in said air velocity resulting from frost accumulation in the air flow path to maintain an air velocity through said air cooling means that increases as the force level of the circulating means increases, and

defrosting the system when the circulating means force level has increased to a selected maximum level and the air velocity has dropped below a selected minimum level.

References Cited

UNITED STATES PATENTS

3,039,278	6/1962	Thompson	62—140
3,222,882	12/1965	Sutton	62—140
3,282,065	11/1966	Flanagan	62—140
3,362,183	1/1968	Sutton	62—140
3,397,550	8/1968	Giwosky	62—140

MEYER PERLIN, Primary Examiner

U.S. Cl. X.R.

62—89, 140, 180