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Tilmanis

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[54] **APPARATUS FOR CONTROLLING REFRIGERATOR DEFROST APPARATUS**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **62/155,** 62/80, 62/156, 62/208, 62/213

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

[58] **Field of Search** 62/80, 155, 208, 213, 156

[56] **References Cited**

UNITED STATES PATENTS

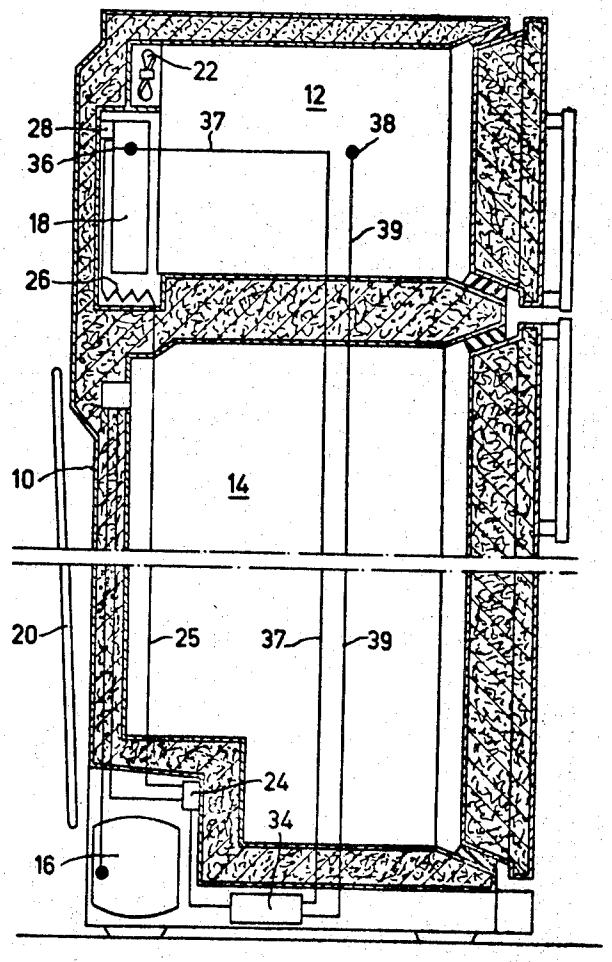
2,719,406	10/1955	Tobey	62/155
2,994,209	8/1961	Mann	62/155
3,018,637	1/1962	Mann	62/155
3,029,611	4/1962	Kuhn	62/155
3,063,250	11/1962	Moorman	62/155
3,222,882	12/1965	Sutton	62/156
3,277,662	10/1966	Winters	62/155
3,363,429	1/1968	Wechsler	62/156
3,474,638	10/1969	Dodge	62/155
3,553,975	1/1971	Sakamoto	62/156
3,681,933	8/1972	Check	62/156

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[57] **ABSTRACT**

Apparatus for controlling a defrosting system in a refrigerator including temperature sensing devices to monitor the temperature of the evaporator coil and the storage space. When the difference in these temperatures exceeds a predetermined value, and one of the monitored temperatures is less than a predetermined value, the defrost operation will be initiated.

4 Claims, 2 Drawing Figures



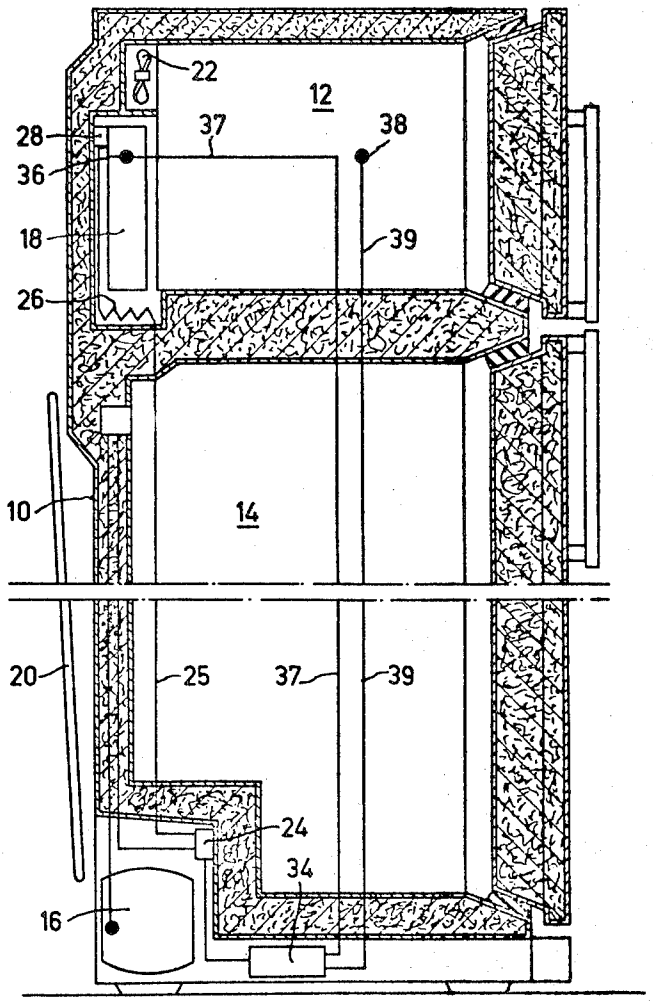

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Fig.1

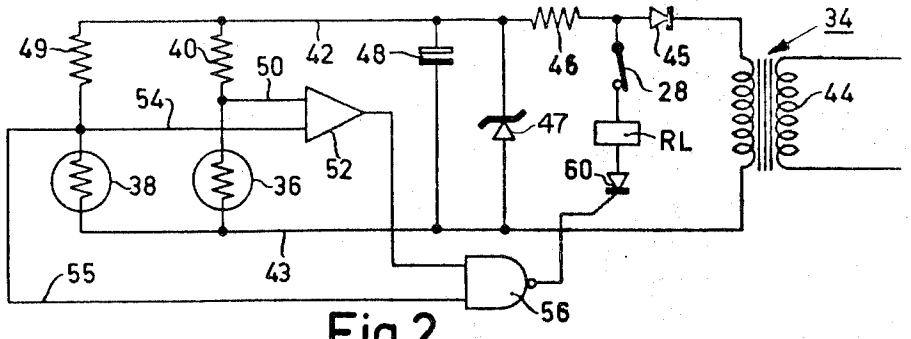

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Fig.2

APPARATUS FOR CONTROLLING REFRIGERATOR DEFROST APPARATUS

This invention relates to automatic defrosting systems for refrigerators, especially domestic and food display refrigerators, but is not limited thereto.

Automatic defrosting apparatus of the kind at present in common use operates on a fixed time cycle so that defrosting occurs at fixed time intervals. However, and particularly in the case of domestic refrigerators, the build-up of frost on the evaporator is quite variable as it depends upon many factors including, among others, the ambient air temperature, ambient air humidity, the frequency with which the refrigerator door is opened and the nature of the goods stored in the refrigerator chamber.

For this reason, a defrosting system which operates on a fixed time cycle is generally inefficient as the fixed interval between successive operations may be either too short or too long according to the particular conditions obtaining. Generally, the fixed time interval is the shortest time likely to be required so that, in most cases, defrosting occurs more often than is necessary and this involves excessive expenditure of power and higher food keeping temperatures because the waste heat absorbed within the refrigerator during each defrost cycle must be removed during the next succeeding refrigeration cycle.

For the foregoing reasons, it has previously been proposed to control automatic defrost apparatus only on demand, i.e., so that defrosting occurs only when this is required due to an excessive accumulation of frost on the evaporator coil.

It is already known for this purpose to provide a refrigerator with a control system which automatically initiates a defrost cycle when the evaporator coil temperature falls to a predetermined low value.

Such a control system however, is subject to the disadvantage that in some circumstances, e.g., when the ambient temperature is low and the refrigerator is only lightly loaded, the evaporator coil temperature may fall to the predetermined low temperature while the temperature in the storage compartment is still sufficiently low and possibly at an optimum value. In such circumstances, an unnecessary defrost cycle would be initiated with consequent wastage of power, and an unnecessary increase would occur in the temperature of the stored food or other material.

Also, in certain other circumstances, e.g., if there is a slight shortage of refrigerant, or if the compressor is inefficient, the temperature of the evaporator coil may never fall to the predetermined value required to initiate a defrost cycle. In such a situation, the system would eventually fail due to excessive build-up of frost.

Now the present invention broadly provides the method of controlling the operation of refrigerator defrost apparatus comprising continuously or periodically sensing the temperature of, or closely adjacent to, the evaporator coil and the temperature of a storage space of the refrigerator, and automatically initiating operation of said defrost apparatus when the difference between said two temperatures exceeds a predetermined value and, a selected one of said two temperatures is less than a predetermined temperature.

The said storage space may be a freezing chamber or a refrigerator chamber so that in a typical refrigerator

of the so-called two-temperature type, the said temperature sensing means for the storage space may be located in or near either the freezing chamber or the refrigerated chamber thereof. Preferably however, this temperature sensing means is arranged in the path of circulated air shortly after it has passed over the evaporator coil so that in the case of a two-temperature refrigerator, it is advantageously arranged at or near the position at which the cold air enters the freezing chamber.

The invention also provides apparatus for the aforesaid purpose comprising means for continuously or periodically sensing the temperature of, or closely adjacent to, the evaporator coil of the refrigerator, means for continuously or periodically sensing the temperature of a storage space of the refrigerator, and means controlled by said temperature sensing means for initiating operation of said defrost apparatus when, the difference between said two temperatures exceeds a predetermined value and, a selected one of said temperatures is less than a predetermined temperature.

Preferably, the duration of operation of the defrost apparatus is controlled by timing means in the known manner, that is to say, the defrost cycle is of uniform duration, though the invention is not limited thereto as alternatively, means also of a known kind may be used to terminate the defrost cycle and re-start the compressor when the temperature in the storage compartment rises to a predetermined value, or the evaporator is fully defrosted.

As frost builds up on the evaporator coil, it exercises a progressively increasing insulating effect, so that eventually the rate of heat inflow to the storage space exceeds the rate at which heat is extracted therefrom by the evaporator. In such circumstances, the temperature of the evaporator coil progressively falls while the temperature of the storage space progressively increases, so that, for both reasons, the difference between these temperatures progressively increases. Thus, while the temperature sensing means for the evaporator coil is preferably mounted in contact with the coil, it may alternatively be mounted out of contact therewith but in such close proximity thereto, that during each refrigeration cycle, said sensing means is progressively covered by the layer of frost which accumulates on the coil and is thus insulated thereby from the circulated air.

This temperature difference therefore may be utilised to effect the start of a defrost cycle when the difference rises to a predetermined value.

However, when the refrigerator is being started up for the first time or after a period of disuse, the temperatures of both the storage chamber and the evaporator coil may both be initially at or about the ambient temperature, and in such circumstances, the temperature of the evaporator coil is normally reduced more rapidly than that of the storage chamber so that the said predetermined temperature difference may be reached while the temperature of the storage chamber is still relatively high.

Consequently, if initiation of a defrost cycle was determined solely by the said temperature difference, a defrosting cycle could occur during the starting-up operation when it is not only not required, but is undesirable. However, according to the invention, a further necessary condition for initiating a defrost cycle is that the temperature of either the evaporator coil or the

storage space, and preferably the latter, is less than a predetermined temperature.

The temperature sensing means may be of any convenient type, e.g., thermistors or thermal bulbs, and any appropriate means controlled thereby may be provided for initiating a defrost cycle when the predetermined control conditions are satisfied.

More particularly, the said apparatus preferably comprises an electrical control circuit having two switches connected in series with means operable, when the circuit is completed by the closure of both switches, to initiate a defrost cycle. The said apparatus also includes means controlled by a sensor for the temperature of either the evaporator coil or the storage space for turning on one of said switches when the respective temperature falls below a predetermined temperature and vice versa, and means controlled by a sensor for the temperature of the storage space and by a sensor for the temperature of the evaporator coil for turning the other said switch when the difference between such temperatures exceeds a predetermined temperature and vice versa. Consequently, during the defrost cycle, the lastmentioned switch at least, is automatically turned off as the temperature differential between the evaporator coil and the storage space, progressively decreases.

Preferably, each of said temperature sensors is a thermistor and each of said switches is preferably an electronic switch to one of which both thermistors are connected, while one of the thermistors is connected to the other switch. Thus potentials, which correspond respectively to the temperature of the evaporator coil and to the temperature of the storage space are continuously applied to one of said switches which is adjusted so as to switch its output from the 0 position to 1 position when the temperature difference increases to the aforesaid predetermined value.

The potential of one of the said thermistors, or of a further thermistor arranged preferably in the storage compartment, is connected to the second electronic switch and when the temperature of this thermistor falls below a predetermined value, this second switch switches to its 1 position.

In order, however, that the invention may be more clearly understood, one form thereof is hereinafter more fully described with reference to the accompanying drawings in which:

FIG. 1 is a diagram showing in side elevation certain parts of a typical domestic refrigerator, and

FIG. 2 is a diagram of one defrost control circuit according to the invention.

Referring initially to FIG. 1, the refrigerator diagrammatically shown therein comprises an outer case **10**, a frozen food storage chamber **12** and a refrigerated food storage chamber **14**, each of these chambers being normally closed at the front by a door.

The refrigeration system is conventional and includes a sealed refrigerating unit **16**, comprising an electric motor and a compressor, an evaporator **18** arranged adjacent to frozen food chamber **12**, a condenser **20** and a fan **22** operated in unison with the compressor to circulate the cold air.

The illustrated refrigerator also includes defrosting means of a conventional kind including a defrost timer **24**.

This timer when actuated, opens switches to effect de-energisation of the sealed unit **16** and fan **22** for a pre-set time interval and also causes the heater **26** to be energized until its circuit is interrupted by the thermostat **28** when the temperature of the evaporator rises to a predetermined value, all in the usual manner.

As previously explained, this invention is concerned with the method of, and means for, starting a defrost cycle and in the illustrated apparatus this is achieved by closing a starting switch (not shown) for the timer **24**. For this purpose, the starting switch is controlled by two thermistors **36** and **38** which are connected by conductors **37** and **39** respectively, to electronic control means diagrammatically indicated at **34** in the figure. These thermistors are of the negative temperature coefficient (NTC) type so that they develop potentials which increase as their respective temperatures decrease.

The thermistor **36** is arranged in contact with the coil of the evaporator **18** while the thermistor **38** is arranged within the frozen food storage chamber **12**.

One suitable control circuit is shown in FIG. **2**, in which the thermistor **36** is connected in series with a resistance **40** between leads **42** and **43** from the output of a power transformer **44**, the lead **42** having a diode **45** and a resistance **46** arranged in series therewith while a zener diode **47** is connected across the leads in parallel with condenser **48** to stabilize the voltage applied to the thermistors.

The other thermistor **38** is similarly arranged in series with a resistance **49** between the leads **42** and **43**.

The thermistor **36** is connected by conductor **50** to an integrated circuit forming an electronic switch **52** while the thermistor **38** is similarly connected by conductor **54** to the same switch and is also connected by conductor **55** to a second electronic switch **56**. These two switches are connected in series with a relay driver **60**, e.g., a silicon controlled rectifier, connected between the leads **42** and **43** in series with a relay winding RL and a normally closed switch **28** controlled by a thermostat responsive to the temperature of the evaporator **18**.

The switch **52** is arranged to switch to its 1 rail or condition when the temperature difference between the thermistors **38** and **36** exceeds a predetermined value, and vice versa, while the switch **56** switches to its 1 rail or condition when the temperature of the thermistor **38** is less than a predetermined value. Thus, when both switches are in the 1 condition, the relay driver is activated whereby the circuit of relay winding RL is completed and this relay operates to close the aforesaid starter switch for the timer **24**.

During the defrost cycle, the temperatures of both thermistors progressively increase and the temperature difference progressively increases consequent upon the melting of the frost on the evaporator.

Thus, at least the switch **52** switches back to its 0 rail or condition during the defrost cycle and generally the switch **56** also returns to its 0 condition.

However, the relay RL when operated, remains energised until the thermostat switch **28** automatically opens consequent upon the increasing temperature of the evaporator.

De-energisation of the relay RL however, does not cause the timer to be de-energised as the latter includes a by-pass switch which is automatically closed when the timer commences to operate and which remains closed until the pre-set time cycle is completed when the compressor motor and fan are automatically restarted.

It will be evident from the foregoing description however, that during the defrost cycle, the control circuit shown in FIG. **2** returns to its original condition with at least one of the electronic switches and usually both of them, in the 0 condition while during the next succeeding refrigeration cycle, the thermostat switch **28** recloses when the predetermined temperature is reached thus preparing the relay circuit for subsequent operation.

Thus, the invention provides an improved method of and apparatus for automatically controlling refrigerator defrost apparatus so that defrosting occurs only when this is required due to excessive frost build-up and not, as is usual, at fixed time intervals.

Moreover, the defrost control is directly responsive to the particular thermal conditions which are indicative of a need for defrosting as contrasted with the known demand system which operates when the evaporator temperature falls to a predetermined value and with a known indirect method which involves sensing variations in air flow consequent upon frost build-up.

What is claimed is:

1. Apparatus for controlling the operation of refrigerator defrost apparatus comprising, means for continuously sensing the temperature of the evaporator coil of the refrigerator, means for continuously sensing the temperature of a storage space of the refrigerator, and means controlled by said temperature sensing means for initiating operation of said defrost apparatus when the difference between said two temperatures exceeds a predetermined value and, a selected one of said temperatures is less than a predetermined temperature, said means for initiating defrost including an electrical control circuit comprising two normally turned off electronic switches arranged in series with means operable, when energized to initiate operation of said defrost apparatus, and including means responsive to said two temperature sensing means to cause one of said electronic switches to turn on when the difference between the two temperatures sensed thereby exceeds said predetermined value, and vice versa, and means responsive to a selected one of said temperature sensing means to cause the other said electronic switch to turn on when the temperature sensed thereby is less than the said predetermined temperature, and vice versa.

2. Apparatus according to claim **1,** wherein said automatic defrost apparatus comprises timing means which determine the duration of operation of the defrost apparatus.

3. Apparatus according to claim **1,** including means responsive to the temperature of a storage space of the refrigerator for terminating operation of the defrost apparatus when the temperature of the storage space rises to a predetermined value.

4. Apparatus according to claim **1,** wherein each of said temperature sensing means is a thermistor.

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