The present invention relates to refrigerators of the type in which at least one compartment is maintained at the desired refrigerating temperature by means of an air stream circulated over an evaporator positioned outside of or separate from the compartment and is particularly concerned with a refrigerator of this type including a combination fan and defrost control including a single drive motor.

While refrigerators are known in which the storage compartment has been maintained at the desired refrigerating temperature by the forced circulation of air over an evaporator disposed outside of the compartment and through the compartment. By positioning the evaporator outside the compartment, it may be periodically warmed to defrosting temperatures without substantially affecting the storage temperatures within the compartment. During the defrost operation of the evaporator, the fan for circulating air is de-energized and the present invention is particularly concerned with a forced air cooled refrigerator in which the fan motor also provides means for operating the defrost control means.

A primary object of the invention is to provide a forced air cooled refrigerator including a storage compartment, an evaporator positioned outside of the compartment, a fan for circulating air from the compartment to the evaporator and a defrost control means operated by the fan motor for controlling the periodic defrosting of the evaporator.

Another object of the invention is to provide a forced air cooled refrigerator including an evaporator disposed outside of the refrigerator storage compartment, a motor driven fan for circulating air over the evaporator and through the compartment and defrost control means disposed in the relatively dry portion of the circulating air stream downstream from the evaporator.

Further objects and advantages of the invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In accordance with one embodiment of the present invention, there is provided a refrigerator including a storage compartment, an evaporator disposed outside of that compartment and a duct defining an air flow passageway outside of the compartment for the circulation of air from the compartment to the evaporator. A fan is provided at the outlet end of the duct and means are provided for energizing the motor driving the fan only when refrigerant is being supplied to the evaporator. A defrost control means for initiating periodic warming of the evaporator to defrosting temperatures is driven by the fan motor so that the evaporator is periodically defrosted as a function of the fan motor running time. In the preferred embodiment of the invention, the combination fan, fan motor and defrost control means is disposed in the path of the air flowing from the evaporator to the storage compartment which air is relatively free from moisture.

For a better understanding of the invention reference may be had to the accompanying drawing in which:

FIGURE 1 is a side elevational view of a refrigerator cabinet embodying the present invention;

FIGURE 2 is an enlarged sectional view of a portion of the cabinet illustrated in FIGURE 1;

FIGURE 3 is a schematic illustration of a refrigerating system employed for refrigerating the cabinet of FIGURE 1; and

FIGURE 4 is a sectional view taken generally along line 4-4 of FIGURE 2.

While the invention is applicable to refrigerators containing one or more storage compartments, it will be described with specific reference to a refrigerator comprising a single storage compartment cooled by the forced circulation of air over an evaporator disposed outside of that compartment.

With reference to FIGURE 1 of the drawing, there is shown an embodiment of the present invention in the form of a household refrigerator including a storage compartment defined by a plurality of insulated walls including a rear wall, the access opening to the compartment being closed by a door. The compartment is maintained at desired refrigerating temperatures by means of a single evaporator positioned in the insulated rear wall of the cabinet. Condensed refrigerant is supplied to the evaporator from a condensing unit positioned in the lower portion of the cabinet and including a compressor and a condenser.

More specifically the evaporator is disposed in an enlarged portion of a duct having an inlet opening communicating with the lower portion of the storage compartment and an outlet 9 at the upper end of the duct. A fan 10 driven by a motor 11 is disposed in the outlet end of the duct 7 and is designed to draw air upwardly through the duct 7 over the evaporator 4 to discharge the cooled air into the storage compartment.

A suitable automatic defrost refrigerating system is shown schematically in FIGURE 5 of the drawing. In addition to the evaporator 4, the compressor 5 and the condenser 6, the system includes a capillary flow restrictor 12 connecting the outlet end of the condenser 6 to the evaporator 4, these components being connected in series flow relationship so that the evaporator 4 withdraws vaporized refrigerant from the evaporator 4 through a suction line 13 and discharges high pressure refrigerant to the condenser 6 through the discharge line 14. For the purpose of periodically warming the evaporator 4 to defrosting temperatures there is provided a bypass or defrost line 15 connecting the compressor discharge line 14 to the inlet end of the evaporator 4. A normally closed defrost valve 17 provided in the line 15 and controlled by means of a solenoid 18 is periodically opened so that hot compressed refrigerant vapor is bypassed to the evaporator through the defrost line 15 for warming the evaporator to defrosting temperatures. The valve 17 is of a construction such that when the bypass line 15 is open, the valve 17 also introduces a restriction into the suction line 13 controlling the flow of condensed refrigerant from the defrosting evaporator 4 back to the compressor 6.

The operation of the compressor 5 and the fan motor 11 is controlled by a control circuitry including a cold control thermostat 21 having its sensing bulb 22 positioned within the storage compartment for sensing the temperatures within that compartment. The thermostat 21 is adapted to energize both the compressor 5 and the fan motor 11 whenever the temperature within the compartment is below a predetermined minimum and to de-energize the compressor and the fan motor whenever the compartment temperature reaches a predetermined maximum. As is shown in FIGURE 2, the compressor 5 and the fan motor 11 are connected in parallel so that the fan operates only when the compressor 5 is also energized during normal refrigerating operation of the refrigerating system.
In accordance with the present invention, the control circuitry also includes defrost control means for operating the valve 17 which defrost control means is driven by the fan motor 11. More specifically with reference to FIGURES 2 and 4 of the drawing, there is provided defrost control means including a defrost switch 23 contained within a housing 24 which fan motor 11 is disposed in the upper end of the duct 5. The switch 23 includes a magnetic switch arm 25 movable into engagement with either a fan motor energizing contact 26 or a defrost valve energizing contact 27. As is shown in FIGURE 4 of the drawing, a magnet 28 provided within the housing 24 is provided for operating the switch arm 25 from one contact to the other. More specifically, the switch 23 is of the type in which the arm 25 is spring biased into engagement with the contact 27 when the switch is not subjected to the field of the magnet 28 but is designed to be magnetically transferred into engagement with the contact 26 when the magnet 28 is brought into close proximity with the non-magnetic switch envelope 30. The purpose of the switch 23 is to energize the fan motor 11 whenever the compressor is running under normal refrigerating operation of the refrigerator and to energize the defrost valve 17 with the compressor running during defrost operation of the refrigerator. In order to periodically initiate a defrost cycle and also time the length of that cycle, means are provided for moving the magnet 28 out of operating position relative to the switch 23 after a given period of operation of the fan motor 11 and for again establishing magnetic contact between the magnet 28 and the switch 23 after a predetermined time sufficient to insure the removal of all of the frost from the defrosting evaporator 4.

The structure of the defrost control means designed to accomplish these results is shown in FIGURE 4 of the drawing. With reference to that figure, it will be seen that the switch 23 is secured by means of an arm 32 to one end of a bellows 35 forming part of a double bellows structure including a bellows 36. The two bellows 35 and 36 are filled with a liquid and are connected by means of a small orifice or aperture 37. The liquid fill for the bellows may be a silicone oil, an alcohol or a similar liquid which has a freezing point lower than any anticipated operating condition of the control. The bellows 36 is biased to a retracted or compressed position by means of a spring 39, the compressive force of which can be adjusted by means of an adjusting screw 43. When the spring compresses the bellows 36, the fluid contained within the double bellows structure is displaced into the bellows 35 so that this bellows is in turn extended.

The magnet 28 is carried on the free end of a pivoted lever arm 41 and this arm is normally biased into magnetic engagement with the switch 23 and mechanical engagement with the foot or pad 42 at the end of the bellows 35 by means of a cam 43. The cam 43 in turn is connected to the fan motor 11 through a suitable gear train (not shown) so that, for example, the cam 43 will rotate one revolution during normal operation of the fan motor 11 during a 12 hour period.

The cam 43 includes a shoulder 45 which is designed to function as a timing means and initiate a defrost cycle after one complete revolution thereof. More specifically, during normal operation of the defrost control means, rotation of the cam 43 maintains the magnet 28 in operating position relative to the switch 23 and also maintains the arm 41 in engagement with the pad 42 provided on the bellows 35. As the cam rotates in a counterclockwise direction as viewed in FIGURE 4, the arm 41 is gradually moved to the right thereby slowly compressing the bellows 35 while at the same time maintaining the magnet 28 in operative position relative to the switch 23. As the cam 43 is supported on the bellows 35 so that the fan motor is energized through that switch. After a predetermined period of time, the cam rotates to the point such that the arm 41 trips off of the shoulder 45 under the action of the biasing spring 46. This results in the magnet 28 being removed from operating proximity to the switch 23 whereby the switch arm 25 becomes disengaged from the contact 26 and engages the contact 27 thereby energizing the defrost valve 17. At the same time, the switch arm 41 becomes disengaged from the liquid fill of the bellows 36 and subject to the spring forces thereof from the bellows 35. As the bellows 35 slowly expands by the return of fluid thereto through the aperture 37 due to the retoring spring forces of each bellows and the force of the spring 39 on the bellows 36, the switch 23 is returned to the left until it is again positioned adjacent to the magnet 28. At this point, the switch 23 is returned to its normal position in which the switch arm 25 is in engagement with the contact 26 thereby terminating the defrost cycle and again placing the operation of the fan motor 11 under the control of the thermostat 21. A new refrigerating cycle is thus initiated and the fan 10 and compressor 5 will cycle on and off to maintain the desired temperatures within the compartment 1. Also when contact of the switch arm 25 with the contact 27 is broken, the solenoid valve 17 is de-energized so that flow of the defrost fluid through the line 15 is stopped and normal refrigeration flow through the condenser 6 to the evaporator 4 is re-established.

The size of the orifice or opening 37 of course determines the length of the defrost cycle using any given bellows charging liquid. The exact size will depend upon the viscosity of the liquid fill for the bellows 35 and 36 under the operating conditions of the defrost control means and the amount of heat which can be supplied to the evaporator 4 during the defrost cycle. It will be understood, of course, that while a hot gas has been illustrated as means for warming the evaporator 4 to defrost temperatures, other suitable means such as electric heat may also be employed in which case the control of the heating means will be the same as that used in the control of the defrost valve 17 but the compressor 5 is also placed under this control so that the refrigerating effect resulting from the operation of the compressor during the defrost cycle will not oppose the defrost action of the electric or resistance heating. However, in the preferred embodiment of the invention, hot gas is employed for defrosting the evaporator 4 and the compressor 5 is operated during the defrost cycle.

It will also be apparent from the foregoing that other types of switches with suitable mechanisms for operating them may be used instead of the hydraulic escapement and reed switch 23. For example, a mechanical escapement such as is used in clock mechanisms may be used. However, the disclosed means including a reed switch which is completely sealed within the glass or similar envelope 30 is preferred because of its simplicity and high reliability under the operating conditions prevailing in a refrigerator.

While there has been shown and described a particular embodiment of the invention it will be understood that the invention is not limited to the embodiments herein described and that other changes, modifications and variations may be made in the structure and arrangement of the parts without departing from the spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A refrigerating apparatus having a storage compartment, an evaporator disposed outside of said compartment, condensing means including a compressor for normally supplying condensed refrigerant to said evaporator, defrost means for periodically defrosting said evaporator, a fan for circulating air from said compartment over said evaporator, a motor for driving said fan, a motor circuit for energizing said motor when the switch is energized to supply condensed refrigerant to said evaporator, and defrost control means including timing means driven
by said motor for initiating operation of said defrost means.

2. A refrigerator comprising a storage compartment, an evaporator disposed outside of said compartment, defrost means for periodically warming said evaporator to defrost temperatures, condensing means including a compressor for normally supplying condensed refrigerant to said evaporator, a fan for circulating air from said compartment over said evaporator, a motor for driving said fan, a motor circuit for energizing said motor only when said compressor is energized to supply condensed refrigerant to said evaporator, and defrost control means including timing means driven by said motor for initiating operation of said defrost means, said motor and said defrost control means being disposed in the path of the air flowing from said evaporator to said compartment.

3. A refrigerator comprising insulated walls defining a storage compartment, a duct in one of said walls having the inlet and outlet ends thereof communicating with said compartment, an evaporator disposed in said duct, condensing means including a compressor for normally supplying condensed refrigerant to said evaporator, defrost means for periodically defrosting said evaporator, a fan in the outlet end of said duct for circulating air cooled by said evaporator through said compartment, a motor for driving said fan, a motor circuit for energizing said motor only when said compressor is energized to supply condensed refrigerant to said evaporator, defrost control means including timing means driven by said motor for initiating operation of said defrost means, said motor and defrost control means being disposed in said duct adjacent the outlet end thereof.

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