Feb. 9, 1943. G. P. DAIGER 2,310,761

REFRIGERATION

Filed Feb. 5, 1940

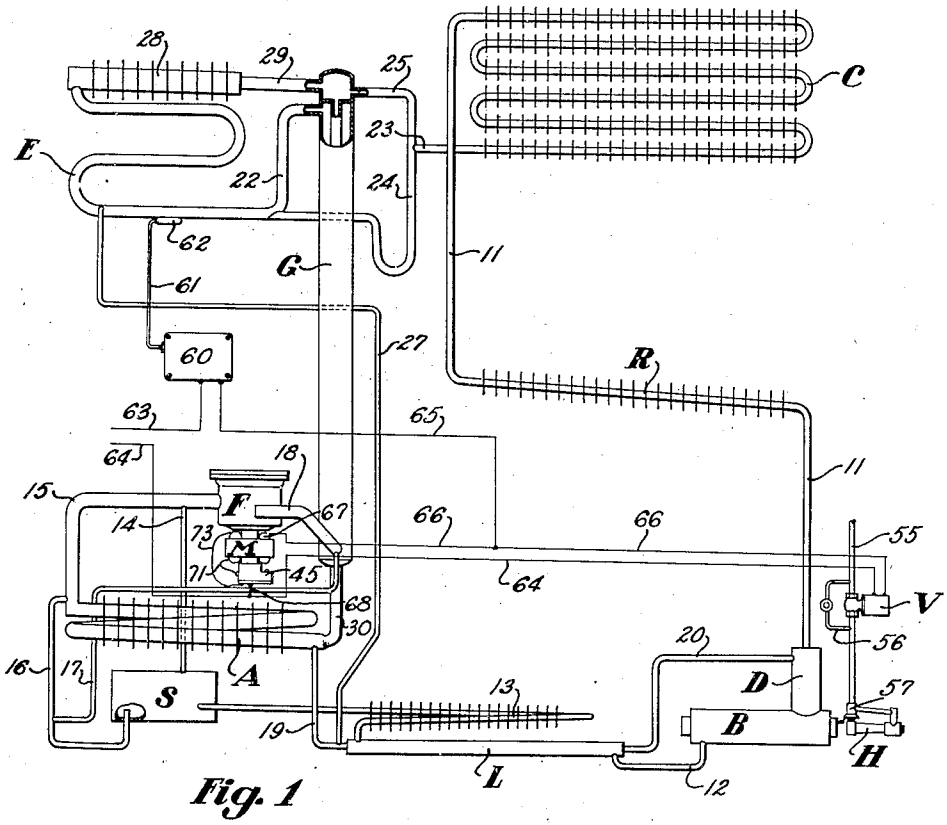


Fig. 1

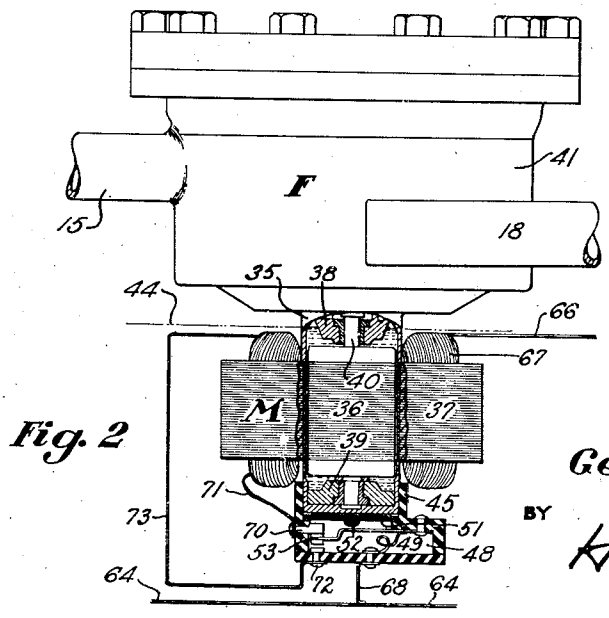


Fig. 2

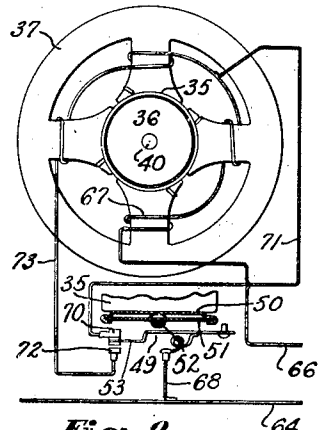


Fig. 3

INVENTOR

George P. Daiger

BY Harry D. Edwards

ATTORNEY

Patented Feb. 9, 1943 2,310,761

UNITED STATES PATENT OFFICE

2,310,761

REFRIGERATION

George P. Daiger, Canton, Ohio, assignor to The Hoover Company, North Canton, Ohio

Application February 5, 1940, Serial No. 317,379

7 Claims. (Cl. 62—119.5)

This invention relates to the art of refrigeration and more particularly to an absorption refrigerating system involving unique control and regulating features.

This invention particularly relates to three-fluid absorption refrigerating systems of the type in which a circulating motor is hermetically sealed within the system in order to circulate the fluids therein. Motors of this type must be lubricated. However, considerable difficulty may arise in handling and installing the system due to the fact that under such circumstances the lubricant in the motor shell may be displaced by foreign material such as absorption solution and once displaced it will be very difficult to return the lubricant to its normal environment without materially reconstructing the apparatus. Moreover, it may occur that the system will not be maintained in upright condition during handling and installation with the result that the lubricant will be spilled out of the motor casing and will not later be returned thereto.

In order to obviate these difficulties it is an object of the present invention to provide an absorption refrigerating system of the above described character in which the motor is submerged in a lubricating material which is not fluid at normal atmospheric temperatures and which will flow at the temperatures maintained by the heat generated by the motor winding in order to perform its lubricating function efficiently.

It is a further object of the present invention to provide an absorption refrigerating system of the above referred to type in which the lubricant in its non-fluid state imposes sufficient drag upon the rotating portions of the motor to block the same until the lubricant has been liquefied, for example by the application of heat thereto.

It is a further object of the present invention to provide an absorption refrigerating system in which operation of the circulating motor is prevented after energization thereof by reason of the lubricant blocking the motor for a period of time sufficient to permit the boiler to come into full operation; that is, to discharge refrigerant vapor to the condenser in order that the same may be liquefied and re-evaporated in the evaporator to produce a useful refrigerating effect.

With some lubricants, such as those having a high paraffin content, the period required to liquefy the same by the heat generated by the small current normally flowing through the winding of the motor is excessive, wherefore it is an object of the present invention to provide a special arrangement for heating the lubricant to render the same fluid which comes into operation substantially simultaneously with the boiler heater and which will render the motor lubricant fluid at substantially the same time that the boiler discharges refrigerant vapor, after which the motor will be normally energized to permit the system to operate on its normal operating cycle.

It is a further object of the present invention to provide an absorption refrigerating system including a circulator, the rotor of which is immersed in a non-fluid lubricant which lubricant is rendered fluid by the heat generated by a high current passing through a portion only of the motor winding and which heat is sufficient to render the lubricant fluid at the time that the boiler comes into full operation.

It is still another object of the present invention to provide an absorption refrigerating system which includes a lubricated circulator in which the circulator operates with a high current to provide sufficient heat to render the lubricant fluid and to provide an extremely high starting torque after which the entire motor winding is energized with the result that the same consumed a much lesser current, generates only sufficient heat to maintain the lubricant in fluid condition and produces a smaller running torque.

Other objects and advantages of the invention will become apparent as the description proceeds when taken in connection with the accompanying drawing in which:

Figure 1 is a diagrammatic representation of a three-fluid absorption refrigerating system embodying the present invention;

Figure 2 is a partial sectional elevational view drawn on an enlarged scale of the motor circulator unit; and

Figure 3 is a schematic wiring diagram of the control circuit.

Referring now to the drawing in detail and first to Figure 1 thereof, there is illustrated a three-fluid absorption refrigerating system comprising a boiler B, an analyzer D, an air-cooled rectifier R, a tubular air-cooled condenser C, an evaporator E, a gas heat exchanger G, a tubular inclined air-cooled absorber A, a liquid heat exchanger L, a solution reservoir S, and a circulating fan F which is driven by an electrical motor M. These elements are suitably connected by various conduits to form a plurality of gas and liquid circuits constituting a complete refrigerat-

ing system to which reference will be made in more detail hereinafter.

The above described refrigerating system will be charged with a suitable absorbent, such as water, a suitable refrigerant, such as ammonia, and an inert pressure equalizing medium preferably a dense inert gas like nitrogen.

The boiler B is arranged to be heated by a gas burner H which will be described in more detail hereinafter. The application of heat to the boiler B generates refrigerant vapor from the solution therein contained. The vapors so generated pass upwardly through the analyzer D in counterflow to the strong solution flowing downwardly therethrough. After traversing the analyzer D the vapor is conveyed from the upper portion thereof to the upper portion of the condenser C by means of a conduit 11 which includes the rectifier R.

The lean solution formed in the boiler by the generation of refrigerant vapor therefrom is conveyed from the boiler to the solution reservoir S by way of the conduit 12, the liquid heat exchanger L, and a finned looped conduit 13 which also serves as a solution precooler.

The solution reservoir S is vented by means of a conduit 14 which connects to the suction conduit 15 of the circulating fan F. The conduit 15 extends between the suction side of the fan F and the upper portion of the absorber A.

The lean solution is conveyed from the reservoir S to the conduit 15 adjacent its point of connection with the absorber A by means of a gas lift pumping conduit 16. Pumping gas is supplied to the conduit 16 by means of a conduit 17 which is connected between the discharge conduit 18 of the circulating fan F and the gas lift pump 16 below the liquid level normally prevailing therein and in the solution reservoir S.

The lean solution flows downwardly through the absorber A in counterflow relationship to a rich mixture of inert gas and refrigerant vapor which is supplied to the bottom portion of the absorber from the evaporator in a manner to be described hereinafter.

In its traverse through the absorber the lean solution absorbs refrigerant vapor from the gas mixture flowing therethrough and the resulting heat of absorption is rejected by the cooling fins to cooling air flowing over the exterior walls of the absorber vessel.

The strong solution thus formed in the absorber is conveyed therefrom to the upper portion of the analyzer D by way of the conduit 19, the liquid heat exchanger L, and a conduit 20, thus completing the absorption solution circuit.

Lean inert gas is formed in the absorber A by the absorption of refrigerant vapor and is then conveyed from the upper portion of the absorber to the suction side of the circulating fan F by means of the conduit 15. The inert gas is placed under pressure in the fan F and is then conveyed therefrom to the lower portion of the evaporator E by way of the conduit 18, the outer path of the gas heat exchanger G and an evaporator gas supply conduit 22.

The refrigerant vapor which is supplied to the condenser C is liquefied therein by heat exchange relationship with atmospheric air and is then conveyed therefrom to the bottom portion of the evaporator E by way of the conduit 23 and a conduit 24 which includes a downwardly extending U-shaped looped portion which is designed to carry a liquid seal and a pressure balancing column of the liquid refrigerant. The conduits 23 and 24 are vented by means of a conduit 25 to the rich gas side of the gas heat exchanger G. As a result of this construction the pressure prevailing in the condenser and the condenser side of the conduit 24 is that prevailing on the discharge side of the evaporator whereas the pressure prevailing on the discharge side of the conduit 24 is that prevailing at the inlet to the evaporator. This pressure difference is compensated by a pressure balancing liquid column which is supported in the condenser side of the conduit 24.

The evaporator E may be of any desired type of construction. However, as diagrammatically illustrated herein, it is of the type in which the high velocity gas stream flowing through the evaporator serves to sweep or drag liquid refrigerant upwardly therethrough as it is evaporating to produce refrigeration. A preferred construction of this type evaporator is disclosed and claimed in the co-pending application of Curtis C. Coons and William H. Kitto, Serial No. 386,395, filed April 2, 1941, which is a continuation-in-part of application Serial No. 220,189, filed July 20, 1938.

An anti-blocking and overflow drain 27 is connected between the upper portion of the bottom conduit in the evaporator E and the strong solution return conduit 19.

The liquid refrigerant supplied to the bottom portion of the evaporator E meets a high velocity gas stream flowing upwardly therethrough with the result that the liquid refrigerant is propelled upwardly through the evaporator as it is evaporating into the gas stream to produce useful refrigeration.

The top portion of the evaporator is provided with a large diameter finned box-cooling conduit 28 into which both the liquid and gas discharge. The gas flows at a slow rate through this conduit, hence the same is inclined rearwardly in order to permit liquid to flow by gravity. The resulting rich gas and unevaporated material in the evaporator is conveyed from the conduit 28 into the rich gas side of the gas heat exchanger G by means of a conduit 29. After traversing the rich gas side of the gas heat exchanger the rich gas and unevaporated material is drained therefrom into the bottom portion of the absorber A by means of the conduit 30. Thus, the conduit 30 serves as a rich gas return conduit and as an evaporator drain. The rich gas then flows upwardly through the absorber A in counterflow relationship with the lean solution flowing downwardly therethrough in the manner heretofore described.

It will be noted that with the construction thus provided evaporator drainage is conveyed to the conduit 19 in a manner such that it cannot reach the circulating fan and the fan is so connected to the absorber that lean solution cannot be conveyed thereinto from the lean solution supply lines. This is of considerable importance in preventing absorbing solution from finding its way to the motor shell, as will be explained in more detail hereinafter.

Referring now to Figures 1 and 2, it is apparent that the fan casing F carries a sealed motor shell 35 depending therefrom. The motor M consists of a rotating element 36 which is mounted within the shell and a stationary field winding or stator structure 37 which is mounted on the outside of the shell whereby the magnetic circuit for the induction rotor 36 must pass through the shell 35. The rotor is supported on suitable bearing assemblies indicated generally at 38 and 39 within the shell 35. The motor shaft 40 passes through the

bearing 38 and carries a suitable fan within the fan housing 41 in a conventional manner.

The depending motor shell 35 is filled with a suitable lubricant up to the level of the line indicated generally at 44; that is, the rotor is completely submerged and part of the bearing 38 is submerged in the lubricant.

One such lubricant is paraffin and it is obtainable in a long range of melting points and specific gravity. By selecting paraffin of the proper melting point or by mixing it with other lubricants, almost any melting point desired can be obtained. This lubricant has the characteristic that it is non-fluid at ordinary room temperatures but will become fluid when heated above that temperature in order to lubricate the bearings to permit the motor to rotate. In its non-fluid state the drag of this lubricant is sufficient to stall the rotor or the motor.

In this connection it should be emphasized that this motor is very small and develops only sufficient power to circulate the inert gas with a few inches of water pressure differential, hence the lubricant drag is easily sufficient to stall the same.

A switch housing 45 of insulating material is mounted on the lower end of the shell 35 directly beneath the stator structure and is provided with a switching housing or chamber 48 within which is mounted an electrical switch 49.

A bracket 50 is attached to the bottom portion of the shell 35 within the housing 48 and carries a snap-acting thermostatic strip or disc 51, as may be desired, directly above the switch 49. The disc 51 is provided with an actuating button 52 which may be made of a composition insulating material and which is positioned to strike the movable element 53 of the switch 49 to actuate the same.

As was mentioned previously a heater H is provided for the boiler B. Gas is supplied to the heater H from a suitable source of supply through a conduit 55 which includes a solenoid valve V. A small by-pass 56 is provided around the valve V in order to maintain a small ignition flame on the heater H. Also included in the conduit 55 adjacent the burner is a suitable thermostatic safety cut-off device 57 which is arranged to discontinue supply of fuel to the burner completely upon failure of flame thereupon, as for example in case the small igniting or pilot flame is extinguished by a draft or the like.

The apparatus is controlled by means of a suitable thermostatic switching mechanism indicated generally at 60 and provided with a capillary conduit 61 which connects to a fluid containing bulb 62 positioned to be influenced by temperature changes at or adjacent the evaporator E. The exact construction of the thermostatic switching mechanism 60 is conventional and need not be disclosed in detail herein. Power is supplied to the apparatus from a pair of electrical conductors 63 and 64.

The conductor 63 connects directly to the switching mechanism 60 which is connected by means of the conductors 65 and 66 to the solenoid valve V and to the winding 67 of the stator of the motor M. The conductor 64 connects directly to the valve V and is connected to the movable element 53 of the switch 49 by means of a conductor 68.

The movable element 53 of the switch 49 is arranged to make contact with an upper fixed contact 70 which is connected to approximately the mid point of the winding 67 by means of a conductor 71 or to make contact with a lower fixed contact 72 which is connected to the end of the winding 67 by means of a conductor 73.

As can readily be seen from an inspection of Figure 3, approximately half the motor winding is energized when the movable switch arm 53 makes contact with the contact element 70 as illustrated, whereas the entire motor winding is energized when the arm 53 makes contact with the fixed contact 72.

The operation of the invention, except insofar as the same has already been disclosed in connection with the construction of the refrigerating apparatus per se, is as follows: When the apparatus is initially installed substantially all portions thereof will be at room temperature and the lubricant which is contained within the shell 35 will be non-fluid or substantially solid and will interpose sufficient resistance to rotation of the motor to prevent operation thereof. Immediately the apparatus is connected to suitable sources of gas and electricity, the thermostatic switch 60, being in closed circuit position, will energize the solenoid valve V to supply fuel to the burner H through the following circuit: 63, 60, 65, 66, V, 64.

Due to the fact that the lubricant is in the cold solid condition the thermostatic disc 51 will be flexed upwardly as is indicated in Figures 2 and 3 to bring the switch arm 53 into contact with the contact 70. Under these conditions that portion of the winding of the motor between the conductors 66 and 71 will be energized by the following circuit: 63, 60, 65, 66, winding 67, 71, 70, 53, 68 and 64. Under these conditions a relatively high current will flow through that portion of the motor winding included between the conductors 66 and 71 and will produce a relatively large quantity of heat. This short winding with its attendant high current produces a starting torque approximately 2 to 3 times the normal running torque of the motor. The drag of the non-fluid lubricant will block the rotor; however, the heat generated by this high current will shortly render the lubricant fluid and the high current flowing in the winding with its attendant high starting torque will start rotation of the rotor 36. After the lubricant has been rendered fluid the temperature of the shell 35 will be increased sufficiently to cause flexure of the thermostat 51 downwardly, as viewed in Figures 2 and 3, thereby breaking the circuit between the elements 53 and 70 and closing the circuit between the elements 53 and 72. The entire winding will now be energized and the motor will run in accordance with its normal operating characteristic.

It will be understood that the winding and lubricant will be selected in such fashion that the lubricant will be rendered fluid and rotation of the motor will begin substantially immediately after the boiler B has come into full operation; that is, immediately after the boiler B is generating refrigerant vapor and is discharging the same to the condenser.

The above operation will continue until the temperature at or adjacent the evaporator reaches a value for which the thermostatic mechanism 60 has been set whereupon the thermostatic switch 60 will break the circuit between the conductors 63 and 65, thus de-energizing the motor and reducing the flame on the heater H to a mere pilot or ignition flame.

The motor will now cool and the lubricant will solidify if the apparatus is maintained de-energized a sufficient length of time to permit the lubricant to solidify. In normal cycling of the apparatus the lubricant will be rendered non-

fluid an appreciable period of time before re-energization of the refrigerating mechanism by the thermostatic switch mechanism 60. However, if for any reason a short cycle should occur, the motor will develop sufficient torque to start without going through the starting cycle as long as the lubricant is in its fluid condition and the thermostat 51 will prevent the motor from attempting to start without going through the normal starting cycle unless the lubricant is in a fluid condition and will not interpose a blocking drag upon the rotor 36.

In normal operation of the apparatus the heat generated by the running winding is sufficient to maintain the lubricant in a fluid condition without other aid.

Thus, the motor has a starting cycle in which the same is supplied with a high current which generates a large amount of heat and produces a high starting torque and a running condition in which a much lesser quantity of heat is generated and a lower or running torque is produced. The starting condition is inefficient but is not objectionable for mere starting purposes, whereas the running condition of the motor is relatively highly efficient and generates a relatively small quantity of heat which, however, is sufficient to maintain the lubricant in a fluid condition.

The illustrated construction is the preferred arrangement. However, the thermostatic cut-out for the starting condition of the motor may be arranged to shift the motor from starting to running condition in response to a change in the condition of another portion of the system which is induced by energization of the system. For example, the thermostatic switch for the motor could be arranged to respond to the temperature of some portion of the pipe 11. This pipe is heated by hot vapor enroute to the condenser. There is a time lag between initiation of full flame operation of the burner and heating of this pipe which will allow sufficient heating of the lubricant to render the same fluid and to render the motor capable of starting. Such a construction will produce the desired lag in operation of the motor with respect to the burner.

Thus, the present invention provides a very advantageous construction of an absorption refrigerating system together with the control mechanism therefor which insures that lubricant will not be lost from the motor shell during transit, handling and installation and which provides a construction whereby the lubricant is rendered fluid prior to energization of the motor and also in which the time period required to condition the motor for energization is so correlated through the control for the boiler-heater that the boiler is brought up to operating condition just prior to energization of the motor whereby the system goes into complete operation immediately the motor is energized and no loss of heat is entailed in the preliminary heating of the boiler-analyzer assembly.

This type of control is not only economical but is also more efficient than the previously known simultaneous energization type of controls which have been used on this type of refrigerating system.

The present control provides a highly efficient construction in which rapid heating of the lubricant is assured and in which the motor is provided with a high starting torque and immediately after operation of the motor the same is changed from its starting heating condition to its more efficient though lower torque operating and lubricant maintenance condition.

While I have shown but one embodiment of my invention, it is to be understood that this embodiment is to be taken as illustrative only and not in a limiting sense. I do not wish to be limited to the particular structure shown and described but to include all equivalent variations thereof except as limited by the claims.

I claim:

1. Absorption refrigerating apparatus comprising a boiler, a condenser, an evaporator, an absorber and a fluid circulator connected in circuit, a drive motor for said fluid circulator including a rotating part at least partially submerged in a lubricant which is non-fluid at atmospheric temperatures, a field winding for said motor, a heater for said boiler, control means for said apparatus arranged to energize said heater and to energize said motor field in such fashion that the same generates a high starting torque and high heat and means responsive to a change in the thermal condition of a portion of the apparatus induced by energization thereof by said control means for energizing said field in such fashion that it produces a normal running torque and a low heat.

2. Absorption refrigerating apparatus comprising a boiler, a condenser, an evaporator, an absorber and a fluid circulator connected in circuit, a drive motor for said fluid circulator including a rotating part contacted by a lubricant which is non-fluid at atmospheric temperatures, a field winding for said motor, a heater for said boiler, control means for said apparatus arranged to energize said heater and to energize said motor field in such fashion that the same generates a high starting torque and high heat and means responsive to the temperature of said lubricant for energizing said field in such fashion that it produces a normal running torque and a low heat.

3. An absorption refrigerating system comprising a boiler, a condenser, an evaporator, an absorber and a fluid circulator connected in circuit, a drive motor for said circulator including a rotating part hermetically sealed in said system and immersed in a lubricant which offers sufficient resistance at atmospheric temperatures to block rotation of said rotating part, a field winding for said motor, a heater for said boiler, refrigeration demand responsive means for energizing a portion of said field winding and said heater, and means for energizing the entire field winding when said lubricant has softened sufficiently to allow said motor to start.

4. Absorption refrigerating apparatus including a fluid circulator, a drive-motor for said fluid circulator having a rotating part sealed in the system and supported in a normally non-fluid lubricant, a multi-polar field for said motor mounted exteriorly of said apparatus, control means for energizing a portion only of said field, and means for energizing all of said field when said lubricant has been rendered fluid by the heat generated by said portion of said field.

5. Absorption refrigerating apparatus including a generator, a liquefier, an evaporator, an absorber and a fluid circulator connected in circuit, a heater for said generator, an electric motor arranged to drive said circulator, said electric motor including a field winding, control means for energizing said heater and for energizing a part of said field winding to produce a high starting torque, and means for energizing

said field winding to produce a normal running torque in response to a change in the condition of a part of the apparatus induced by operation thereof.

6. Absorption refrigerating apparatus including a generator, a liquefier, an evaporator, an absorber and a fluid circulator connected in circuit, a heater for said generator, an electric motor arranged to drive said circulator, a lubricant for said motor and in contact therewith which is sufficiently thick at atmospheric temperatures to impose a stalling load upon said motor, said electric motor including a field winding, control means for energizing said heater and for energizing a part of said field winding to produce a high starting torque and a large quantity of heat for softening said lubricant, and means for energizing said field winding to produce a normal running torque when said lubricant has been heated sufficiently to serve its lubricating function without imposing a stalling load upon said motor.

7. Absorption refrigerating apparatus including a fluid circulator, a drive motor for said fluid circulator having a field winding, starting connections for said motor arranged to energize a portion only of said winding, running connections for said motor arranged to energize all of said field winding, refrigeration demand responsive control means arranged to energize said motor through said starting windings, and means operated by a change in the condition of a part of the apparatus induced by initiation of operation thereof for energizing said motor through said running connections.

GEORGE P. DAIGER.