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CONTROL APPARATUS

Original Filed June 6, 1939

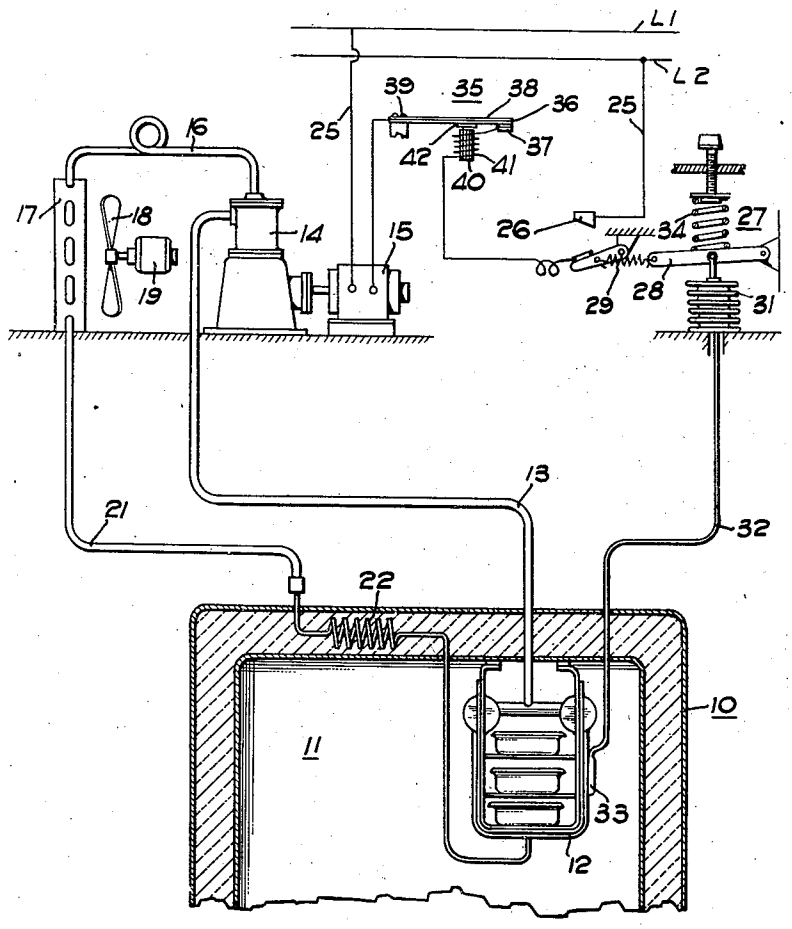

FIG. 1.

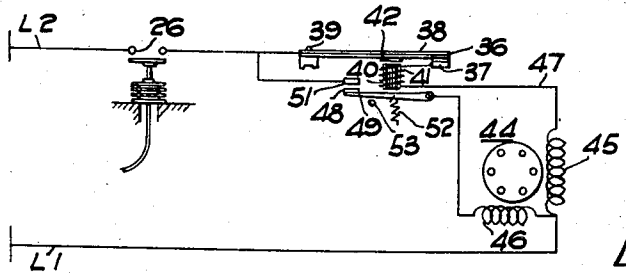

FIG. 2.

INVENTOR
LESLIE B. M. BUCHANAN.
BY W. A. Steiger
ATTORNEY

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CONTROL APPARATUS

Leslie B. M. Buchanan, Springfield, Mass., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

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10 Claims. (Cl. 62—4)

My invention relates to control systems for electric motors and particularly to control systems for motors which drive refrigerating apparatus. This application is a division of my application, Serial No. 277,605, filed June 6, 1939, for Control apparatus.

It is an object of the invention to provide an improved control system of the type set forth.

A further object of the invention is to preclude the energization of an electric motor until a period of time of predetermined duration has elapsed subsequent to a deenergization of the motor.

A further object is to provide an improved control system for a motor which precludes starting of the motor until a period of time of predetermined duration has elapsed subsequent to a previous stopping of the same and which terminates operation of the motor in response to an overload thereon.

It is another object of the invention to provide improved control apparatus for a motor having different starting and running circuits wherein starting of the motor is prevented unless a time period of predetermined duration has elapsed subsequent to a prior stopping of the same and which is effective to establish selectively the starting and running circuits of the motor.

Another object of this invention is to prevent the starting of an electrically-driven refrigerating machine, having an expansion device of the so-called capillary tube type, until sufficient time has elapsed for the tube to reduce to a predetermined value, the pressure differential between the high and low sides of the machine, subsequent to a prior stopping of the machine.

A still further object of the invention is to provide improved control apparatus for compression refrigerating machines that obviates the necessity of an unloader, that affords starting of the machine while maintaining the starting current at a relatively low value, that affords overload protection for the compressor motor and which selectively adjusts the circuit of the motor from "starting" to "running" conditions.

The foregoing and other objects are effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawing, forming a part of this application, in which:

Fig. 1 is a diagrammatic view of my novel control system as applied to a refrigerating system of the compression type.

Fig. 2 is a diagrammatic view of a modified form of control system when applied to a motor having different starting and running circuits.

Reference will now be had to Fig. 1 of the drawing wherein I have shown a refrigerating system of the compression type including an insulated cabinet structure 10 which encloses a space or chamber 11 to be refrigerated. Heat is abstracted from the media in the chamber 11 by means of an evaporator 12 constructed in any well understood manner. Refrigerant vaporized in the evaporator is withdrawn therefrom through a conduit 13 by means of a compressor 14, the latter being driven by an electric motor 15 of any suitable type. The withdrawn vapor is compressed by the compressor 14 to a relatively high pressure and delivered through a conduit 16 to a condenser 17 wherein it is cooled and condensed. Cooling of the condenser 17 may be effected in any well understood manner, such as, for example, by means of a fan 18 driven by an electric motor 19.

The condensed refrigerant is returned to the evaporator through a conduit 21 having an expansion device 22 connected therein for reducing the pressure of the condensed refrigerant from the relatively high pressure at which it is condensed to the relatively low vaporizing pressure maintained in the evaporator 12 by the compressor 14. The expansion device 22 is of the type having a fixed flow area of relatively high resistance and preferably includes an elongated tube of small diameter. This form of expansion device is commonly referred to in the industry as a capillary tube. It will be understood that the tube 22 provides communication at all times between the condenser 17 and the evaporator 12 so that there is a flow of refrigerant from the condenser to the evaporator as long as a pressure differential prevails therebetween.

During active periods of the compressor 14, a relatively high pressure differential obtains between the high and the low sides of the system so that the condensed refrigerant is forced from the condenser 17 through the tube 22 to the evaporator 12 at a relatively high rate, the pressure of the condensed refrigerant being reduced as it traverses the tube 22. Vaporization of the liquid in the evaporator at low temperature and pressure is effected. When operation of the compressor 14 is terminated, the delivery of refrigerant from the condenser to the evaporator continues at progressively reduced rates until the pressures therein are substantially equalized. In a conventional domestic machine equalization of pressures in the condenser and evaporator is

effected in approximately two minutes. This period of time will, however, vary with different types and sizes of machines.

As the pressure difference between the high and low sides of the system is reduced to a low value during the inactive period of the compressor, it will be apparent that, upon starting, the compressor 14 is subjected to a very light load. Accordingly, a machine of this type may be operated without an unloader as the motor is subjected to a light load during starting. If, however, the machine is stopped and then quickly started due, for example, to a momentary power failure, the motor 15 is subjected to a very heavy load because of the high pressure differential obtaining between the condenser and the evaporator and the resultant high compressor load. This operation may result in the blowing of the fuses in the motor supply circuit or stalling of the motor.

The motor 15 is energized from a suitable source of power represented by the line conductors L_1 and L_2 and is connected in an electrical circuit 25 having a master control switch 26 connected therein. The switch 26 may be operated in any well understood manner but preferably defines a part of a thermostatic switch structure, generally shown at 27, and including a movable arm 28 connected to the movable contact of the switch 26 by means of a snap-acting mechanism 29. Movement of the arm 28 is effected by an expansible bellows 31 which communicates with a tube 32, one end of which is closed and is disposed in intimate heat exchange relationship with the evaporator 12 as shown at 33. The bellows 31 and tube 32 preferably contain a volatile fluid, the pressure of which is a function of the temperature of the evaporator 12. Movement of the bellows 31 is opposed by a spring 34, the bias of which may be adjusted for varying the temperatures at which the switch 26 is opened and closed. As the construction and operation of thermostatic switches of the type shown at 27 are well understood in the art no further description of the same is deemed necessary.

In accordance with my invention, means is provided for preventing the starting of the compressor motor 15 until a period of time of predetermined duration has elapsed subsequent to stopping of the motor. The means for accomplishing this operation includes a time interval and protective device, generally indicated by the numeral 35, and including a switch having a movable contact 36 and a stationary contact 37 which are connected in series in the electrical circuit 25. The movable contact 36 is carried by a thermal responsive element, preferably a strip of bimetal 38, the latter being fixed at 39 and so arranged that when heated, it deflects upwardly in switch-opening direction and when cooled it is deflected downwardly in switch-closing direction. The device 35 further includes a magnet 40 having a winding 41 which is energized and deenergized with the motor 15. Preferably, the winding 41 is connected in series in the electrical circuit 25. A magnet armature 42 is carried by the thermal responsive element 38 and is attracted by the magnet during periods when the winding 41 is energized.

The thermal responsive element 38 is electrically heated in any suitable manner during periods when the motor is energized. As shown, the current in the circuit 25 and motor 15 traverses the element 38 for heating the same although it will be understood that the element 38 may be heated otherwise. Preferably, the rate of heating of the element 38 bears a relation to the degree of energization of the motor 15 for a purpose to be referred to hereinafter. During inactive periods of the motor 15, the thermal responsive element 38 is deenergized and cooled so that the switch contacts 36 and 37 are engaged. The motor 15 and the circuit 35 are, therefore conditioned for energization upon closing of the master switch 26.

During active periods of the motor 15, the thermal responsive element 38 is heated by the motor current and tends to deflect upwardly in switch-opening direction. At this time, however, the magnet 40 is also energized and the armature 42 and thermal responsive element 38 are biased downwardly in switch-closing direction. Normally, the bias imposed by the magnet 40 overcomes the upward bias of the element 38 and maintains the switch contacts 36 and 37 in engagement. When the motor 15 and magnet winding 41 are deenergized by the opening of the master switch 26, the bias imposed by the magnet 40 is terminated and the thermal responsive element 38, being heated at this time, moves upwardly for disengaging the contacts 36 and 37. It will be apparent, therefore, that the motor 15 and its circuit 25 are incapable of energization until the thermal responsive element 38 is cooled sufficiently to engage the contacts 36 and 37. The duration of the period of time that the contacts 36 and 37 are disengaged is predetermined and is sufficient to allow the expansion device 22 to effect a reduction in the pressure differential between the condenser and the evaporator to a value at which starting of the motor may be effected without drawing excessive line current.

It will be apparent from the foregoing description that the device 35 functions to permit starting of the motor 15 only when the load thereon is below a predetermined value. If the power fails during a period of operation of the motor, deenergization of the magnet winding 41 relieves the downward bias on the element 38 so that the latter, being heated, immediately moves upward for opening the motor circuit 25 by disengaging of the contacts 36 and 37. If the supply of power is immediately resumed, energization of the motor cannot be effected until the thermal responsive element 38 is cooled sufficiently to engage the contacts 36 and 37. The period of time required for such cooling is sufficient to permit the capillary expansion device 22 to reduce the condenser pressure to a value at which starting of the motor 15 may be effected without drawing excessive current from the supply source.

Overload protection for the motor 15 may be provided by the time interval and protective device 35. The downward bias imposed by the magnet 40 is a function of the amount of current in the circuit 25. The amount of heat imparted to the thermal element 38 and the upward bias thereof vary, substantially, as the square of the current in the circuit 25. Accordingly, during periods of normal operation or when the running current of the motor is below a predetermined value the bias imposed by the magnet 40 overcomes the bias of the thermal element 38 and maintains the circuit 25 closed. As the current in the circuit 25 increases to an abnormal value the upward bias of the thermal element 38 increases more rapidly than the downward bias imposed by the magnet 40 so that at some predetermined overload current value.

the bias of the thermal element 38 overcomes the bias of the magnet 40 and the switch contacts 36 and 37 are disengaged for terminating operation of the motor 15. Closing of the contacts 36 and 37 subsequent to the opening of the same because of the overload, is effected after the time interval during which the condenser pressure is reduced to the low value at which starting of the motor 15 may be readily effected.

It will be apparent from the foregoing description that the device 35 functions as a time interval device, that is, it prevents energization of the motor 15 subsequent to a deenergization thereof for a period of time which is of sufficient duration to allow the pressure in the condenser 17 to be reduced to a value at which starting of the motor 15 may be effected without excessive starting current. The device 35 furthermore functions as an overload device which terminates operation of the motor 15 for a predetermined period of time sufficient to effect the pressure reduction referred to heretofore upon the occurrence of an overload of predetermined value.

In Fig. 2 I have shown a partial diagram of the electrical circuit for a motor having different starting and running circuits and protected by a device constructed along the lines of the device 35 in Fig. 1 but including provisions for selectively establishing the starting and running circuits. Portions of the system which are common to Figs. 1 and 2 are indicated by similar reference characters. The compressor motor indicated at 44 which I have shown in Fig. 2 is of the split phase type and includes a running winding 45 and starting winding 46. The running winding 45 has one of its terminals connected to the line conductor L_1 and the other terminal connected in a circuit, indicated at 47, and including the magnet winding 41 and thermal responsive element 38 in the same manner as described heretofore. The starting winding 46 has one of its terminals connected to the line conductor L_1 and its opposite terminal electrically connected to a movable contact 48 that is carried by a pivoted lever 49. The movable contact 48 cooperates with a stationary contact 51 which is electrically connected through the master switch 26 to the line conductor L_2. The pivoted lever 49 is biased downwardly by a spring 52 and is engageable with a stop 53 when switch contacts 48 and 51 are disengaged. The lever 49 functions as a second armature for the magnet 40 and is directed upwardly for engagement of the contacts 48 and 51 during starting periods of the motor, or when the current in the winding 45 is above a predetermined value. When the starting current is reduced below said predetermined value, the spring 52 moves the armature 49 downwardly for disengaging the contacts 48 and 51 and thereby deenergizing the starting winding 46. The operation of the protective device in Fig. 2 in affording the time interval and overload protection is the same as described heretofore in connection with the device 35 in Fig. 1; the only difference being that the device in Fig. 2 is also employed for controlling the starting winding of the compressor motor. I have shown a motor of the split phase type wherein the starting winding is open circuited during running operations but it will be understood that other types of motors having circuits which are adjusted between "starting" and "running" may be controlled equally well in accordance with the invention.

While my invention is particularly adaptable for application to a motor for driving a refrigerating machine of the type set forth, it is to be understood that it is adaptable for controlling motors which drive other types of apparatus wherein a time interval between stopping and starting of the motor is desired.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are specifically set forth in the appended claims.

What I claim is:

1. In apparatus for controlling the operation of a refrigerating machine, the combination of means for starting and stopping operation of the refrigerating machine, and means for preventing starting of the refrigerating machine until a time interval of predetermined duration has elapsed subsequent to stopping thereof during normal operation.

2. In apparatus for controlling the operation of a refrigerating machine, the combination of electrical means for actuating the refrigerating machine, means for energizing and deenergizing said electrical means, means energized simultaneously with the electrical means for precluding a succeeding energization of the electrical means until a predetermined period of time has elapsed subsequent to deenergization during normal operation thereof.

3. In combination, a refrigerating machine, a motor for driving the same, means for energizing and deenergizing said motor, and electrical means for precluding energization of said motor subsequent to a deenergization during normal operation thereof until a predetermined period of time has elapsed, said electrical means being effective to terminate operation of the motor in response to an overload thereon.

4. In combination, a refrigerating machine, a motor for driving the same, a switch for controlling energization of the motor, a second switch for controlling energization of the motor independently of the first switch, a member heated during operation of the motor for biasing the second switch in opening direction and magnetic means energized only during operation of the motor for biasing the second switch closed and overcoming the bias of the heated member during normal operation of the motor, said heated member effecting opening of the second switch for a predetermined period of time when the magnetic means is deenergized and when the current in the motor increases to a predetermined high value.

5. In combination, a refrigerating machine, a motor for driving the same, a switch for controlling energization of the motor, a heat responsive element for biasing the switch toward its open position when heated, said element being connected in the electrical circuit of the motor and heated by the current in said circuit, the value of the bias of the element varying substantially with the square of the motor current, and electro-magnetic means for biasing the switch toward its closed position, said magnetic means being connected in the electrical circuit of the motor and energized by the current in said circuit, the value of the bias of the magnetic means varying at a rate which is less than the square of the motor current.

6. In a control system for a refrigerating machine having refrigerant evaporating means, refrigerant condensing means and an expansion device having a passage of fixed flow area for conveying refrigerant from the condensing means to the evaporating means, the combination of a switch for initiating and terminating operation of the refrigerant condensing means, and a control mechanism for precluding starting of the refrigerant condensing means until a predetermined time interval has elapsed subsequent to stopping of the same during normal operation.

7. In a control system for a refrigerating machine having refrigerant evaporating means, refrigerant condensing means and an expansion device having a passage of fixed flow area for conveying condensed refrigerant to the evaporating means, the combination of a switch for controlling energization of the condensing means, an electrically heated element for biasing said switch to its open position when heated, and electro-magnetic means for biasing said switch closed when energized, said element and electromagnetic means being energized at rates varying with the flow of current energizing the condensing means.

8. In refrigerating apparatus, the combination of means for evaporating refrigerant at relatively low pressure, means for condensing refrigerant at relatively high pressure, an expansion device having a passage of fixed flow area for conveying condensed refrigerant from the condensing means to the evaporator, said device effecting a reduction in pressure of the condensed refrigerant to the pressure of vaporization in the evaporator during active periods of the condensing means and effecting a reduction of the pressure differential between the condensing and evaporating means during inactive periods of the condensing means, electrically energized means for actuating the condensing means, means for initiating and terminating energization of the electrically energized means, a switch for also controlling energization of the electrically energized means, means for maintaining said switch closed during periods of normal energization of the electrical means and means for opening said switch for a predetermined period of time subsequent to deenergization of the electrical means after normal energization thereof, said period of time being of sufficient duration to permit the expansion device to reduce said pressure differential to a value at which starting of the condensing means is readily effected.

9. In refrigerating apparatus, the combination of a refrigerant evaporator, a refrigerant condensing system including a compressor and a condenser, an electric motor for driving said compressor, an electric circuit for energizing said motor, means between the condenser and the evaporator for conducting refrigerant liquid and for maintaining a pressure differential therebetween when the condensing system is in operation, said last means also providing for slow equalization of pressure between the evaporator and the condensing system when the operation of the condensing system ceases, a normally-closed bimetallic switch in said motor energizing circuit, said switch being adapted to open when heated, electric means for heating said bimetallic switch, said heating means being energized simultaneously with said motor, and means also energized simultaneously with said motor for holding said switch in closed position, whereby said bimetallic switch is heated when said motor is energized and released by said holding means to open at the termination of the energization of the motor to prevent energization of the motor until said switch has closed, the reclosing of said switch being timed to permit substantial equalization between the pressures in the evaporator and the condensing system.

10. In apparatus for controlling the operation of a refrigerating machine, the combination of means for starting and stopping operation of said machine and means conditioned for action during normal operation of the machine for precluding a succeeding starting of the machine until a predetermined period of time has elapsed subsequent to the stopping of the machine.

LESLIE B. M. BUCHANAN.