Dec. 19, 1967 D. N. SHAW 3,358,468

CONTROL APPARATUS FOR REFRIGERATION COMPRESSOR

Filed Aug. 3, 1965

FIG. 1

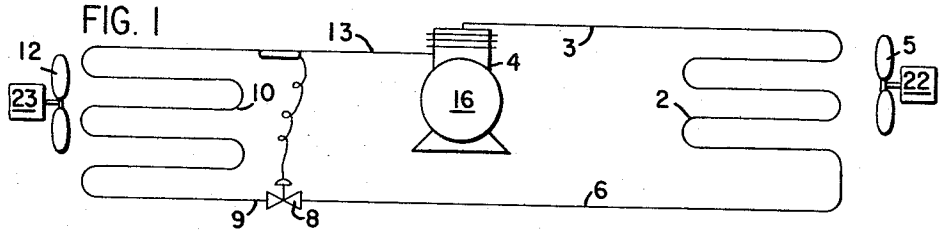


FIG. 2

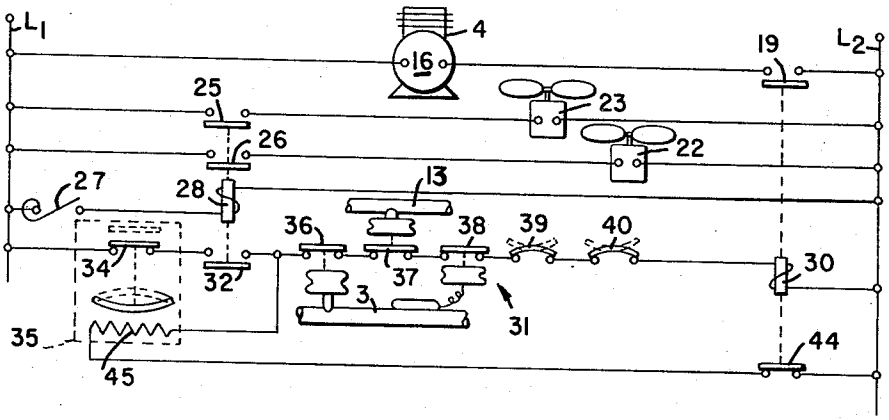
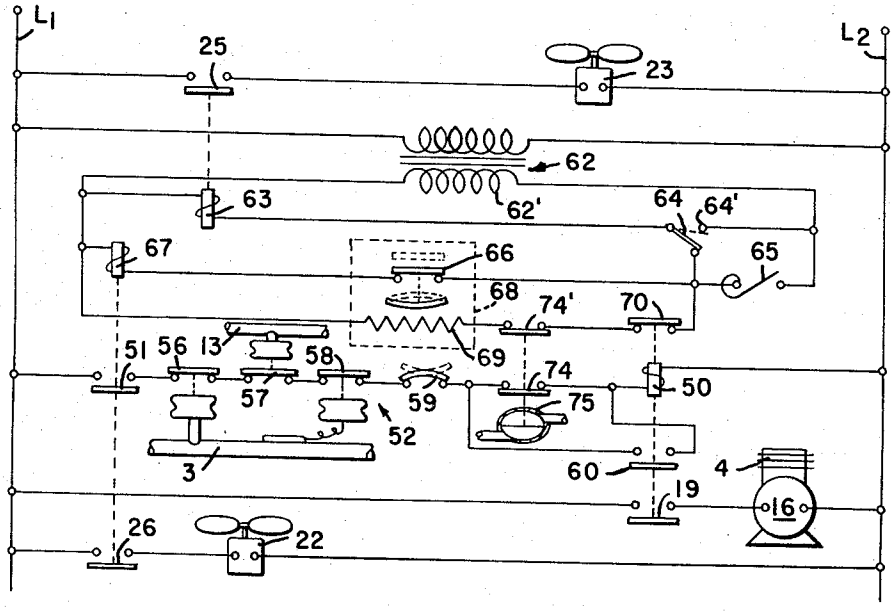


FIG. 3



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CONTROL APPARATUS FOR REFRIGERATION COMPRESSOR

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ABSTRACT OF THE DISCLOSURE

A heat based control to limit the number of malfunction induced start-stop cycles of a compressor. During the periods of malfunction induced compressor shutdown, heat is added to the control such that on a single relatively long shutdown or on a series of shorter shutdowns, the control reacts to preclude further restarting of the compressor.

This invention relates to a refrigeration system, and, more particularly, to a control arrangement for the compressor of the refrigeration system.

Refrigeration systems usually incorporate one or more protective devices, each effective at a certain malfunction in the system or the system compressor to render the compressor inoperative. Typical protective devices are, for example, an over-temperature sensor for the compressor motor windings, system pressure measuring devices, devices for sensing adequate compressor oil pressure, etc. In refrigeration systems incorporating protective devices of the type described heretofore, the system compressor is restarted following stoppage thereof upon resetting of the affected protective device. Where, however, the malfunction remains, the system compressor is stopped and started indefinitely until the operator becomes cognizant of the system malfunction or the compressor becomes totally inoperative. This situation is of particular concern in commercial systems where the system is apt to be left unattended for prolonged periods of time.

It is a principal object of the present invention to provide a new and improved control arrangement for refrigeration system compressors.

It is a further object of the present invention to provide a control arrangement effective to limit the number of compressor restarts that may be made within a predetermined period of time.

It is an object of the present invention to provide an apparatus effective to prevent restarting of a compressor following a certain number of malfunction initiated shutdowns within a given period of time.

It is a further object of the present invention to provide a control apparatus for compressors incorporating an energy storage means adapted upon each malfunction initiated compressor shutdown to store energy, the control apparatus responding to a predetermined energy level to permanently shut down the compressor.

The invention relates to a refrigeration system comprising, in combination, a compressor; an energizing circuit for the compressor; condition sensing means operable at the occurrence of a predetermined malfunction to interrupt the compressor energizing circuit and stop the compressor; means for limiting the number of compressor start-stop cycles including control means effective when at a predetermined energy level to interrupt the compressor energizing circuit to prevent start-up of the compressor; and means for changing the energy level of the control means in response to starting and stopping of the compressor, the energy changing means being arranged to establish the predetermined energy level following uninterrupted stoppage of the compressor for a preset timed interval.

Other objects and advantages will be apparent from

the ensuing description and the accompanying drawings in which:

FIGURE 1 is a schematic representation of a refrigeration system incorporating the compressor control arrangement of the present invention;

FIGURE 2 is a wiring diagram of the compressor control arrangement of the present invention; and

FIGURE 3 is a wiring diagram illustrating a modified compressor controlling arrangement of the present invention.

Referring to FIGURE 1 of the drawings, there is shown a refrigeration system incorporating the control arrangement of the invention. The system includes an outdoor heat exchange coil or condenser **2** connected by means of line **3** with the discharge side of a suitable refrigerant compression mechanism, for example, a reciprocating type compressor **4**. The gaseous refrigerant from compressor **4** flowing through outdoor coil **2** is condensed by ambient air from outdoor fan **5**. Liquid refrigerant from coil **2** flows through line **6**, thermal expansion valve **8**, and line **9** to indoor coil or evaporator **10**. It is understood that other suitable expansion devices, i.e. a capillary tube may be employed in place of expansion valve **8**.

Liquid refrigerant in indoor coil **10** is vaporized by the stream of air from indoor fan **12**, the cooled air being thereafter passed to the area being condition by suitable means (not shown). Vaporous refrigerant from coil **10** flows through line **13** to compressor **4**.

Referring to FIGURE 2 of the drawings, drive motor **16** of compressor **4** is connected through contactor **19** across leads L_1, L_2. Leads L_1, L_2 are connected to a suitable source of alternating current power (not shown). It is understood that a polyphase source of electrical power may be employed if the circuit is suitably modified.

Indoor fan motor **23** is connected by switch **25** across leads L_1, L_2. Outdoor fan motor **22** is connected by switch **26** across leads L_1, L_2. Control relay **28** is series connected with temperature responsive switch **27** across leads L_1, L_2. Switch **27** controls operation of the system in response to temperature conditions of the area being conditioned, as will be more apparent hereinafter.

Compressor contactor coil **30** is connected through a series of system protective devices, designated generally by the numeral **31**, control relay switch **32**, and switch **34** of lockout mechanism **35** across leads L_1, L_2. The system protective devices **31** comprise, in the exemplary showing of FIGURE 2, system high pressure switch **36**, system low pressure switch **37**, discharge temperature switch **38**, compressor motor winding thermostatic switch **39**, and current overload switch **40**. Switches **36**, **37** are arranged to open at the occurrence of predetermined high or low system pressures in discharge line **3** or suction line **13**, respectively. Switch **38** senses temperature conditions of the refrigerant in discharge line **3**, switch **38** opening at the occurrence of a predetermined high discharge line temperature.

Thermostatic switch **39** responds to thermal conditions of the compressor motor windings. At a predetermined high motor winding temperature, due, for example, to a locked rotor, thermostatic switch **39** opens. Switch **40** responds to current conditions in the energizing circuit to compressor drive motor **16**, switch **40** opening at a predetermined high compressor motor current. Switch **40** preferably incorporates a delayed re-closing mechanism.

Lockout mechanism **35** comprises any suitable power actuated operator adapted on the input of a preset amount of energy to prevent further operation of the compressor **4**. Any suitable energy source such as pressure, electrical potential, thermal, etc., may be used. A spring may, for example, be used as the pressure energy source. Energy in the form of eelctrical potential may comprise a capacitor or battery. In the description of the invention that

follows, a thermal energy source in the form of heating resistor 45 is employed.

In the lockout mechanism 35 of FIGURE 2 of the drawings, a source of thermal energy, resistor 45, is disposed circumjacent a suitable temperature responsive control switch 34. Switch 34 opens at a predetermined temperature to interrupt the energizing circuit to compressor contactor coil 30 and render compressor 4 inoperative. Preferably, switch 34 is arranged to remain open until manually reclosed. If desired, opening of switch 34 may trigger a signal such as a light.

Resistor 45 serves as the thermal power source for switch 34. Continuous energization of resistor 45 for a timed interval raises the temperature of switch 34 to that temperature at which switch 34 opens. To accommodate variations in temperature conditions of the surrounding area and maintain the response time of switch 34 substantially constant, switch 34 may be ambient compensated in a manner known to those skilled in the art. Resistor 45 and auxiliary contactor 44 are series connected with one another and with control relay switch 32 and switch 34 across leads L_1, L_2.

Where the compressor 4 incorporates an oil pressure responsive control for deenergizing the compressor drive motor 16 when compressor operating oil pressures fall below a safe level, the switch operator, therefore may be substituted for coil 30. When that arrangement is employed, the oil pressure responsive switch operator closes contactor 44 whenever compressor oil pressures drop below a predetermined minimum differential pressure. Thus, whenever compressor 4 is stopped and control relay switch 32 is closed, there is completed the energizing circuit to heater 45 of lockout mechanism 35.

With the several contacts and switches in the position shown in FIGURE 2 of the drawing, upon a demand for cooling, thermostatic switch 27 closes to complete the energizing circuit to control relay 28. Control relay 28, when energized, closes switches 25 and 26 to complete energizing circuits to indoor and outdoor fans 23, 22, respectively. Control relay 28 also closes switch 32 to complete, through lockout switch 34 and the system protective devices 31, an energizing circuit to compressor contactor coil 30. Coil 30 closes contactor 19 to complete the energizing circuit to compressor drive motor 16. At the same time coil 30 opens contactor 44 to interrupt the circuit to heater 45 of lockout mechanism 35.

Upon satisfaction of the cooling demand, thermostatic switch 27 opens to interrupt the energizing circuit to control relay 28 which, in turn, opens switches 25, 26, 32. Switches 25, 26, when opened, interrupt the energizing circuits to indoor and outdoor fans 23, 22, respectively. Switch 32, when opened, interrupts the energizing circuit to compressor contactor coil 30 which in turn, opens contactor 19 to deenergize the compressor drive motor 16 while closing auxiliary contactor 44 in the lockout mechanism energy circuit.

If, during operation of compressor 4, one of the system safety devices should open, such as system high pressure switch 36 in response to a predetermined high pressure condition in discharge line 3, the energizing circuit to compressor contactor coil 30 is interrupted and contact 19 is opened to deenergize compressor drive motor 16.

At the same time auxiliary contactor 44 is closed to complete an energizing circuit through lockout switch 34, control relay switch 32, and auxiliary contactor 44 to resistor 45. Following expiration of the timed interval required for resistor 45 to raise the temperature level of lockout mechanism 35 to the temperature setting responded to by switch 34, switch 34 opens interrupting the energizing circuit to contactor coil 30 and preventing further operation of compressor 4 until lockout switch 34 is reset.

Where the period of energization of resistor 45 is less than the timed interval required for resistor 45 to raise the temperature level of lockout mechanism 35 to that temperature required to open switch 34, the circuit to contactor coil 30 is completed and compressor drive motor 16 energized upon reclosure of a protective switch that initiated compressor deenergization. Where high pressure switch 36, for example, initiated compressor deenergization due to a high system pressure, reclosure of switch 36 in this circumstance restarts compressor 4. When compressor 4 is restarted, resistor 45 is deenergized and lockout mechanism 35 begins to cool. If a malfunction occurs before the temperature of lockout mechanism 35 approximates ambient temperatures, the timed interval required by resistor 45 to raise the temperature of lockout mechanism 35 to the response temperature of switch 34 is reduced. Thus, where a persistent system or compressor malfunction prevails, resulting in intermittent energization and deenergization of compressor drive motor 16, resistor 45, which is energized each time motor 16 is deenergized, progressively raises the overall temperature level of lockout mechanism 35 so that the timed interval for response of lockout switch 34 progressively decreases.

It may be understood that the rate of heat transfer to lockout mechanism 35 by resistor 45 relative to the rate at which lockout mechanism 35 dissipates heat determines the number of malfunction induced stops of compressor 4 that can occur before switch 34 of lockout mechanism 35 opens. The relative rates of heat transfer are affected, among other things, by the material, construction and location of lockout mechanism 35; the temperature setting thereof; and the duration of the compressor stop period or periods relative to the duration of any intervening compressor starts.

Where the malfunction does not re-occur, lockout mechanism 35 ultimately reverts to an ambient temperature level and the full timed interval for response of lockout mechanism 35 is restored.

Where current overload switch 39 incorporates a delayed reclosure, the timed interval of response of lockout mechanism 35 is greater than the timed interval required by current overload switch 39 to reclose. Where current overload switch 39 is arranged to interrupt power leads L_1, L_2, there is no necessity that the timed interval of response of lockout mechanism 35 be greater than the reclosure interval of overload 39.

Referring to FIGURE 3 of the drawings, wherein like numerals refer to like parts, the primary circuit therein shown includes contactor coil 50 series connected with control relay switch 51, system protective devices 52 and switch 74 of system pressure differential sensor 75 across leads L_1, L_2. Sensor 75, which responds to pressure differences between compressor discharge and suction lines 3, 13, respectively, prevents start-up of the compressor 4 when the pressure differential existing between discharge and suction lines 3, 13, respectively, is above a predetermined pressure. At or above the predetermined pressure differential, switches 74, 74' of differential pressure sensor 75 are opened, precluding completion of the energizing circuits to compressor contactor coil 50.

In the exemplary showing of FIGURE 3 of the drawings, system protective devices 52 comprise system high and low pressure responsive switches 56, 57, respectively, discharge line thermostatic switch 58, and compressor motor winding temperature responsive switch 59. The functions of the system pressure responsive switches 56, 57, the system temperature responsive switch 58 and the motor winding temperature responsive switch 59 are the same as that described heretofore in conjunction with switches 36, 37, 38 and 39 of the FIGURE 2 arrangement. Contactor 60 parallels switch 74.

A suitable stepdown transformer 62 operatively connects the primary control circuit with a secondary control circuit. Indoor fan relay 63 is series connected by manual selector switch 64 across the secondary winding 62' of transformer 62. Switch 64, when moved to the dotted line position of the drawing, closes contact 64' to energize

relay 63, relay 63 closing indoor fan switch 25 whereby indoor fan 23 is continuously operated. In the solid line position of the drawing, switch 64 permits automatic operation of indoor fan 23 under the control of room thermostat switch 65.

Thermostat switch 65 is series connected through switch 66 of lockout mechanism 68 to control relay 67 across transformer secondary winding 62'. Resistance type heater 69 of lockout mechanism 68 is series connected with contactor 70, switch 74' of pressure differential sensor 75, and thermostat switch 65 across the secondary winding 62' of transformer 62.

Indoor fan selector switch 64 is assumed to be in the solid line position of FIGURE 3 of the drawings. Upon a demand for cooling, thermostat switch 65 closes to complete an energizing circuit through lockout switch 66 to control relay 67 and indoor fan relay 63. Control relay 67 closes control relay switch 51 to complete an energizing circuit through system protective devices 52 and switch 74 of pressure differential sensor 75 to contactor coil 50. Coil 50 closes contacts 19, 60. Closure of contact 19 completes an energizing circuit to compressor drive motor 16. Closure of contact 60 bypasses switch 74 of pressure differential sensor 75. Additionally, contactor coil 50, upon energization, opens contactor 70 to prevent energization of resistor 69 of lockout mechanism 68.

Control relay 67 additionally closes switch 26 to complete an energizing circuit to outdoor fan 22. Relay 63 closes switch 25 to complete an energizing circuit to indoor fan 23.

Upon satisfaction of the cooling demand, thermostat switch 65 opens to interrupt the energizing circuits to relays 63, 67, thereby deenergizing compressor drive motor 16, outdoor fan 22, and indoor fan 23.

If, during operation of compressor 4, one of the system protective devices 52 opens, such as discharge line temperature responsive switch 58, the circuit to compressor contactor coil 50 is interrupted and contactor 19 is opened. Contactor 19, upon opening, interrupts the energizing circuit to the compressor drive motor 16. The deenergization of compressor contactor coil 50 permits closure of contactor 70 in the energy circuit of lockout mechanism 68.

With the deenergization of compressor drive motor 16, switch 74' of differential pressure sensor 75 closes when the pressure differential across the compressor 4 falls below the predetermined pressure differential responded to by sensor 75 to complete an energizing circuit through thermostat switch 65, contactor 70 and switch 74' to resistor 69. Resistor 69 raises the temperature level of lockout mechanism 68. Following a predetermined timed interval within which resistor 69 raises the temperature level of switch 66 to the response temperature thereof, lockout switch 66 opens to interrupt the energizing circuit to control relay 67. Subsequent operation of compressor 4 is prevented until lockout switch 67 is manually reset.

Where the system or compressor malfunction results in intermittent operation of compressor 4, resistor 69, energized during each period when compressor drive motor 16 is deenergized, gradually raises the energy level of lockout mechanism 68 to progressively shorten the timed interval of response of the lockout mechanism 68 as explained heretofore in conjunction with the FIGURE 2 arrangement.

While I have described and illustrated a preferred embodiment of my invention, it will be understood that my invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

I claim:

1. In a refrigeration system including a compressor, the combination of an energizing circuit for said compressor, condition sensing means operable at the occurrence of a predetermined malfunction to interrupt said compressor energizing circuit and stop said compressor, and means for limiting the number of compressor start-stop cycles including a control means effective when at a predetermined energy level to interrupt said compressor energizing circuit and prevent restarting of said compressor, and means for increasing the energy level of said control means in proportion to the length of time said compressor is stopped by said condition sensing means, said energy increasing means being adapted to establish said predetermined energy level following uninterrupted stopping of said compressor by said condition sensing means for a preset timed interval.

2. The refrigeration system according to claim 1 in which said energy increasing means includes a source of energy, and means for actuating said energy source upon stopping of said compressor by said condition sensing means.

3. The refrigeration system according to claim 2 including means regulating completion of said compressor energizing circuit in response to system demands, said regulating means interrupting said compressor energizing circuit and stopping said compressor upon satisfaction of said system demand, said regulating means being effective to render said compressor cycle limiting means inoperative to permit normal stopping and starting of said compressor an unilimited number of times in response to system demands.

4. The refrigeration system according to claim 3 in which said control means includes a switch effective, when actuated, to interrupt said compressor energizing circuit, and temperature sensitive means adapted at a predetermined temperature to actuate said switch; said energy source comprising a heater for said control means.

5. The refrigeration system according to claim 4 including an energizing circuit for said heater having first and second switches, said regulating means being adapted to close said first switch in response to system demand, said actuating means being adapted to close said second switch upon stoppage of said compressor by said condition sensing means, simultaneous closure of said first and second switches completing said heater energizing circuit.

6. The refrigeration system according to claim 1 in which said condition sensing means includes means responding to a predetermined overcurrent in said compressor effective to interrupt said compressor energizing circuit and stop said compressor, said overcurrent responsive means preventing restarting of said compressor for a second preset timed interval, said first mentioned preset timed interval being greater than said second preset timed interval.

7. The refrigeration system according to claim 1 including means responding to system pressure differentials across said compressor effective at a predetermined pressure differential to prevent completion of said compressor energizing circuit and startup of said compressor, said compressor pressure differential responsive means being arranged to prevent actuation of said energy source whereby said compressor cycle limiting means is rendered ineffective when said pressure differential is above said predetermined pressure differential.

8. The refrigeration system according to claim 2 in which said condition sensing means includes compressor oil pressure responsive means effective at a predetermined compressor oil pressure to interrupt said compressor energizing circuit while actuating said energy source.

9. In a refrigeration system including a compressor, the combination of an energizing circuit for said compressor; condition sensing means operable at the occurrence of a malfunction to interrupt said compressor energizing circuit and stop said compressor; and means for limiting the number of compressor start-stop cycles including a control switch effective, when actuated, to interrupt said compressor energizing circuit and prevent starting of said compressor; a thermal powered operator for said control switch adapted at a preset temperature to

actuate said control switch; and heating means energized upon stopping of said compressor by said condition sensing means, said heating means being effective to heat said operator to said preset temperature upon uninterrupted energization thereof for a predetermined time interval.

10. The refrigeration system according to claim **9** in which said heating means is deenergized upon start-up of said compressor within said predetermined time interval to terminate heating of said control switch operator thereby permitting said operator to cool and reestablish said predetermined time interval, energization of said heating means in response to stopping of said compressor while said operator is cooling being effective to heat said

operator to said preset temperature upon uninterrupted energization thereof for a second predetermined time interval, said second predetermined time interval being of less duration than said first mentioned predetermined time interval.

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MEYER PERLIN, *Primary Examiner.*