United States Patent

Harris

[15] **3,640,085**

[45] **Feb. 8, 1972**

[54] **REFRIGERATION SYSTEM WITH DELAY TIMING MECHANISM**

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[73] Assignee: **Deltrol Corp.**, Bellwood, Ill.

[22] Filed: **Apr. 12, 1971**

[21] Appl. No.: **133,038**

Related U.S. Application Data

[62] Division of Ser. No. 849,961, Aug. 14, 1969, Pat. No. 3,598,214.

[52] **U.S. Cl.** **62/158**, 62/231, 200/38, 307/116, 318/484

[51] **Int. Cl.** **F25b 19/00**

[58] **Field of Search** 62/157, 158, 231; 318/484; 200/38; 307/116

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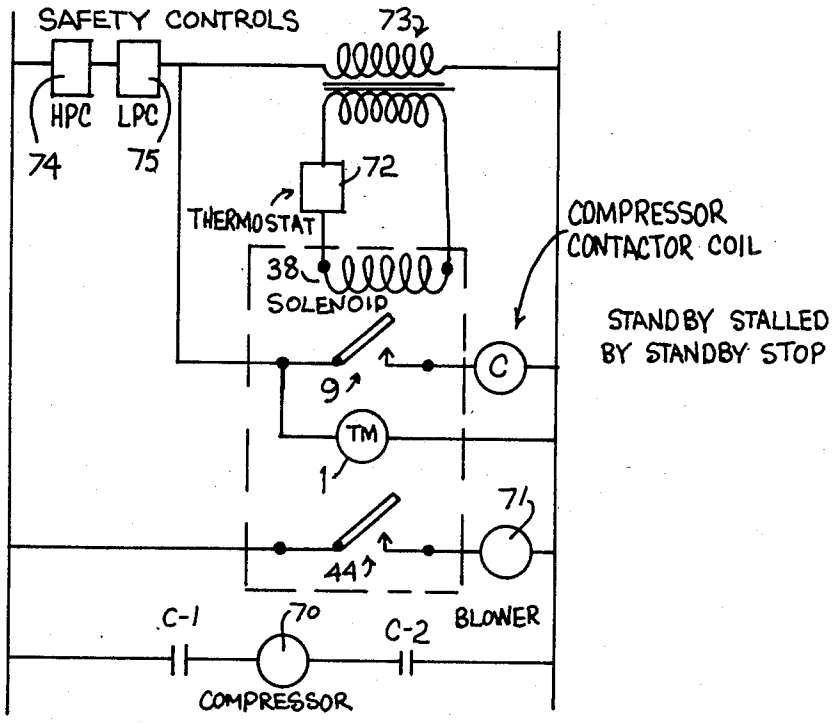
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Primary Examiner—Meyer Perlin

[57] **ABSTRACT**

Protection against refrigeration compressor burnout by short cycling is provided by a delay timing mechanism having a motor and solenoid. The motor is constantly energized and the solenoid controlled by a thermostat stalls or releases the mechanism causing timer operation through its cycle. The timer runs through its delay period during the normal off period, allowing fast restart of the compressor. Also the timer provides a longer delay following a short cycle then following a normal cycle. This is accomplished by operating the timer for a period of time after the compressor is started.

9 Claims, 7 Drawing Figures



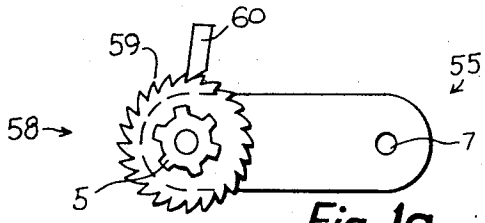


Fig. 1a

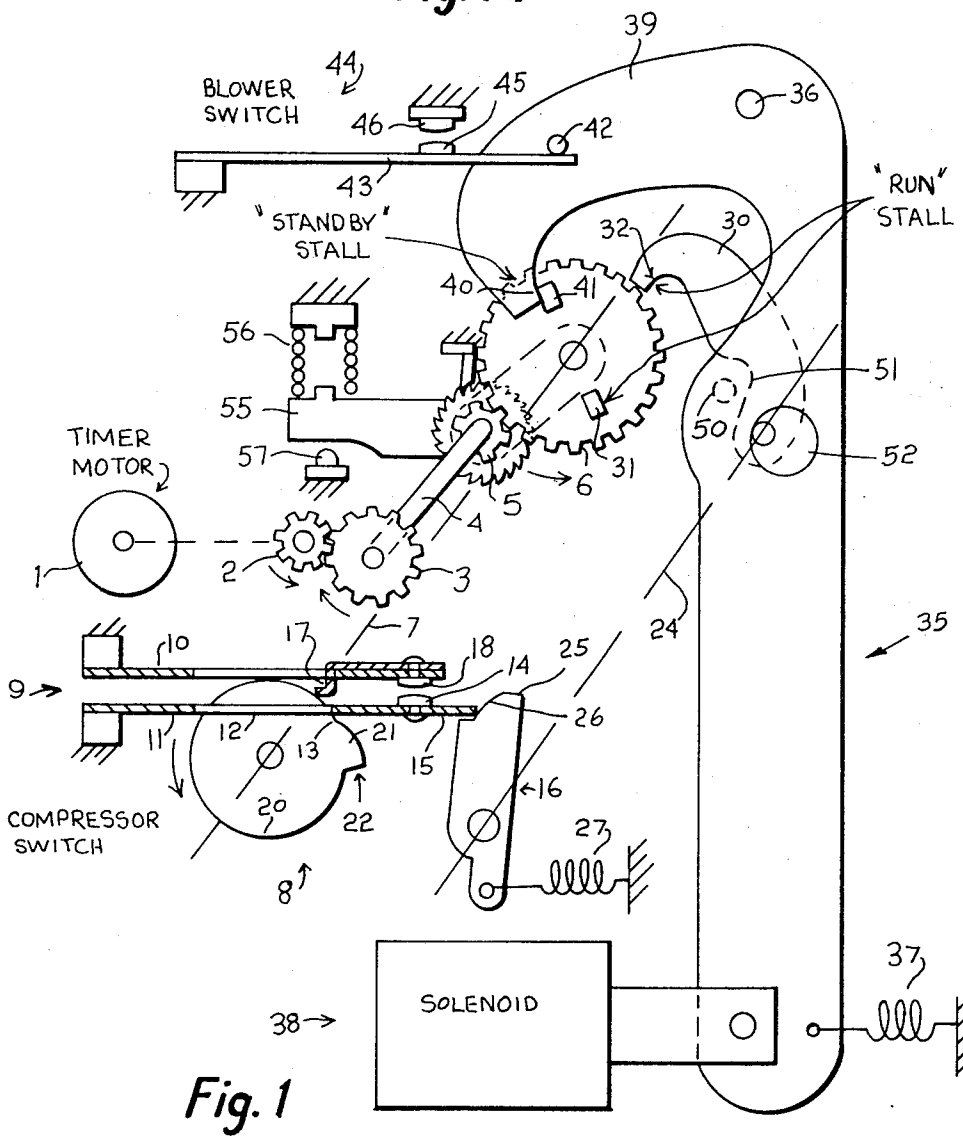


Fig. 1

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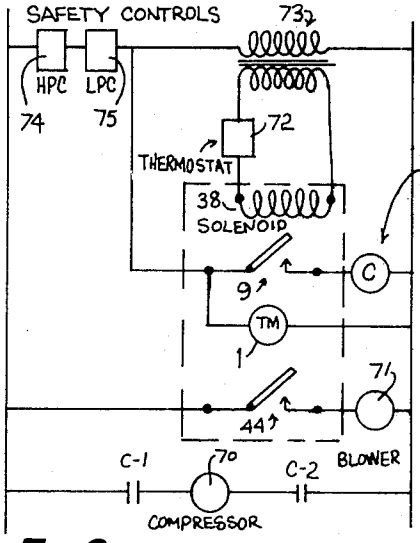


Fig. 2

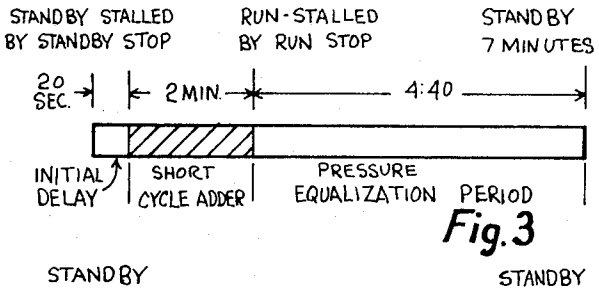


Fig. 3

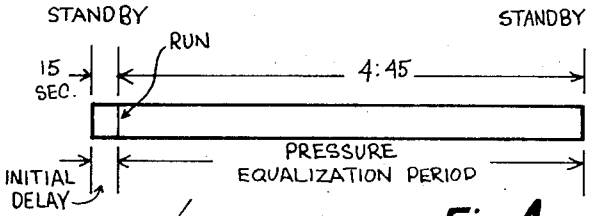


Fig. 4

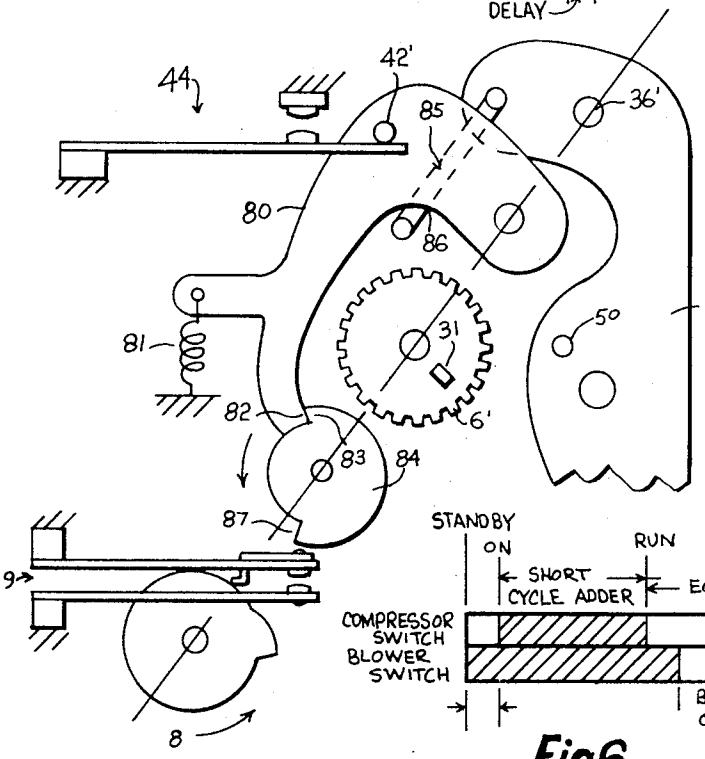


Fig. 5

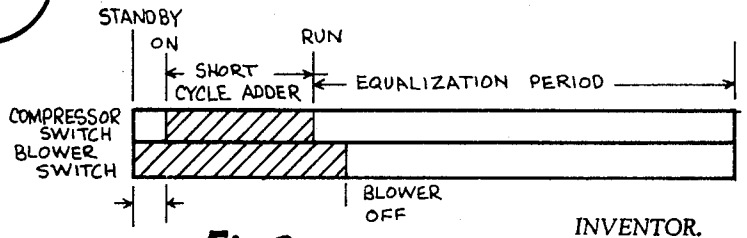


Fig. 6

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REFRIGERATION SYSTEM WITH DELAY TIMING MECHANISM

CROSS-REFERENCE TO RELATED APPLICATION

This application is a division of my application Ser. No. 849,961 filed Aug. 14, 1969, now U.S. Pat. No. 3,598,214 dated Aug. 10, 1971.

BRIEF SUMMARY OF INVENTION

This invention relates to automatic controls and more particularly to timing devices for controlling and protecting compressors in refrigeration systems.

The primary object of the invention is the provision of a compact and simplified control system which stops and starts the refrigeration compressor at the command of a condition responsive device and also interposes a delay in restarting the compressor for protecting against overload.

A further object of the invention is the provision of a simplified refrigeration control system and control device which provides a normal delay before restart for pressure equalization following a normal cycle, but which interposes a substantially longer delay if the compressor stoppage was due to operation of a safety control.

Another object of the invention is the provision of a device and system providing operation of the blower for the refrigeration system for longer periods than the compressor is operated.

A further object of the invention is to provide a simplified timing control system using an electric motor, and which operates in a predetermined cycle without requiring circuitry or switches for timer motor control.

Another object is to provide a timing device in which operation is controlled by selectively stalling or releasing the timer motor.

A further object is to provide a stalling mechanism in which a timing motor is selectively stalled or released and in which the actual stalling force is removed from the mechanism controlling the stalling or releasing.

Other objects will appear from the following description and appended claims.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic exploded view of a mechanism embodying the invention;

FIG. **1***a* is an enlarged view of the stalling wheel of FIG. **1**;

FIG. **2** is a schematic wiring diagram of a complete refrigeration control system embodying the mechanism of the invention;

FIG. **3** is a chart showing the preferred operating sequence as occurs on a normal refrigeration cycle;

FIG. **4** is a chart showing a modified operating cycle;

FIG. **5** illustrates a modification of FIG. **1**, and in which;

FIG. **6** is a chart showing the operating sequence provided by the arrangement of FIG. **5**.

DETAILED DESCRIPTION OF INVENTION

Referring now to FIG. **1**, reference character **1** indicates the timer motor shown schematically, this motor driving a pinion **2** meshing with gear **3** which is carried by and drives a shaft **4** which in turn drives a pinion **5**. This pinion drives a final gear **6** which is carried by and drives a cam shaft **7** carrying a cam **8**. The timer motor **1** drives the final gear **6** and the cam or controller **8** in a counterclockwise direction as indicated by the arrows.

The timing means above described, through cam **8** operates a compressor switch generally indicated as **9**. This switch or control device comprises an upper switchblade **10** and a lower switchblade **11**, each anchored at its left-hand end and both blades being biased downwardly toward the cam **8**. The lower switchblade **11** is provided with an opening **12** allowing the blade to straddle the cam **8** and providing an internal cam follower surface **13**. This blade **11** carries a contact **14** and is provided with an extended portion **15** cooperating with the latch **16**. The upper switch blade **10** includes a cam follower bracket **17** which extends downwardly and rides the cam **8** at a point spaced counterclockwise from the cam follower surface **13**. Switchblade **10** also carries contact **18** arranged for engaging contact **14** on switchblade **11**. The cam or controller **8** consists of a main cam surface including a generally circular portion **20** and a rise portion **21**. The cam also includes a dropoff section **22** which causes dropping of both switchblades with snap action.

The latch **16** is pivoted on a shaft diagrammatically shown as **24** and includes a latching surface **25** and a camming surface **26**, these surfaces cooperating with extension **15** of lower switchblade **11** as will be described. The latch **16** also is provided with a biasing spring **27** which biases this latch toward the end **15** of the switchblade **11**.

The shaft **24** which carries the latch **16** also carries a "run" stalling lever **30**. The latch **16** and the run staller **30** are arranged to operate in unison. While these two parts are shown as separated and spaced apart for illustrative purposes, it will be apparent that these two parts may be molded into a single piece thus ensuring correct alignment of the working surfaces and lowering production cost.

The run-stalling member **30** is shown in disengaged position and is arranged to cooperate with the run-stalling lug **31** carried by the final gear **6** to provide a mechanical stopping means. When the run stalling member **30** is rotated counterclockwise, its stalling surface or movable abutment **32** will be brought into the path of the stalling lug **31** on the final gear. Thus the final gear will be stalled when it rotates to the point where lug **31** engages stalling surface **32**. Clockwise rotation of the stalling member **30** takes the stalling surface **32** out of the path of the stalling lug **31** and thus the timer is free to proceed beyond this point.

Reference character **35** indicates a solenoid lever which is pivoted at **36**. This lever **35** is biased in a counterclockwise direction by a spring **37** and is rotated clockwise against the force of spring **37** by the solenoid or electromagnet **38**. The solenoid lever **35** includes an arm **39** carrying a stalling surface **40** adapted to be engaged by a stalling lug **41** on the final gear **6** providing a mechanical stopping means. The solenoid lever also carries a pin **42** which is arranged to engage the switchblade **43** of the blower switch generally indicated as **44**. The switchblade **43** is anchored at its left-hand end and is biased upwardly. This switchblade includes a movable contact **45** adapted to engage a stationary contact **46**. This switchblade is biased upwardly for causing the contacts to engage. The pin **42** on the solenoid lever pushes the switchblade **43** downwardly when the solenoid is deenergized for openings switch **44**.

The solenoid lever **35** also carries a pin **50** which is adapted to engage the portion **51** of the run stall member **30**. This pin serves to rotate the run stall member in a clockwise direction when the solenoid is deenergized. The solenoid lever is also formed with an opening **52** through which the supporting shaft **24** for the run stall member **30** and latch **16** passes. This serves as a stop for limiting outward travel of the solenoid lever **35** and also limits the inward travel of the stalling surface **40** on this lever.

The shaft **4** which carries the pinion **5** is journaled in a spring lever generally indicated as **55**. This spring lever is pivotally supported on the same center as the cam shaft **7** and is biased in a counterclockwise direction by a spring **56**. The amount of counterclockwise movement is limited by a fixed stop **57**. This stop is located in a manner to cause the gear shaft **4** to be in alignment with the cam shaft **7** when the spring lever **55** engages stop **57**. Spring lever **55** thus provides a movable bearing for pinion **5**. The pinion **5** is rigidly attached to a stalling wheel **58** having ratchetlike teeth **59** adapted to come in contact with a stationary stalling lug **60**. The stalling lug **60** may be struckout of the enclosure for the timing unit or mounted in any suitable manner. It is preferable that the angle of this lug at the point where engaged by the stalling wheel be

tangent to a circle centered with the shaft 7. It is also preferable that the teeth of the stalling wheel be cut so that the stalling surfaces at the point of engagement with lug 60 are parallel with lug 63. The location of the stalling lug 60 relative to the fixed stop 57 must be such as to provide clearance between the stalling wheel 58 and the stalling lug 60 when the spring lever 55 is engaging the fixed stop 57.

FIG. 2 shows the preferred complete refrigeration control system embodying the mechanism of FIG. 1. This system includes a compressor motor 70 and a blower motor 71 which blows air across the evaporator and/or condenser of the refrigeration system. The compressor motor is controlled by the usual contactor having a contactor coil C and switches C–1 and C–2 operated thereby. The system also includes a low-voltage thermostat 72, a low-voltage transformer 73 and safety controls comprising a high-pressure cutout 74 and a low-pressure cutout 75. The latter controls and associated wiring comprise a means for energizing the motor 1. The operation of the mechanism and complete system will now be described.

OPERATION OF FIGS 1 AND 2

With the parts in the positions shown, the system is in the "-Standby" position. The timer solenoid is deenergized which has the "Standby" stalling surface 40 in the path of lug 41 on final gear 6. Even though the timer motor 1 is energized, no motion can take place as the timer is effectively stalled. The compressor switch 9 is open and thus the compressor motor contactor C is deenergized causing the compressor motor to be at rest. Also the blower switch 44 is open and the blower is at rest. Assuming that the pressures within the refrigeration system are satisfactory and that switches 74 and 75 are closed, the timer motor 1 is energized and is ready to drive the timer any time the timing mechanism is released by the stalling mechanism. When the thermostat 72 calls for cooling, it will energize the timer solenoid 38 which rotates the solenoid lever 35 about its pivot 36. This closes blower switch 44 and also removes the stalling surface 40 from the path of the stalling lug 41 on gear 6. This in turn allows the spring 56 to rotate the spring lever 55 downwardly releasing the stalling wheel 59 from the stationary stalling lug 60. This same clockwise rotation of solenoid lever 35 also moves the pin 50 on this lever away from the surface 51 of the stalling member 30. The stalling member 30 however does not move into stalling position at this time as it is being held in released position by latch 16.

As the "Standby" stall has been released, the timer motor now drives the gear 6 and cam 8 in a counterclockwise direction. In a short time the inclined section 21 of the cam engages the cam follower surfaces 13 and 17 of the switchblades 10 and 11 and starts raising the switchblades in unison with the contacts separated. As lower blade 11 is cammed upwardly, the end 15 rides up the camming surface 26 on the latch 16 allowing gradual counterclockwise rotation of the latch. When the end 15 of the blade rises above the latching surface 25 of the latch, the spring 27 is free to pull the latch into complete latching position. This same counterclockwise latching motion also causes the run-stalling member 30 to bring its stalling surface 32 into the path of the stalling lug 31 on gear 6. Inward travel of the latch 16 and stalling member 30 is now limited by the surface 51 on member 30 engaging the pin 50 on the solenoid lever 35.

As the cam 8 continues to rotate, the cam follower surface 13 on switchblade 11 will ride down the dropoff section 22 allowing the end 15 of the switchblade to rest on the latching surface 25 of latch 16 which is now in latching position. On continued rotation of the cam 8, the follower surface 17 on upper switchblade 10 drops off the dropoff section 22 of the cam. Switchblade 10 now drops abruptly bringing contact 18 into engagement with contact 14 and thus closing the load switch 9. This energizes the compressor contactor coil C which in turn closes its contacts C–1 and C–2 starting the compressor motor 70.

The timing mechanism will now continue to run for a predetermined time until the run stall lug 31 on gear 6 engages the stalling surface 32 on the run stall member 30 which is now in stalling position.

When the run stall member 31 engages the stalling surface 32, it stops further rotation of the drive gear 6. In reaction to this, the pinion 5 begins moving bodily in an upward direction, this motion being allowed by the spring lever 55 disengaging stop 57 and moving against the biased of the spring 56. When the teeth on the staller wheel 58 engage the stalling lug 60, the timer motor is effectively stalled.

Due to the reaction-type stalling mechanism provided by the invention, the pressure required for stalling at the stalling lugs 31 or 41 is only that required to compress the spring 56 sufficiently to bring the stalling wheel into engagement with the stalling surface 60. The stalling lugs 31 and 41 on the final gear are never required to stall the full torque of the motor through the reduction gears. Instead, the actual stalling force for the motor is applied ahead of the gear reduction where the torque and force required is considerably lower. This arrangement in which the stalling force is merely triggered by the solenoid operated surfaces makes it possible to design the timer mechanism with the light duty parts and with a relatively small solenoid. This special stalling mechanism could be omitted, using a direct drive between the timer motor and the gear 6. However, this would require the parts being designed sufficiently strong to carry the relatively high loads, and to use a solenoid sufficiently strong to engage or release the higher stalling forces.

On a normal operating cycle, the mechanism will remain in the run stall position with the switches 9 and 44 closed until the thermostat 72 is satisfied. When this occurs, it deenergizes the solenoid 38 causing counterclockwise rotation of the lever 35 by spring 37. This movement of the solenoid lever 35 causes the pin 50 to engage surface 51 on the stalling member 30 and to rotate this member clockwise. This simultaneously moves the stalling surface 32 out of the path of the lug 31 and also moves the latch 16 into released position allowing the switchblade 11 to drop against cam 8 thus opening the compressor switch 9. This same motion of the lever also causes pin 42 to engage switchblade 43 and thus open the blower switch 44. Summarizing, opening of the room thermostat switch 72 deenergizes solenoid 38. This action releases the run-stop 30 and the latch 16 opening load switch 9 and also opening the blower switch 44.

The timing mechanism is now free to proceed back to the standby position where lug 41 on gear 6 engages the standby stalling surface 40 on solenoid lever 35. It is important on this point of the cycle that the run lug 31 on the gear 6 be clear of the stalling surface 40 on the lever 35. This is accomplished by limiting the inward motion of the stalling surface by a stop as provided by the edge of hole 52 in lever 35 engaging the shaft 24. Any other stop arrangement may, of course, be used. The "Run" lug 31 on gear 6 is located inwardly sufficiently that it never engages the Standby stalling surface 40 even when this surface is in stalling position. When the lug 41 engages surface 40, the stalling wheel 58 again engages the stalling lug 60 and stalls the timer motor 1.

It should be noted that there is only one point in the complete revolution of the timer cam where the load switch 9 can be closed. That is the point at which the cam follower surface 17 on switch blade 10 drops off the dropoff section on the cam. In order to effect switch closure, the latch 16 must be in place. If the latch happens to be held released at this time, the load switch will remain open and it will be necessary for the cam 8 to complete another complete revolution before the load switch can be closed.

If during a cycle either the high-pressure switch 74 or low-pressure switch 75 opens, it will break the circuit to the transformer 73 thus deenergizing the solenoid 38. This will have the same effect as dropping out of the solenoid 38 by the thermostat 72 as described. In other words, it will open the compressor motor switch stopping the compressor and will also release the run-stop so that the timer mechanism can proceed

back to the starting point. However, at this time the timer motor is deenergized as it is in circuit with the switches **74** and **75**. Thus the duration of the unfavorable condition causing opening of the safety switches is added to the delay in restarting the compressor.

FIG. **3** shows one type of operating cycle that my control may be arranged to provide. Here the timer motor speed and gear reduction are selected to give an overall cycle of one revolution in 7 minutes. The standby lug **41** on gear **6** is located relative to the dropoff section **22** on cam **8** so as to provide a 20 second delay between energization of the solenoid **38** and closure of the switch **9**. The run stall lug **31** on final gear **6** is located so as to allow a period of 2 minutes after switch closure before the run lug **31** engages the run-stalling surface on lever **30**. This leaves a balance of 4 minutes 40 seconds that the timer must run before it returns to the standby position in which lug **41** engages standby stalling surface **40**.

With the cycle as above described, the timer will run for a period of 2 minutes after the compressor is started. Thus if the compressor runs the full 2 minutes before stopping, there will be a delay of 5 minutes before the compressor can be restarted. This is the sum of the 4 minute 40 second pressure equalization period plus the 20 second initial delay period.

If the system malfunctions and one of the safety switches **74** or **75** opens, for example 10 seconds after start, the timer must now run an additional 1 minute 50 seconds before the compressor can be started. In other words, the timer must now run 6 minutes 50 seconds instead of 5 minutes. In addition, the timer motor is deenergized during the period that the safety switch remains open and this indeterminate time is added to the delay imposed by the timer itself. Thus this system provides substantially longer delays in event of malfunction than during normal cycle providing only time enough for pressure equalization.

The 2 minute short cycle adder of course, can be made substantially longer, even as long as the average on period of the compressor in the system.

FIG. **4** shows an optional cycle in which the gearing is selected to provide a 5 minute revolution on the cam shaft. The cam is arranged to give a 15 second delay in starting and the run lug **31** arranged to stall the timer immediately after switch **9** closes. This gives a 4 minute 45 second interval for the timer to run to return to the standby position.

It will be seen that the duration of the short cycle adder can be made whatever desired simply by selecting the proper gear reduction and by locating the run-stall lug **31** at the proper angle on gear **6**.

FIGS. 5 AND 6

In the embodiment of the invention shown in FIG. **1**, the blower switch **44** is opened and closed by the solenoid **38**. If desired, the blower switch **44** can be held by the timer until a predetermined period after the compressor is stopped. This arrangement is shown in FIG. **5** and the operation charted in FIG. **6**. Here the pin **42'** for operating switch **44** is carried by a separate lever **80** which is pivoted on the same bearing **36'** as the solenoid lever **35'**. The latch **16** and run stall member **30** are identical with FIG. **1** and are omitted from FIG. **5** for reasons of clarity. The lever **80** is biased counterclockwise by a spring **81** and carries a standby-stalling surface **82** adapted to be engaged by a stalling surface **83** carried on a cam **84** located between the cam **8** and the final gear **6'**. A pin **85** carried by the solenoid lever **35'** is arranged to engage a surface **86** on the lever **80**, this pin causing clockwise rotation of the lever **80** when the lever **35'** is rotated in the same direction by energization of the solenoid.

In operation, energization of the solenoid rotates the lever **35'** clockwise which lifts the lever **80** releasing the pin **42'** from switch **44** and also releasing the stalling surface **82** from the corresponding surface **83** on cam **84**. The cam **84** will now hold lever **80** in this position until the timer rotates to the point where the dropoff portion **87** on the cam clears the cam follower surface of lever **80**. At this time, the spring **81** is free to rotate the lever **80** clockwise opening switch **44** and also bringing the stalling surface **82** into position for stalling cam **84**.

The arrangement shown in FIG. **5** has the advantage of maintaining the blower in operation in the event that the compressor is shut down by either safety switch **74** or **75**. Operation of the blower at this time helps to remove the condition causing the shut down.

From the foregoing, it will be apparent that the invention provides an extremely simple compressor control system. Only one switch is required to give response to the thermostat and to provide starting of the compressor or load. In addition, the invention provides for control of the blower giving blower operation both before and after the compressor running cycle. In addition, the invention provides for extra delay in the event of short cycle, thus giving additional protection to the compressor. It will also be apparent that substantial changes in the operating cycle may be made as desired, simply by selecting the necessary gear reduction and locating the stall lugs at the proper locations on the final gear.

While a preferred form of the invention has been shown and described, many changes may be made without departing from the spirit and scope of the invention as defined in the following claims.

I claim:

1. In a control system for a refrigeration system having an electric motor driven compressor, the combination of, a condition responsive device, timing means including an electric timing motor for driving the same and an electromagnet, a control circuit including the condition responsive device and electromagnet whereby the electromagnet is controlled by said condition responsive device, an energizing circuit for the electric timing motor, said energizing circuit being independent of said condition responsive device, a switch for controlling the compressor motor, means including the timing means and the electromagnet for closing said switch in response to a call for condition change by the condition responsive device, said timing means being arranged to delay closure of said switch for a predetermined minimum time, means for mechanically stopping said timing means at a point providing said minimum time, said mechanical stopping means effectively stopping the timing means even though the electric timing motor remains energized by said independent energizing circuit, and means controlled by the condition responsive device including said electromagnet for rendering the mechanical stopping means ineffective and opening said switch when the condition responsive device calls for stopping the compressor.

2. The combination set forth in claim **1** in which a second condition responsive means breaks the energizing circuit for the electric timing motor and also deenergizes the electromagnet in response to an unfavorable condition associated with the refrigeration system, the duration of the unfavorable condition thus being added to said predetermined minimum delay.

3. The combination set forth in claim **1** in which the timing means provides a first delay period sufficient to allow equalization of pressure in the refrigeration system and an additional delay period in the event of a short cycle, said mechanical stopping means being arranged to allow operation of the timing means following starting of the compressor through said additional delay period and then to stop said timing means.

4. The combination set forth in claim **3** in which a second condition responsive means breaks the energizing circuit for the electric timing motor and also deenergizes the electromagnet in response to an unfavorable condition associated with the refrigeration system, the duration of the unfavorable condition thus being added to the delay provided by the timing means.

5. The combination set forth in claim 1 in which the refrigeration system includes a blower having a blower motor therefore, and a switch for the blower motor closed by said electromagnet in response to call for condition change by the condition responsive device.

6. In a control system for a refrigeration system having a compressor and a blower, a compressor motor for driving the compressor, a blower motor for driving the blower, a condition responsive means, an electromagnet, a control circuit including the condition responsive means and electromagnet whereby the condition responsive means controls the electromagnet, means including a compressor motor switch for controlling the compressor motor, means including a blower motor switch for controlling the blower motor, timing means including electric motor means, means for energizing said electric motor means, means actuated by the electromagnet for closing the blower motor switch on call for operation of the compressor by the condition responsive means, means including the timing means for causing closure of the compressor motor switch on call for compressor operation by said condition responsive means, said timing means being arranged to provide a delay between successive energizations of the compressor motor, means for stopping the timing means at a point providing said delay, means operated by the electromagnet on call for stopping of the compressor by the condition responsive means for opening the compressor motor switch, and means also operated by the electromagnet for rendering said stopping means ineffective, allowing the timing means to proceed with a new cycle.

7. The combination recited in claim 6 in which the blower motor switch is maintained closed by the timing means for a predetermined time following stopping of the compressor motor by said electromagnet.

8. The combination recited in claim 6 in which the timing means is restarted immediately following opening of the compressor motor switch by the electromagnet, and runs to a predetermined point, thereby shortening the delay before restart of the compressor during the time the compressor is stopped by the condition responsive means.

9. The combination recited in claim 6 in which the blower motor switch is maintained closed by the timing means until it has run for a predetermined length of time, and in which the energization of the electric motor means for the timing means is interrupted in response to an unfavorable operating condition associated with the refrigeration system.

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