United States Patent

[11] **3,599,006**

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

[54] **CONDITION CONTROL DEVICE AND SYSTEM**
35 Claims, 41 Drawing Figs.

[52] **U.S. Cl.** **307/39,**
62/158, 200/39 R, 200/50 C, 307/41, 307/116
[51] **Int. Cl.** **G05g. 21/00,**
H01k 43/12
[50] **Field of Search** 62/157,
158, 231; 307/39, 41, 116, 117, 115; 317/25;
200/30, 3950c

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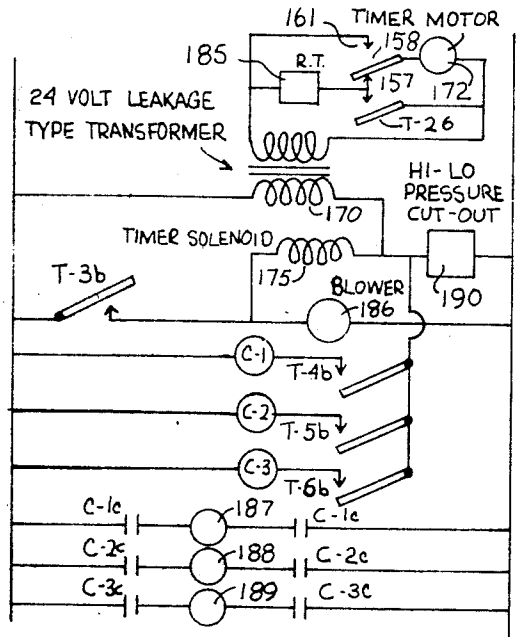
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Primary Examiner—Robert K. Schaefer
Assistant Examiner—William J. Smith

ABSTRACT: A number of compressor motors or electric beaters are turned on and off in sequence to avoid line surges. Each load switch consists of two flexible blades raised by a cam with the contacts separated. A latch serves to hold one blade up when the blades are lowered by the cam, causing contact engagement. A solenoid releases the latches of all the switches to open them simultaneously in response to a thermostat becoming satisfied or indicating an unfavorable condition.

Special circuitry protects against compressor short cycling when the control is applied to refrigeration.



CASCADE ON AND OFF MULTIPLE COMPRESSOR CONTROL

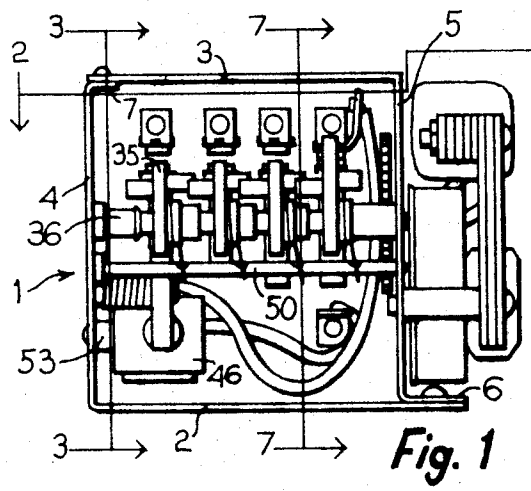


Fig. 1

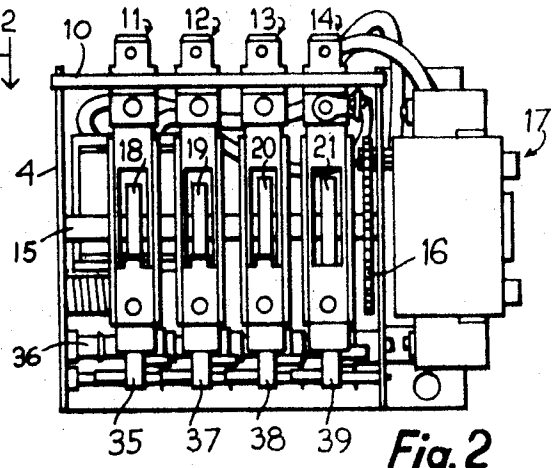


Fig. 2

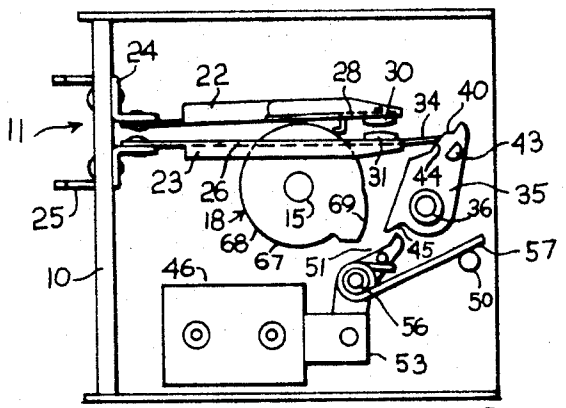


Fig. 3

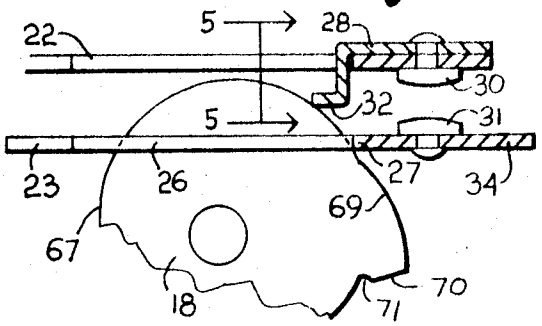


Fig. 4

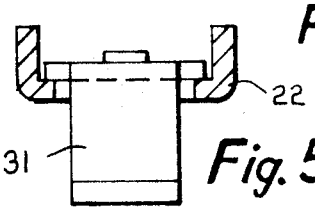


Fig. 5

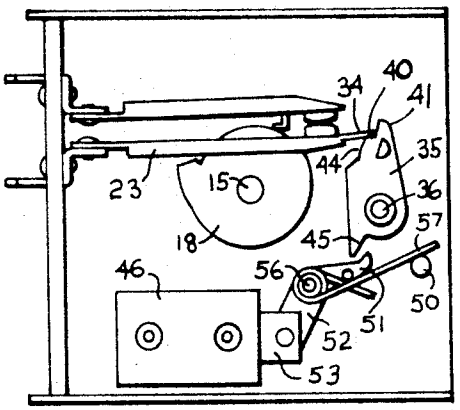


Fig. 6

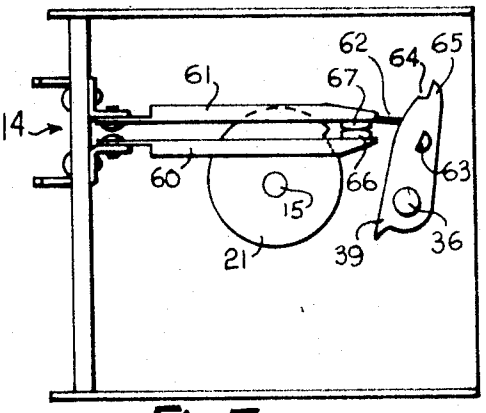


Fig. 7

INVENTOR.

John L. Hall

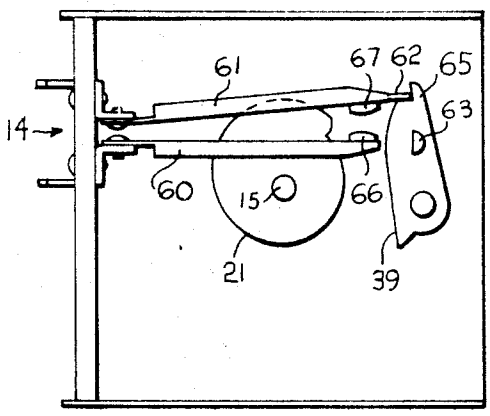


Fig. 8

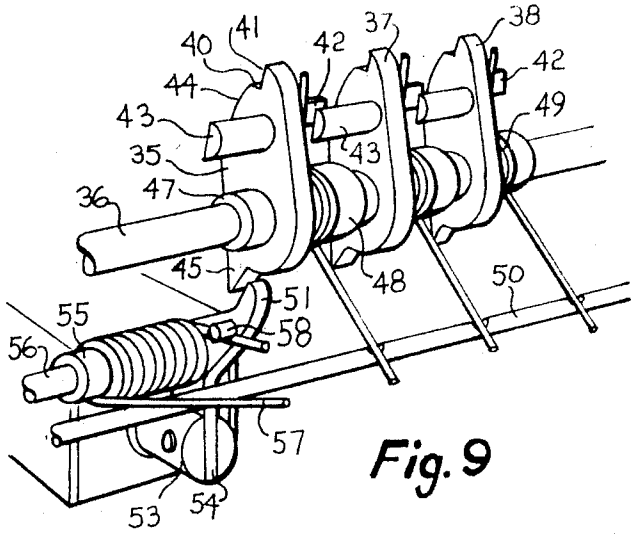


Fig. 9

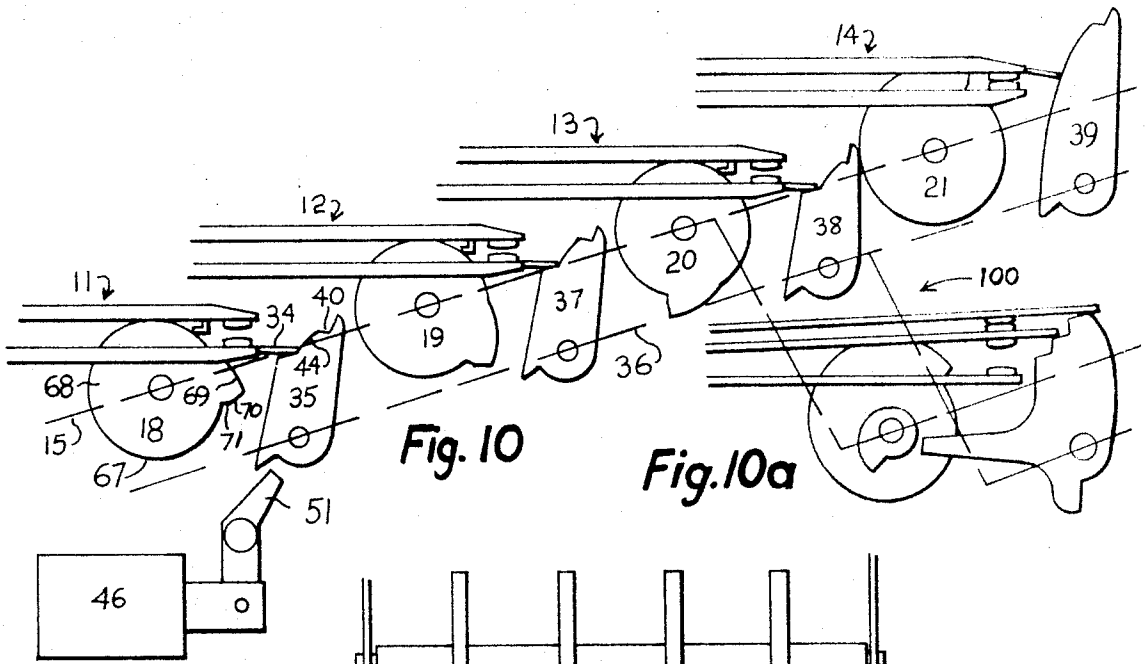


Fig. 10

Fig. 10a

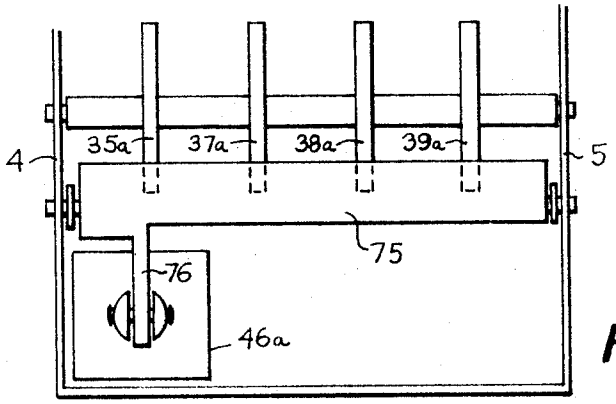


Fig. 11

INVENTOR

John L. Harris

CASCADE ON-REFRIGERATION CONTROL

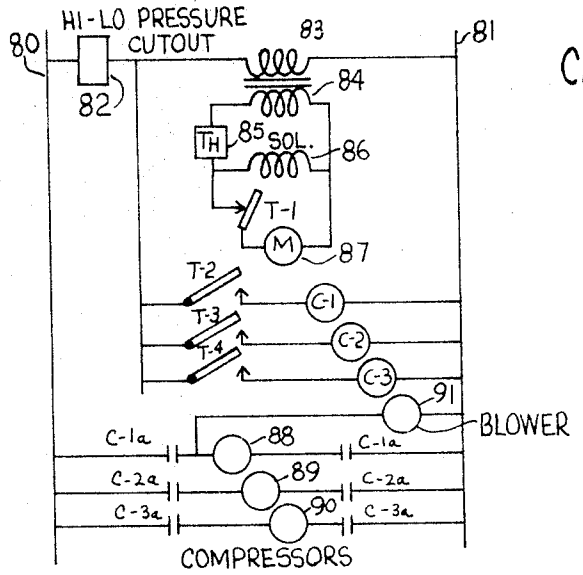


Fig. 12

CASCADE ON-ELECTRIC HEAT CONTROL

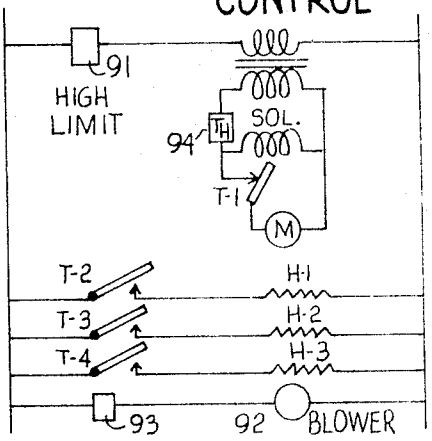
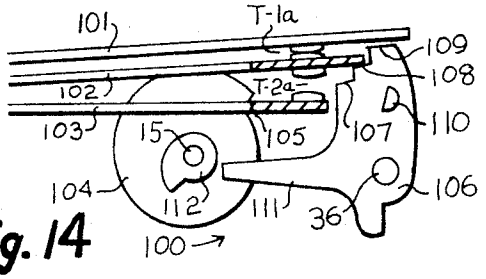
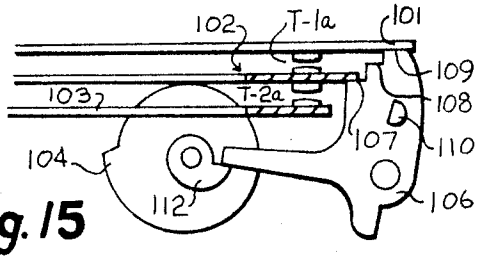


Fig. 13



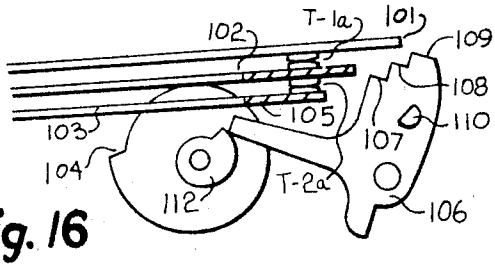
CYCLING SWITCH STAND-BY POSITION

Fig. 14



CYCLING SWITCH RUN POSITION

Fig. 15

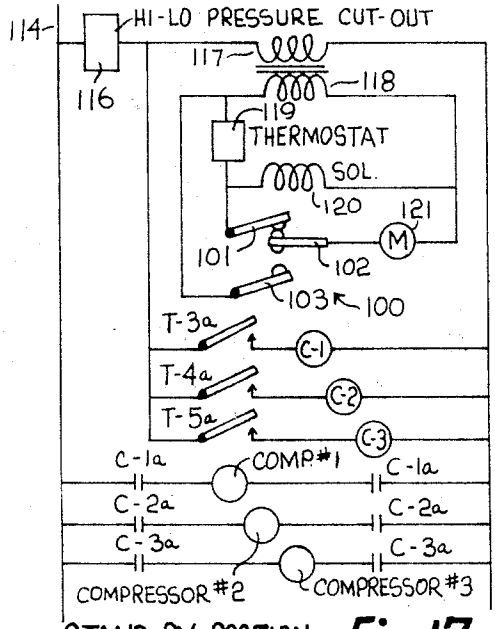


CYCLING SWITCH RETURN TO STAND-BY POSITION

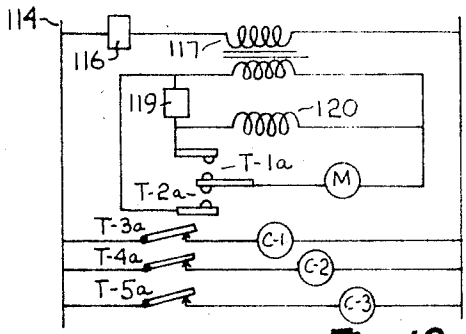
Fig. 16

INVENTOR.

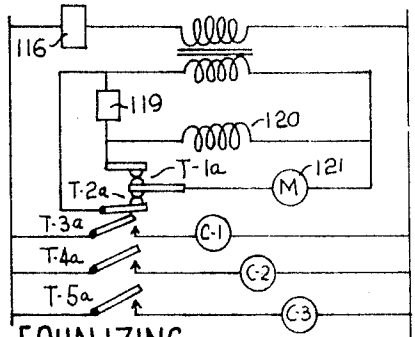
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STAND-BY POSITION **Fig. 17**



RUN POSITION **Fig. 18**



EQUALIZING PERIOD **Fig. 19**

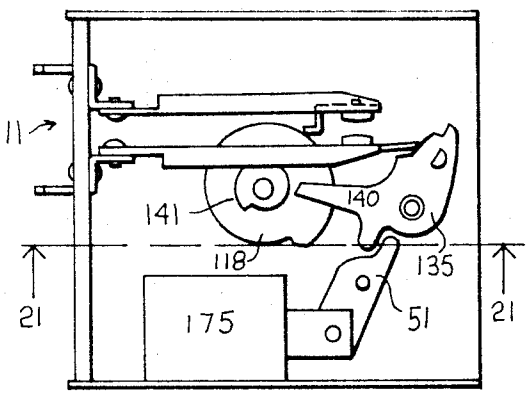


Fig. 20

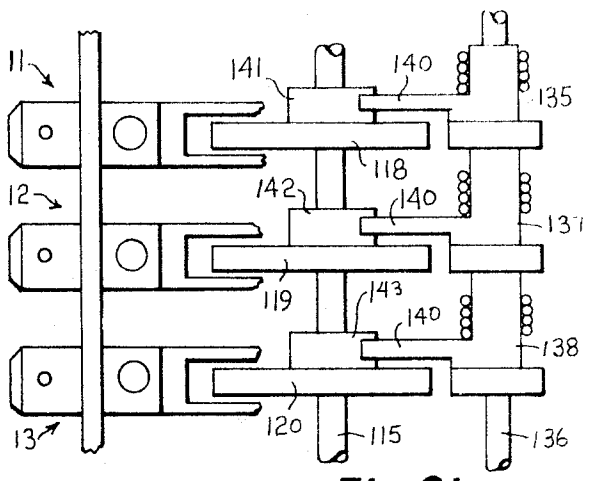
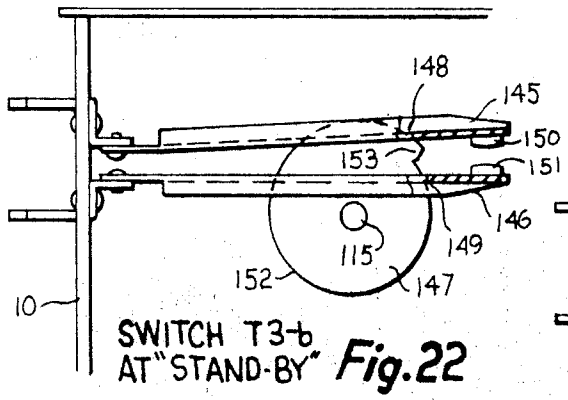


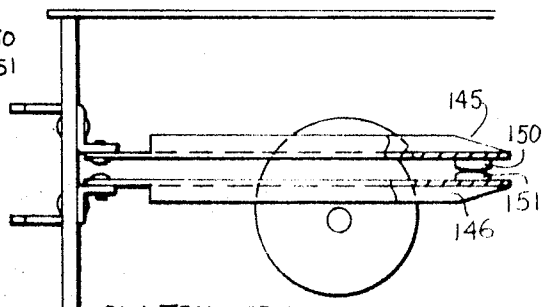
Fig. 21

INVENTOR.

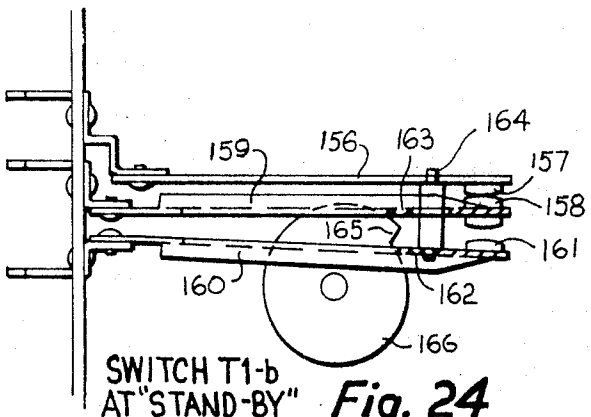
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SWITCH T3-b AT "STAND-BY" Fig. 22



SWITCH T3-b AT "RUN" Fig. 23



SWITCH T1-b AT "STAND-BY" Fig. 24

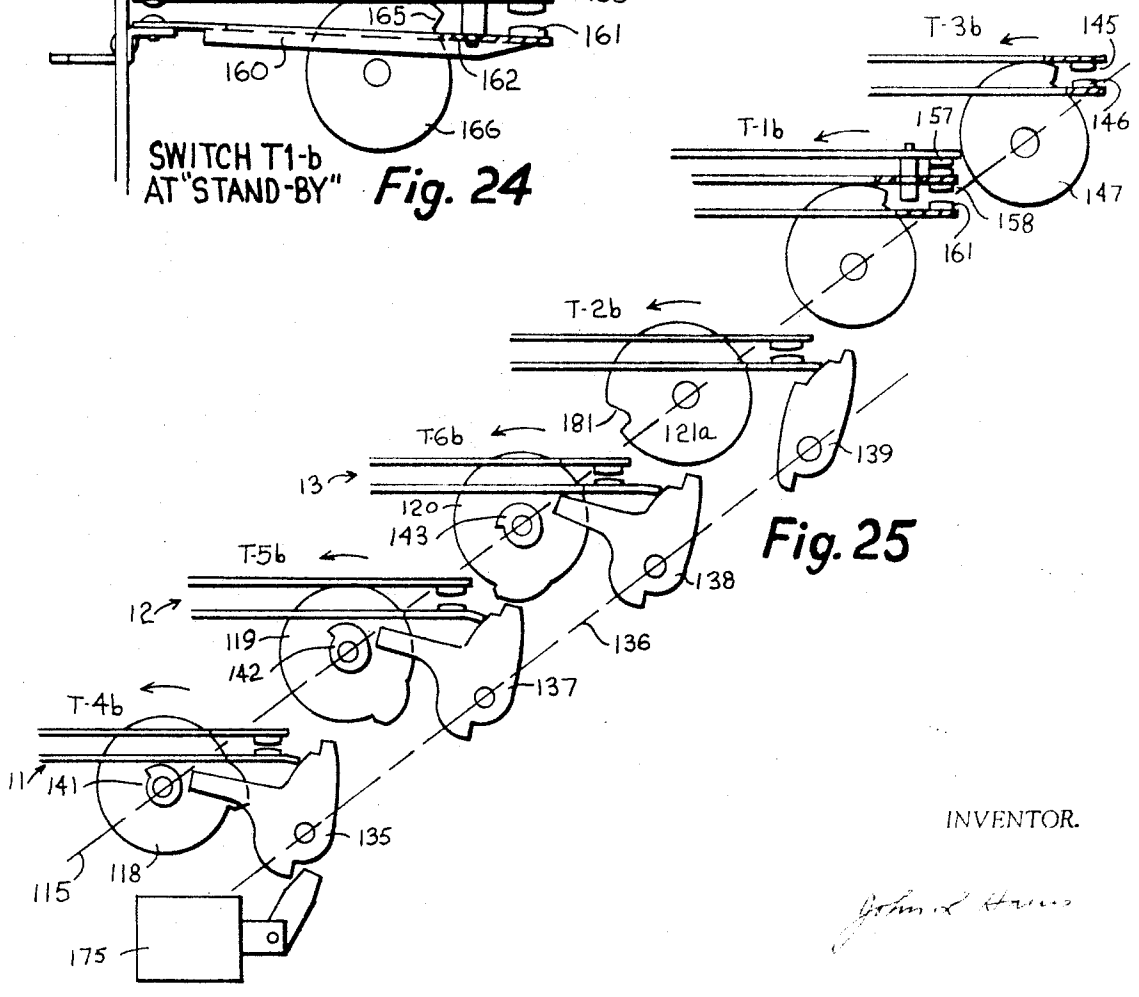


Fig. 25

INVENTOR.

John R. Harris

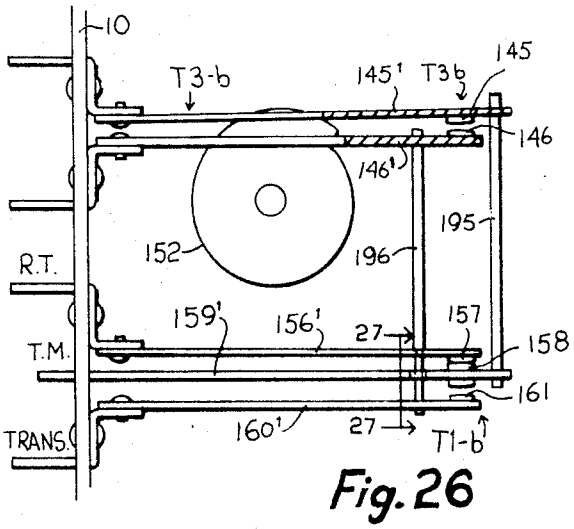


Fig. 26

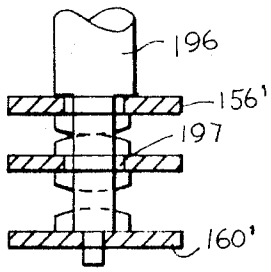
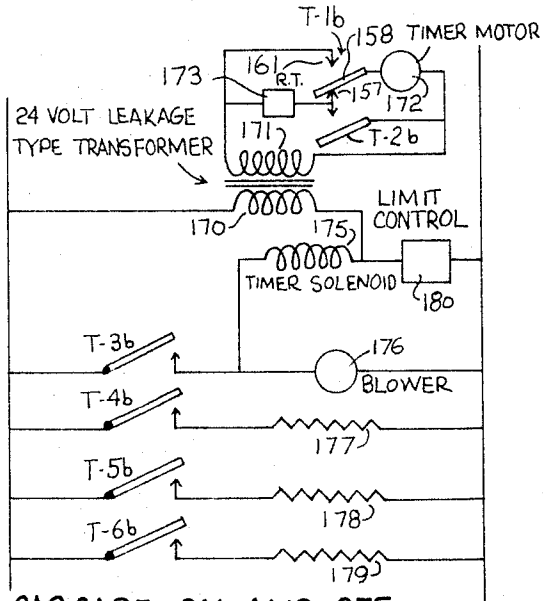
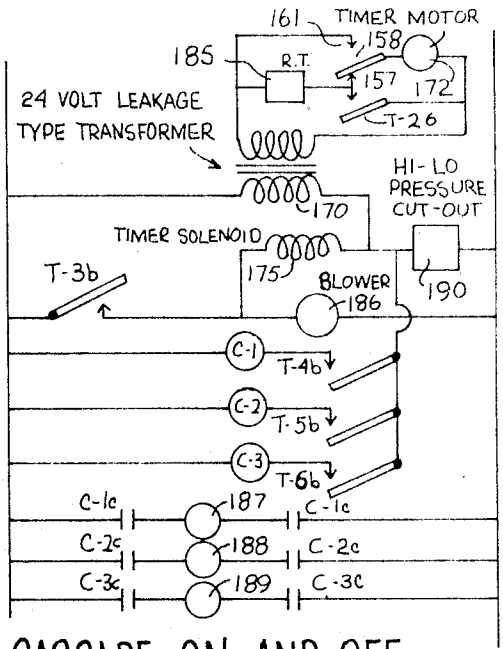


Fig. 27



CASCADE ON AND OFF ELECTRIC HEAT CONTROL

Fig. 28



CASCADE ON AND OFF MULTIPLE COMPRESSOR CONTROL

Fig. 31

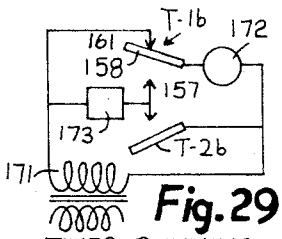


Fig. 29

TIMER RUNNING

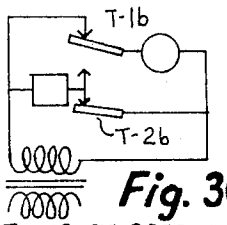


Fig. 30

TIMER STOPPED WITH LOAD SWITCHES CLOSED

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CASCADE ON - SIMULTANEOUS OFF

FOR REFRIGERATION

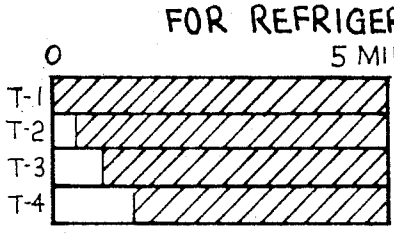


Fig. 32

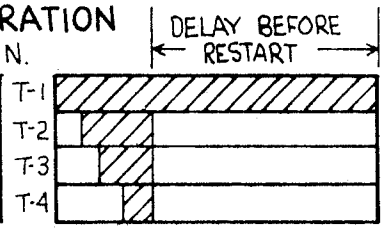


Fig. 33

FOR HEAT

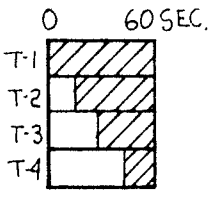


Fig. 34

CASCADE ON - SIMULTANEOUS OFF

MINUMUM EQUALIZING PERIOD WITH SHORT CYCLE ADDER

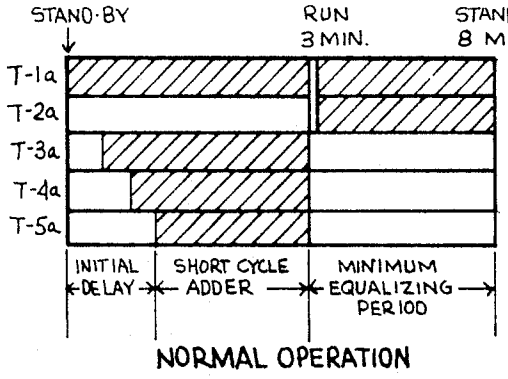


Fig. 35

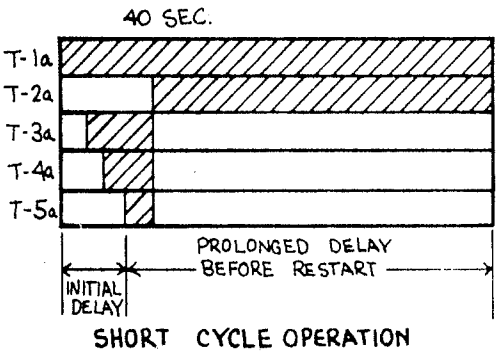


Fig. 36

CASCADE ON- CASCADE OFF

FOR ELECTRIC HEAT

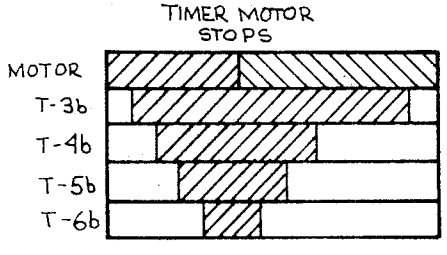


Fig. 37

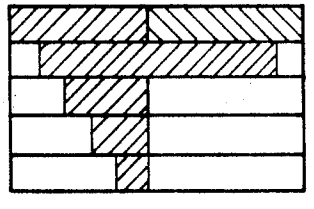


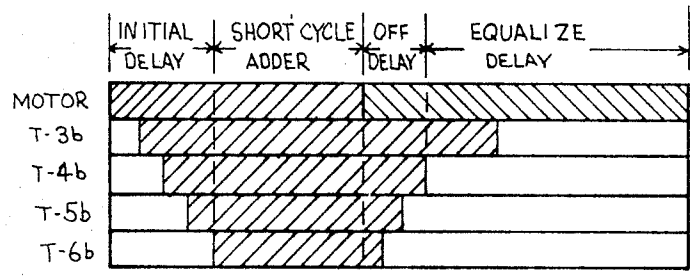
Fig. 38

INVENTOR.

John L. Haines

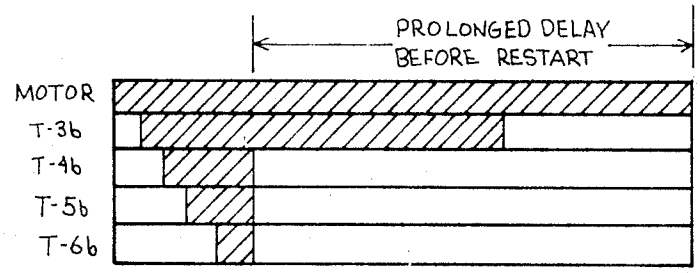
CASCADE ON-CASCADE OFF

FOR MULTIPLE COMPRESSOR REFRIGERATION



NORMAL CYCLE

Fig. 39



SHORT CYCLE

Fig. 40

INVENTOR.

John L. Harris

CONDITION CONTROL DEVICE AND SYSTEM

This invention relates in general to automatic controls and control systems, and more particularly to timing controls for use in refrigeration systems having multiple compressors; electric heating systems having multiple heating banks, machine tools, etc. having a plurality of motors to be started.

In the refrigeration and air conditioning industry it has become common to build up a system using a number of smaller compressors instead of one large one. Such compressors usually take 5 or more times the current to start as to run. By starting the compressors in sequence and allowing each to come up to speed before the next compressor is started, the power requirements for getting the system into operation are greatly reduced. This reduces the cost of the power supply and also avoids objectionable light dimming when the system is started up.

In the electric heating field, it is becoming common to use a central system having a number of electric heater banks drawing approximately 5 kw. each. These heater banks are controlled by a room thermostat which turns them on in response to call for heat and turns them off when the requirement is satisfied. Due to the heavy current consumption of the heater banks, turning them on and off simultaneously would cause objectionable sudden decreases and increases of light level. It is therefore desirable to bring on the heater banks one at a time spaced far enough apart so that the human eye adjusts to the preceding dimming effect occurs. The same sequence operation in deenergizing the heater banks is also desirable but is not as important.

The primary object of the present invention is to provide a simple and compact timing device which is in effect a self-contained control system for sequence starting and/or stopping of a plurality of condition changing units such as electric heaters, motors, etc. A further object of the invention is the provision of a sequence control unit in which the load switches are closed in sequence by a timing mechanism and in which these same switches can be instantly opened in the event of power interruption or a malfunction in the system being controlled. A further object is the provision of a device of this type in which the timing mechanism must recycle back to the starting point before any of the load switches will reclose.

A further object of the invention is to protect the compressors or compressor of a refrigeration system by interposing a delay between the stopping and restarting of a compressor on normal operation which is sufficient to provide pressure equalization in the system so that the compressor is never started under a heavy load.

A further object of the invention is to provide a substantially longer delay between the stopping of the compressor and restarting if the stopping of the compressor was occasioned by a malfunction in the system.

Other objects of the invention will appear as this description proceeds.

For a full disclosure of the invention, reference is made to the following detailed description and to the accompanying drawings in which:

FIG. 1 is an elevation with the cover removed showing the preferred form of multiple switch sequence control mechanism;

FIG. 2 is a top sectional view taken on line 2–2 of FIG. 1;

FIG. 3 is an end sectional view taken on line 3–3 of FIG. 1 and showing a load switch in open position;

FIG. 4 is an enlarged fragmentary view of a portion of FIG. 3 showing the switch blades riding the cam with the contacts in open position;

FIG. 5 is a sectional view taken on line 5–5 of FIG. 4;

FIG. 6 is a view similar to FIG. 3, but showing the solenoid energized and the load switch in closed position;

FIG. 7 is a sectional view taken on Line 7–7 of FIG. 1 and showing the timer motor switch in closed positions;

FIG. 8 is a view similar to FIG. 7 but showing the motor switch in open position at the end of a timing cycle;

FIG. 9 is a perspective fragmentary view showing the cascade latching mechanism in which the release of one latch causes the release of the next latch;

FIG. 10 is a schematic view showing the sequence switch operation by the cams on the cam shaft, and the latches on the latch shaft;

FIG. 10*a* is a fragmentary showing an alternative motor control switch for the sequence controller of FIG. 10.

FIG. 11 is a fragmentary view showing a modification in which an elongated solenoid lever serves to release all of the latches simultaneously;

FIG. 12 is a schematic wiring diagram showing a preferred application of the sequence controller to a refrigeration control system in which a number of separate compressors are brought into operation in sequence;

FIG. 13 is a schematic wiring diagram showing the application of the controller to a central electric heating system in which a number of heater banks are energized in sequence;

FIGS. 14, 15 and 16 show a modified form of cycling switch for the timer motor for use in refrigeration systems where a positive pressure equalization period is provided between the stopping and restarting of the compressors;

FIGS. 17, 18 and 19 are schematic wiring diagrams showing a refrigeration control system embodying the switch shown in FIGS. 10*a*, 14, 15 and 16 and the positions assumed by the switches at different portions of the refrigeration control cycle;

FIG. 20 is a view similar to FIG. 3, but showing a modified form of the invention in which the switches are opened in sequence instead of simultaneously;

FIG. 21 is a fragmentary top view of FIG. 20, showing the double cam and latch construction;

FIGS. 22 and 23 are fragmentary views showing the construction and operation of Switch T–3*b* used in schematic FIGS. 25 and 28;

FIG. 24 is a detailed view of the switch T–1*b* also used in the schematic FIGS. 25 and 28;

FIG. 25 is a schematic view showing the cam and switch arrangement of the sequence controller applied to cascade on-cascade off operation;

FIG. 26 shows a modified form of switch construction in which switches T–1*b* and T–3*b* are operated simultaneously by a single cam;

FIG. 27 is a view taken on Line 27–27 of FIG. 26;

FIG. 28 is a schematic wiring diagram showing the invention applied to a cascade on-cascade off electric heat control in which banks of electric heaters are energized in sequence on call for heat and deenergized in sequence when the thermostat is satisfied;

FIG. 29 is a fragmentary schematic wiring diagram showing the position of the timer motor switches when the timer is running;

FIG. 30 is a similar view showing the timer motor switches when the timer is stopped with the load switches closed;

FIG. 31 is a schematic wiring diagram showing the application of the cascade on-cascade off controller to a refrigeration system in which the compressors are brought on in sequence and also turned off in sequence;

FIG. 32 is a switch sequence chart showing the embodiment of the invention illustrated in FIGS. 1 to 10 applied to refrigeration control using the wiring diagram of FIG. 12, and showing operation on a normal cycle;

FIG. 33 is the same chart as shown in FIG. 32, but showing the operation which occurs in the event of a short cycle;

FIG. 34 is a sequence chart showing the same embodiment of the invention applied to electric heating control using the wiring diagram of FIG. 12;

FIG. 35 is a switch operating chart of the sequence controller applied to refrigeration control but using the motor control switch illustrated in FIGS. 14 to 19, inclusive, this chart showing operation on a normal cycle;

FIG. 36 is a view similar to FIG. 35, but showing the difference in operation that occurs in the event of a short cycle;

FIG. 37 is a switch operation chart showing the cascade on-cascade off embodiment of the invention as applied to electric heating control, this chart showing the switch operation occurring on a normal cycle;

FIG. 38 is the same chart shown in FIG. 37, but showing the operation occurring in the event of termination of a cycle by the limit control or by a power interruption;

FIG. 39 is a switch operation chart of the cascade on-cascade off embodiment of the invention as applied to refrigeration control, this chart showing the switch operation as occurs on a normal cycle;

FIG. 40 is the same chart as shown in FIG. 39 but showing the switch operation as occurs on a short cycle.

FIGURES 1 TO 10 INCLUSIVE

Referring to FIGS. 1 and 2, reference character 1 indicates generally a timer housing formed of base member 2 and a top member 3. The base member 2 is generally l-shaped and includes an upwardly extending portion 4, forming one end wall of the enclosure 1. The top member 3 is generally Z-shaped having a vertical portion 5, forming the other end wall of the enclosure. The member 3 also includes a horizontal lower portion 6 which is secured to the base member 2. The upper end of the base member 2 is in-turned as at 7 and supports the top member 3. Secured between the housing members 2 and 3 is a terminal panel 10, carrying load switches 11, 12 and 13, and a timer motor control switch 14. The panel 10 may also be used for supporting various terminals required in the control system circuits as hereinafter described.

As shown in FIG. 2, a cam shaft 15 is rotatably supported between the housing members 4 and 5. This cam shaft 15 carries a gear 16 which is driven by a timer motor generally indicated as 17. The cam shaft 15 also carries cams 18, 19, 20 and 21.

The load switches 11, 12 and 13 are identical, each consisting of an upper switch blade 22 and a lower switch blade 23 (FIG. 3). The upper switch blade 22 at its left-hand end is attached to a terminal bracket 24 which is in turn attached to the switch panel 10. The lower switch blade is similarly mounted to a terminal 25 also secured to the panel. The switch blade 23 is preferably of channel construction as disclosed in my U.S. Pat. No. 2,786,907 dated Mar. 26, 1967. As shown more clearly in FIG. 4, the switch blade 23 is provided with an opening 26 into which the cam 18 extends. The switch blade 23 is also formed with an internal cam follower surface 27 riding the cam 18. The upper switch blade 22 may be of the same construction and includes a cam follower bracket 28 secured to the blade 22 by means of the contact rivet 30. As shown in FIGS. 4 and 5, the bracket 28 includes a downwardly extending section 31 which at its lower end is formed inwardly at 32 to provide a cam follower surface. The lower switch blade 23 also carries a contact 33 and is provided with an extension 34 which is selectively supported or released by a latch member 35 (FIG. 3) pivoted on a latch shaft 36. This shaft is supported between the housing upright members 4 and 5. The latch shaft 36 also carries latches 37, 38 and 39 for switches 12, 13 and 14 respectively. Switch blades 22 and 23 are both biased downwardly toward the cam or activator 18.

The latch 35 is provided with an upper latching surface 40 which is adapted to support the extension 34 of the lower switch blade 23 when the latch is engaged (See FIG. 6). This latch is also provided with a stop surface 41 which engages the end of the switch blade and limits the inward motion of the latch. As shown more clearly in FIG. 9, the latches 35, 37 and 38 are identical construction and are preferably molded and include driving members 42 and driven members 43. The driving members 42 and driven members 43 extend toward each other and the driving member 42 of one latch is located behind the driven member 43 of the next latch. It will be apparent that when the latch 35 is rotated clockwise in latch releasing direction, its driving member 42 will engage the driven member 43 of latch 37 and move latch 37 in releasing direction. This movement of latch 37 will release latch 38 and this action will continue until all of the latches in a given unit are released. In addition to the driving and driven surfaces 42 and 43, the latches are each provided with a camming surface 44, below the latching surface 43. This camming surface on the latch causes the downward bias of the switch blade to apply power to the latch in releasing direction after the latch has released its switch blade. Thus the force released when the latch releases the switch blade is used to drive the latch further in releasing direction and this force thus serves to release the next latch.

The latch 35 is also provided with an additional latch releasing surface 45 for release by the solenoid or electromagnet 46. As shown more clearly in FIG. 9, the latches are molded and are formed with integral bearing numbers 47 and 48 which also serve as spacers for the latches on the latch shaft 36. Each latch is provided with a latch spring 49. These springs are of the torsion type and are carried by the bearing numbers 48 of each latch. One end of each spring bears against the rear of the driving member 42 and the other end of each spring bears upon a spring shaft 50 which is mounted between the housing members 4 and 5 and is generally parallel with the latch shaft 36. Thus each latch is biased in a counterclockwise direction.

The releasing surface 45 of the latch 35 is adapted to be engaged by one leg 51 of a bell crank lever, the other leg 52 of which is activated by the plunger 53 of solenoid 46. This solenoid 46 is mounted on the end wall 4 of the enclosure by spacers 53 which serve to line up the solenoid lever with the latch 35. The solenoid lever is preferably molded including hub portion 55 carried by a stud 56 mounted on the housing member 4. A torsion type biasing spring 57 surrounds the hub or bearing member 55. One leg of this biasing spring rests on the spring shaft 50, and the other bears against a stud 58 forming a part of the solenoid lever. It will be apparent that the spring 57 serves to bias the solenoid lever in a counterclockwise direction withdrawing the plunger 53 from the solenoid proper.

The construction of the timer motor switch mechanism is shown in FIGS. 7 and 8. This switch, generally indicated as 14, includes a lower switch blade 60 of channel shaped configuration which rides the cam 21. The upper blade 61 if of like configuration but is longer providing a latching portion 62. This latching portion 62 of the switch blade is arranged to be supported by the latch 39 also carried on the latch shaft 36. This latch includes a driven surface 63 and a latching surface 64. This latch is also provided with a stop surface 65. Latch 39 is similar in configuration to latch 34 but is longer as its function is to support the upper switch blade instead of the lower switch blade. The switch blades 60 and 61 carry contacts 66 and 67 respectively. These switch blades are both biased downwardly toward the cam 21.

OPERATION OF FIGURES 1 TO 10 INCLUSIVE

With the parts in the position shown in FIGS. 3, 7 and 10, the control is in the off or standby position. Latches 35, 37 and 38 have been released thus causing the lower switches 11, 12 and 13 to be open. The latch 39 is also released which causes the timer motor control switch 14 to be closed. Load switches 11, 12 and 13 are open due to the cam follower portions of each blade (FIG. 4) riding the main section 67 of each cam. This main cam surface includes the generally circular low portion 68 and a rise portion 69. The parts are proportioned so that as long as both blades ride upon this main cam surface, the load contacts 30 and 33 remain open.

It will be understood that the timer motor switch 14 is wired in series with the timer motor. Thus when power is applied to the timer motor circuit and to the solenoid, the solenoid is energized and the timer motor is also energized. This will cause the cam shaft assembly or actuating means to be rotated in a counterclockwise direction as seen in FIGS. 3, 7 and 10. As shown in FIG. 10, the cam 18 for switch 11 is in advance relative to the other cams on the shaft. As the cam shaft is

rotated in a clockwise direction, the cam follower portions of the switch blades both ride off the circular low portion **68** of the cam **18** and up the slope **69** of the main cam surface. The contacts **30** and **31** remain separated at this time. As the switch blades continue the rising motion, the latch **35** is allowed to rotate counterclockwise by the camming surface **44**. Eventually the end portion **34** of the switch blade **23** will clear the camming portion **44** of the latch, allowing the latch to rotate to bring the latching surface **40** beneath the end portion **34** of the switch blade. On continued rotation of the cam shaft assembly in the counterclockwise direction, the cam follower surface **27** of the lower switch blade will ride down the sloping portion **70** of cam **18** and the latching portion **34** will rest on the latch surface **40** of latch **35**. On continued rotation of the cam shaft assembly, the follower portion **32** of the upper switch blade **22** will start riding down the incline portion **70** allowing contact **30** to slowly approach contact **31**. Shortly before the contacts engage, the cam follower surface **32** of switch blade **22** drops off at the drop off section **71** of cam **18**, allowing the contacts to engage with snap action. This arrangement in which the upper contact **30** is brought slowly into near engagement with the contact **31** and then dropped off a short distance for contact engagement avoids contact bounce. This increases the current handling capacity of the switch which is desirable in heavy current handling obligations such as electric heating.

It should be noted that latch **35** was allowed to assume latching position due to the solenoid **46** having been energized. This action rotated the solenoid bell crank lever clockwise against the action of its biasing spring, causing the latch releasing portion **51** to be clear of the releasing surface **45** of latch **35**. It should also be noted that due to the latch being in engaging position as shown in FIG. **6**, the driving surface **42** (FIG. **9**) is now out of the path of the driven surface **43** of the adjacent latch **37**. As the cam shaft assembly continues its counterclockwise rotation, the switch **12** is actuated in the same manner as described for switch **11**. The latch **37** comes into place and the switch blades are lowered causing the contacts of switch **12** to engage. Later, on continued clockwise rotation of the cam shaft assembly, switch **13** is closed in the same manner.

During this time switch blade **60** of the timer motor switch **14** has been gradually rising due to the gradual rising surface of the cam **21**. Due to the engagement of the contacts **66** and **67**, the upper motor switch blade **61** rises and its latching end **62** rises above the latching surface **64** of latch **39**. This permits the latch **39** to rotate counterclockwise into latching engagement with blade **61**. At the end of the cycle, the cam follower portion of the lower switch blade **60** drops off the drop off surface of cam **21**. The end **62** of switch blade **61** is maintained in its upper position by the latch **36** and the switch assumes the position shown in FIG. **8** in which the contacts **66** and **67** are disengaged. As the switch **14** is in series with the timing motor means **17**, it serves as a stopping means for stopping the timer motor and the actuating means consisting of the cam shaft assembly.

From the foregoing, it will be apparent that when the timer motor circuit and the solenoid are energized, the solenoid allows the latches to assume operative position and the timer motor is energized for causing the load switches **11**, **12** and **13** to close in sequence. After these load switches have been closed the motor switch **14** opens which stops the motor, allowing the load switches to remain closed indefinitely.

The load switches will remain closed indefinitely.

The load switches will remain closed and the motor switch open until the solenoid **46** is deenergized either by a control switch or by a power interruption. When the solenoid is deenergized, its bell crank lever rotates counterclockwise under the influence of biasing spring **57**. Portion **51** of the bell crank lever engages releasing portion **45** of the latch **35** rotating this latch in a clockwise direction causing the end **34** of switch blade **23** to ride off the latching surface **40** onto the camming surface **44** of the latch. As the switch blade **23** is biased downwardly it moves down and its engagement with the camming surface **44** of the latch causes continued clockwise rotation of the latch. After the switch blade starts riding down the camming surface on the latch, the driving portion **42** of the latch **35** engages the driven portion **43** of the adjacent latch **37**. This releases latch **37** which in turn releases latch **38** which then releases the motor switch latch **39**. Due to the releasing of latches **35**, **37** and **38**, both switch blades of switches **11**, **12** and **13** once again ride the main camming surfaces of their respective cams. The switch blades thus assume the positions shown in FIGS. **3** and **4** in which the contacts are open. Due to the latch **39** of motor switch **14** being released, contacts **66** and **67** of the motor switch **14** are reclosed which will permit resumption of the timing means when power is reapplied to the timing motor **17**.

It should be noted that unless the solenoid is energized during the timing cycle, none of the loading switches will ever close. Thus if power is applied to the timing motor but not to the solenoid, the timer will run and drive the cam shaft assembly in a counterclockwise direction as previously described. However, due to the solenoid being deenergized, the initial latch **35** is in released position and can never assume latching position. Due to the arrangement of the driving and driven surfaces **42** and **43** between the latches, none of the latches can ever move into engaging position. Thus, if the cam shaft assembly rotates it simply raises and lowers the switch blades without engagement of the contacts.

It should also be noted that with the interlocking relationship of the latches, load switch **12** can never close unless the latch **35** of load switch **11** is already in latching position. Similarly, load switch **13** can never close unless the latch **37** of load switch **12** is already closed. In the same manner the motor switch **14** can never open unless the latch **38** of load switch **13** is in latching position. The only switch that can close independently of the other switches is the first operated load switch **11**. If a power interruption should occur after the load switch **11** has closed, the solenoid will drop out and immediately release latch **35** causing load switch **11** to immediately reopen. The latch **35** in being released prevents latches **37**, **38** and **39** from ever moving into engaging position. Thus when power is interrupted to the solenoid, the timer cam shaft assembly must make a complete revolution and reclose the load switch **11** before the other load switches **12** and **13** can close. In other words, a power interruption during a cycle opens all of the load switches and the timer will recycle on resumption of power and reclose the switches in the predetermined order.

In applications where this complete recycling feature is not desirable, the arrangement shown in FIG. **11** may be used. Here, the driving and driven surfaces **42** and **43** are omitted from the latches. Instead an elongated solenoid lever **75** is pivoted between the enclosure ends **4** and **5** and includes a lever portion **76** operated by the solenoid **46A**. The lever **75** is arranged to actuate the releasing portions **45** of the latches simultaneously. With this arrangement, if a power interruption occurs during a cycle, the switches then closed will immediately reopen. However, on resumption of power, succeeding switches may be closed even though the switches ahead are still open. This arrangement also has the disadvantage of requiring a larger solenoid as it must be powerful enough to release the latches simultaneously. In the arrangement shown in FIG. **9**, the only power required from the solenoid is enough to release the initial latch as the force then released is used to release the next latch.

REFRIGERATION SEQUENCE CONTROL — FIGURE 12

FIG. **12** shows a schematic wiring diagram for applying my sequence timing mechanism to a refrigeration system having multiple compressors. In this circuit, power is supplied to the system by line wires **80** and **81**. A high-low pressure cutout **82** controls the power to the primary **83** of a low voltage transformer having a secondary **84**. This secondary supplies low

voltage power to the thermostat **85** which is connected to the timer solenoid **86** and to the timer motor switch T–1 which controls the timer motor **87**. It will be understood that the solenoid in this circuit corresponds to the solenoid **46** in the structural figures. Switch T–1 corresponds to the motor switch **14** and the timer motor **87** corresponds to the motor **17**.

The high-low pressure cutout **82** also supplies power to the timer load switches T–2, T–3 and T–4 which correspond to the timer structural switches **11**, **12** and **13** respectively. Switches T–2, T–3 and T–4 control compressor contacted coils C–1, C–2 and C–3 respectively. These coils in turn control double pole contacts C–1*a*, C–2*a* and C–3*a* which control compressors **88**, **89** and **90** respectively. The contactor C–1 may also control a fan or blower **91** which supplies air to the evaporator or condenser or both of the refrigeration system, as well understood in the art.

In refrigeration control, it is preferable to arrange the cams and the timer gearing to provide a time cycle as shown in FIGS. **32** and **33**. An overall cycle of approximately 5 minutes is shown in FIG. **32** with switches T–2, T–3 and T–4 closing in sequence. Switch T–2 may close 10 seconds after the start of the cycle. Switch T–3 may close 10 seconds later and switch T–4 closes another 10 seconds later. In operation, assuming the high-low pressure cutout **82** is closed, the thermostat **85** on call for cooling will energize the timer solenoid **86** and also will energize the timer motor **87** through the timer motor switch T–1 which is now closed. The timer will run for 10 seconds closing switch T–2 which energizes the contactor coil C–1 which in turn energizes the compressor motor **88** and the blower motor **91**. Ten seconds later timer switch T–3 closes, energizing the contactor C–2 which in turn energizes the compressor motor **89**. Ten seconds later, the switch T–4 closes, energizing the contactor coil C–3 which energizes the compressor **90**. The timer motor switch T–1 will remain closed for the full 5-minute cycle. When it reaches the end of the cycle, this switch will open, stopping the timer with the load switches T–2, T–3 and T–4 closed. Thus, on call for cooling in normal operation, the thermostat closes the timer to bring on the compressors in sequence and then run for an additional period of approximately 4 minutes 30 seconds. At this time, the timer motor stops and the three compressors will operate until terminated by a power interruption, by opening of the high pressure cutout **82**, or by opening of the thermostat **85**. When this happens, the solenoid drops out, causing an immediate opening of the load switches T–2, T–3 and T–4 and reclosing of the timer motor switch T–1. The timer motor does not run at this time as its power is broken elsewhere. The compressors immediately stop and will remain out of operation until restarted in sequence on a new cycle.

FIG. **33** charts the switch operation occurring if the refrigeration system should short cycle by opening of switch **82** after all three compressors are in operation. If the short cycle occurs, for example 10 seconds after the third compressor has started, a total of 40 seconds of the overall cycle will have elapsed. This means that when power is restored to the control circuit by closure of the high-low pressure cutout, the timer must run through the balance of the 5-minute cycle to get to the starting point. This, in the illustration, would come out to 4 minutes 20 seconds. In addition, the timer must run the 10-second delay period before closure of switch T–2 for starting the first compressor. This means that an overall delay of 4 minutes 30 seconds is assured before restart of the first compressor. To this delay provided by the timer is added the time that the high-low pressure switch **82** is open. Thus a substantial delay may be provided before restart of a compressor in the event of a short cycle. This gives a certain amount of protection against compressor burnout from short cycling.

In the event of a short cycle or power interruption during the period that the compressors are being started in sequence, any compressor that has been started will immediately be deenergized. When power is reapplied to the timer, it will run back to the starting point before any of the load switches can reclose. Thus the timer must always recycle to the starting point and restart the compressors in the proper sequence.

CASCADE ELECTRIC HEAT CONTROL —FIGURE 13

FIG. **13** shows the application of the timing mechanism disclosed in FIGS. **1** to **10** inclusive to control of the heating banks of a central electric space heating system. Here, the primary of the low voltage transformer is connected in series with a high limit temperature control responsive to the temperature in the bonnet of the electric heating furnace. The low voltage room thermostat controls the timer solenoid and also controls the timer motor through the timer motor switch T–1. Switches T–2, T–3 and T–4 of the timer are connected respectively to electric heater banks H–1, H–2 and H–3. In this illustration, the blower **92** for the warm air heating furnace is controlled by a thermostat **93** responsive to the bonnet temperature of the warm air heating furnace.

In the electric heating application, there is no need for a prolonged cycle as in the refrigeration control application previously described. A recommended sequence chart is shown in FIG. **34**. Here, the timer is geared for an overall cycle of 60 seconds and the load switches T–1, T–2 and T–3 are arranged to close at 15-second intervals. This is provided by proper positioning of the cams on the timer cam shaft.

In this illustration, when the room thermostat **94** calls for heat, it energizes the timer solenoid and also energizes the timer motor through the switch T–1. The timer motor will run for 15 seconds at which time switch T–2 closes. This will energize the heater bank H–1. Fifteen seconds later, timer switch T–3 closes energizing heater bank H–2. Fifteen seconds after switch T–3 closes (45 seconds from start), switch T–4 closes, energizing the heater bank H–3. The timer will continue to run for a 15-second overtravel period at which time the switch T–1 opens, stopping the timer motor with the load switches T–2, T–3 and T–4 all closed. When the air temperature in the warm air furnace rises to the cut-in point of the bonnet thermostat **93**, the blower **92** will be started.

The timer will remain in this ON position until either the room thermostat **94** or the high limit thermostat **91** opens its circuit. This will immediately deenergize the timer solenoid causing the load switches T–2, T–3 and T–4 to open and the timer motor switch T–1 to reclose. This same action of opening the load switches and reclosing the timer motor switch will also occur in the event of a power interruption.

If power should be interrupted during the period that the timer is closing the load switches in sequence, any switch already closed will reopen and the timer must return to the starting point and bring on the heaters in the specified sequence.

FIGURES 14 TO 19 INCLUSIVE

REFRIGERATION CONTROL SYSTEM PROVIDING A POSITIVE PRESSURE EQUALIZATION DELAY A NORMAL CYCLE WITH ADDED DELAY IN EVENT OF A SHORT CYCLE

In the embodiment of the invention described in FIGS. **12**, **32** and **33**, a minimum delay of 5 minutes is provided between successive restarts of the compressors. This provides protection against short cycling. However, it does not provide a positive delay between the stopping and restarting of the compressors which insures pressure equalization in the refrigeration system. On a normal cycle where the compressors are in operation for over 5 minutes, the timer is back at the starting point when the compressors stop and thus the first compressor can be restarted in a period as short as 10 seconds from the time it stopped. An improved system is shown in FIGS. **14** to **19** inclusive and the sequence is charted in FIGS. **35** and **36**.

In this embodiment of the invention the timer mechanism including the switches **11**, **12** and **13** is exactly as shown in FIGS. **1** to **10** inclusive. The only change is in the control of the timer motor. A special double throw switch **100** as shown in FIGS. **10***a*, **14**, **15** and **16** is substituted in place of the timer motor switch **14** in the schematic diagram shown in FIG. **10**. The switch **100** (FIG. **14**) consists of an upper switch blade

101, a middle switch blade 102, and a lower switch blade 103. This lower switch blade 103 extends across the cam 104 and includes an internal cam follower surface 105. In this embodiment of the invention only the lower switch blade 103 rides the cam 104. The upper switch blades 101 and 102 are controlled by a latch 106. This latch is pivoted on the latch shaft 36 along with the load switch latches 35, 37 and 38. This latch is provided with three latching surfaces 107, 108 and 109. The latch 106 is also provided with a driven surface 110, adapted to be engaged by the driving surface 42 of the adjacent load switch latch. Latch 106 also is formed with an operating lever portion 111 extending toward the cam shaft 15. This lever arm 111 is adapted to be engaged and operated by a cam 112 which is mounted adjacent the cam 104 and in fixed angular relationship therewith. FIG. 14 shows the relationship of the parts in the "Standby Postion" where a new cycle is ready to be started on call for cooling by the room thermostat or other condition responsive device. Here the contacts between the top blade 101 and middle blade 102 (T-1*a*) are closed. Also, the contacts between the middle blade 102 and the lower blade 103 (T-2*a*) are open. The middle blade 102 is supported on the intermediate latch surface 108 of latch 106. Switch blade 103 has just dropped off the dropoff section of the cam 104. The switch blade 101 is supported by the closed contacts T-1*a* and a space exists between this switch blade and the upper latching surface 109 of the latch 106.

FIG. 17 shows the schematic wiring diagram for the refrigeration control system embodying the timer motor switch 100. Power is supplied to the system by line wires 114 and 115. A combination high-low pressure cutout 116 controls the power supply to the primary 117 of a low voltage transformer having a secondary 118. A room thermostat 119 controls the power supply to the timer solenoid 120 and also to the upper switch blade 101 of the timer motor switch 100. The middle switch blade 102 is connected to the timer motor 121. The lower switch blade 103 is connected directly to the transformer secondary 118 and serves to shunt the thermostat 119.

OPERATION OF FIGURES 14 TO 19 INCLUSIVE

With the parts in the positions shown in FIGS. 14 and 17, the load switches T-3*a*, T-4*a* and T-5*a* (corresponding to switches 11, 12 and 13 of FIG. 10) are open. Contacts T-1*a* of timer motor switch 100 are closed and thus the timer motor 121 is in circuit with the room thermostat 119. This thermostat in the Standby Position is open and thus the timer motor 121 and the solenoid 120 are deenergized.

Assuming the pressures in the refrigeration system are satisfactory, causing the high-low pressure switch 116 to be closed, the thermostat 119 on cal for cooling will directly energize the timer solenoid 120 and will simultaneously energize the timer motor 121 through contacts T-1*a* of the motor switch 100. The timer will now begin functioning as charted in FIG. 35. Ten seconds from start, switch T-3*a* will close, energizing the compressor contactor C-1 causing the first compressor of the refrigeration system to start. Ten seconds later, switch T-4*a* closes energizing compressor contactor C-2 causing the second compressor to start. Ten seconds later switch T-5*a* closes energizing the compressor contactor C-3 causing the third compressor to start. This completes the initial delay period of 30 seconds. Switch T-1*a* will remain closed for an additional 2 minutes 30 seconds (3 minutes from start). At this point switch 100 assumes the Run position shown in FIGS. 15 and 18. As shown in FIG. 15, the operating lever portion 111 of the latch 106 has been lifted by the cam 112 on the cam shaft 15. This has caused clockwise rotation of the latch 106 to the point at which the middle switch blade 102 has dropped from the latching surface 108 to the lower latching surface 107. The upper switch blade 101 has dropped to the upper latching surface 109 and is supported thereby. With this position of the parts, switches T-1*a* and T-2*a* are both open. Thus the timer motor stops with the load switches T-3*a*, T-4*a* and T-5*a* closed causing operation of all three compressors.

On a normal cycle this condition will prevail until the room thermostat 119 becomes satisfied. When this occurs, the circuit to the timer solenoid 120 is broken. This releases the latch 35 which in turn releases latches 37, 38 and 106. The compressor motors are immediately deenergized and the timer motor switch assumes the position shown in FIGS. 16 and 19. Release of the latch 106 at this point is caused by engagement of the driving surface 42 of latch 38 with the driven surface 110 of latch 106. The clockwise rotation of latch 106 removes the supporting surface 109 from under the upper switch blade 101. This same motion also removes the lower latching surface 107 from the middle switch blade 102. As all of the switch blades are biased toward the cam 104, the middle switch blade 102 drops to engage switch T-2*a* and the top switch blade 101 drops to engage switch T-1*a*. As shown in FIG. 19, closure of the switch T-2*a* establishes a new circuit to the timer motor 121 which is independent of the thermostat 119. Thus when the thermostat becomes satisfied, switches T-3*a*, T-4*a* and T-5*a* open and switches T-1*a* and T-2*a* close. The compressors are thus deactivated and the timer motor is restarted. The timing means will now run through the minimum equalizing period of 5 minutes back to the Standby Position. In this illustration it involves 8 minutes running time from one Standby position to the next.

As the timer approaches the Standby position, the cam follower surface 105 of switch blade 103 nears the topmost point of the cam 104. This has raised the three switch blades to the point where the latching surface 108 comes under the blade 102 and latching surface 109 is under the blade 101. When the timer arrives at the Standby position, the cam follower surface 105 of switch blade 103 drops off the dropoff portion of the cam 104 and assumes the position shown in FIG. 14. The middle blade 102 drops to the latching surface 108 and is supported thereby, this causing switch T-2*a* to open. In this Standby position, switch T-1*a* remains closed due to a space existing between this switch blade and the upper latching surface 109.

If the room thermostat should call for cooling during the minimum equalizing period, it will energize the solenoid 120 of the timer. However, this will not affect any of the switches. The timing means must first run through the minimum equalizing period to get to the Standby position and then must run the additional 10 second delay period before the first compressor is started.

From the foregoing description, it will be apparent that on a normal operating cycle, this embodiment of the invention will provide a minimum delay of 5 minutes 10 seconds between stopping of the compressors and a restart. This insures an adequate time for the pressures in the refrigeration system to equalize so that the compressors are never started under heavy loads.

FIG. 36 charts the operation of the switches in the event of a short cycle. Here on call for cooling, the thermostat energizes the timer motor through switch T-1*a*. The load switches T-3*a*, T-4*a* and T-5*a* close in sequence starting the compressors. However, something associated with the refrigeration system is malfunctioning and the high-low pressure cutout 116 responds by opening its switch for example 40 seconds from the starting time. This breaks the circuit to the transformer primary 119 and thus deenergizes the solenoid 120. This solenoid drops out immediately opening the load switches to stop the compressors, and closing switch T-2*a*. The additional delay now interposed before the compressors can restart is the unused balance of the 2-minute 30-second "Short Cycle Adder." In this illustration, the additional delay would amount to 2 minutes 20 seconds.

In addition to the additional delay imposed by the timer, there is also a delay of variable duration provided by the opening of the high-low pressure switch 116. It should be noted that switch 116 in deenergizing the timer solenoid also breaks the power circuit to the timer motor. The timer motor does not restart immediately on closure of switch T-2*a* as occurs in the normal cycle charted in FIG. 35. Instead the delay period provided by the timer does not start until conditions within the

refrigeration system have been corrected to the point allowing reclosure of the high-low pressure switch **116**.

From the foregoing description, it will be apparent that the control system shown in FIGS. **14** to **19** inclusive provides for sequence starting of a plurality of compressors or condition changing units in response to a call for condition change by the device **119**. On a normal cycle, the compressors are stopped simultaneously and a delay is imposed by the timing means before restart which is sufficient for allowing satisfactory pressure equalization in the refrigeration system. In the event of a short cycle, a longer delay before restart is provided. This longer delay is the sum of the time that the high-low pressure switch is open and the unused balance of the "Short Cycle Adder" provided by the timing mechanism.

CASCADE ON-CASCADE OFF OPERATION-FIGURES 20 to 30 INCLUSIVE

The two embodiments of the invention previously described bring on the condition changing units in sequence and turn them off simultaneously when the requirement for condition change is satisfied. This simultaneous Off operation in some cases can cause an undesirable power surge making it preferable to deactivate the condition changing units in sequence instead of simultaneously. The present invention also provides for sequence off operation which will now be described.

Referring to FIG. **20**, the timer latch **135** for the load switch **11** is provided with an inwardly extending arm **140** which is adapted to be engaged by an "off" cam **141** which is mounted beside the "on" cam **118**. The cam **118** is identical with the cam **15** of FIG. **3** and operates the switch blades of the switch **11** in exactly the same manner. As shown in FIG. **21**, the cam **141** is mounted on the shaft **115** beside cam **118**. The latch **135** is formed with the lever portion **140** offset so as to ride cam **141** and be clear of the cam **118**. Latches **135**, **137** and **138** are of identical construction. The lever portion **140** of latch **137** rides cam **142** located beside the cam **119** for switch **12**. The lever portion **140** of latch **138** rides on cam **143** located beside the cam **120** for switch **13**.

The present invention provides a system for controlling electric heater banks in a central electric system in which the heater banks are energized in sequence on call for heat and deenergized in sequence when the call for heat is satisfied. The invention also provides simultaneous shut down of all the heater banks in the event the temperatures within the system become excessive such as by a malfunction in the system.

This type of operation involves extra switches in the sequence controller as shown in FIGS. **22**, **23**, **24** and **25**. The schematic wiring diagram showing the location of these switches in the control circuit is shown in FIG. **28**.

Referring to FIG. **25**, switches **11**, **12** and **13** are the same as shown in FIGS. **20** and **21**. These switches correspond to switches T–**4***b*, T–**5***b* and T–**6***b* in the wiring diagram of FIG. **28**. In this embodiment of the invention the timer motor must be stopped after the timing mechanism has operated the load switches for activating the heater banks. Also, the timer motor must be restarted when the controlling thermostat becomes satisfied so as to deactivate the heater banks in sequence. This is achieved by switches T–**1***b* and T–**2***b* shown in FIG. **25** wired as shown in FIG. **28**. Switch T–**2***b* is identical in construction to the load switch **11** shown in FIG. **3**. Thus, the contacts of switch T–**2***b* are normally open, and are closed by the conjoint action of cam **121**–*a* and latch **139** at the proper point in the timing cycle. This switch T–**2***b* is immediately opened by release of the latch **139** along with the other latches **135**, **137** and **138**.

The construction of switch T–**3***b* is shown in FIGS. **22** and **23**. This switch consists of an upper switch blade **145** and a lower switch blade **146** mounted on the switch panel **10** and riding cam **147** mounted on the cam shaft **115** along with the other cams of the controller. As shown in FIG. **22**, the upper switch blade **145** has an internal cam follower surface **148** and the lower switch blade has a similar cam follower surface **149**. Blade **145** carries a contact **150** cooperating with a similar contact **151** carried by the lower blade **146**. The cam **147** preferably has a uniform rise section **152** and a dropoff section **153**. The edge of cam follower surface **149** is located on the cam surface in advance of the edge of the surface **148**. Normally, only the lower cam follower surface **149** engages the cam and the contacts **150** and **151** are closed as shown in FIG. **23**. These contacts support the upper switch blade **145** so that the cam follower surface **148** at this time does not engage the cam. When the cam **152** rotates to the point where the dropoff **153** passes under the cam follower surface **149**, the lower blade **146** drops to the lower cam surface. At the same time contacts **150** and **151** separate and the upper cam follower surface **148** now rests on the upper surface of the cam. On continued rotation of cam **152**, its dropoff section **153** will pass under the upper cam follower surface **148** allowing the upper switch blade to drop closing contacts **150** and **151**. As shown in FIG. **28** this switch T–**3***b* is used for controlling the timer solenoid and also for controlling the blower for the electric heating system.

The other timer motor control switch T–**1***b* is similar in construction and operation to switch T–**3***b* as shown in FIG. **22**. However, this switch is of the double throw type including an additional switch blade **156** carrying a contact **157** adapted to engage a double contact **158** carried by the middle switch blade **159**. The lower switch blade **160** carries a contact **161** engageable with contact **158** on blade **159**. Blade **160** includes a lower cam follower surface **162** and blade **159** carries an upper cam follower surface **163**. All three switch blades are biased toward the cam and a spacer **164** causes the upper switch blade **156** to move in unison with the lower switch blade **160**. This spacer passes through a suitable opening in the middle switch blade **159**. FIG. **23** shows the switch T–**1***b* at the Standby position in the timing cycle. In this position, the switch blade **160** has dropped off the dropoff portion **165** of cam **166**. Contacts **161** and **158** are separated whereas upper contacts **157** and **158** are engaged. When the cam **166** rotates clockwise from the Standby position, the dropoff portion **165** of the cam passes beneath the follower portion **163** of the middle switch blade **159**. This blade now drops causing engagement of contacts **158** and **161** and disengagement of contacts **157** and **158**. At this time, the upper switch blade **156** is supported by the spacer **164** and thus prevented from following the dropping of middle blade **159**. The timer will now make almost a full revolution before the dropoff section of the cam **165** passes beneath the cam follower surface **162** of blade **160**. At this time blade **160** drops and the parts reassume the position shown in FIG. **24**.

Referring to FIG. **28**, low voltage power is supplied to the timer motor and room thermostat circuit by a 24 volt leakage type transformer having a primary **170** and a secondary **171**. The timer motor **172** is connected to the common terminal of switch T–**1***b* (blade **159** in FIG. **24**). The room thermostat **173** is connected to one side of the transformer primary and also to one terminal of switch T–**2***b*. This room thermostat **173** is also connected to contact **157** of switch T–**1***b*. It is important in this embodiment of the invention that the transformer be of the leakage type in which the secondary **171** may be short circuited without damage. This is for the reason that this transformer is actually short circuited by the control system for stopping the timer motor in the "Run" position. The operation of the complete cascade on-cascade off system will now be described.

OPERATION OF FIGS. 20 TO 30 INCLUSIVE CASCADE ON-CASCADE OFF ELECTRIC HEATER CONTROL

Referring to FIGS. **25** and **28**, the switches are all shown in the positions assumed in the Standby position of the sequence controller. The timer motor switch T–**1***b* has just dropped off causing engagement of contacts **157** and **158** and disengagement of contacts **158** and **161**. The room thermostat **173** is thus in circuit with the timer motor through the closed con-

tacts **157** and **158**. The other timer motor cycling switch T-2*b* is open at this time. Also switch T-3*b* is open which has broken the circuit to the timer solenoid **175** and the blower **176** for the electric heating system. Also, load switches T-4*b*, T-5*b* and T-6*b* are open and thus the heater banks **177**, **178** and **179** are deenergized.

Assuming that the temperature in the electric heating system is satisfactory and the limit control switch **180** is closed, the room thermostat will be in command of the system. On call for heat, the room thermostat switch will close and complete a circuit to the timer motor through contacts **157** and **158** of the switch T-1*b*. The timer motor will now start driving and rotate the cam shaft **115** in a counterclockwise direction turning all the cams in unison. The first action to occur is shifting of the switches T-1*b* and T-3*b*. This action may be simultaneous or one switch may precede the other. Closure of switch T-3*b* energizes the timer solenoid **175** in series with the limit control **180**. It also initiates operation of the blower for the electric system. Shifting of the switch T-1*b* opens the timer motor starting contacts **157—158** and closes the maintaining contacts **158—161**. This establishes a circuit to the timer motor **172** which is now independent of the room thermostat **173**. Switches T-4*b*, T-5*b* and T-6*b* will now close in sequence at predetermined time intervals as charted in FIG. **37** bringing on the heater banks **177**, **178** and **179** in sequence. After the load switches are closed, switch T-2*b* closes as described in connection with switch **11** FIG. **3**. Closure of switch T-2*b* establishes a shunt circuit for the timer motor in series with the room thermostat switch **173**. This short circuiting of the transformer secondary reduces the voltage supplied to the timer motor to zero and thus the timer motor stops at this point. The timing mechanism therefore stops with all three heater banks energized and the blower in operation.

Unless overheating should occur and the limit control switch **180** opens, the heating will continue until the room thermostat **173** is satisfied. This will break the shunt circuit across the transformer secondary and reapply power to the timer motor through the maintaining switch **158—161**. The switches will now operate as shown in the chart, FIG. **37**. Referring to FIG. **25**, it will be noted that the cam **143** for the switch T-6*b* is in advance of the cams **142** and **141**. Thus when the timing mechanism is restarted by opening of the room thermostat switch **173**, the first action that occurs is the releasing of the latch **138** of switch T-6*b* which opens this switch, deenergizing the heater bank **179**. A predetermined time later, the cam **142** releases latch **137**, thus opening switch T-5*b* deenergizing heater bank **178**. A predetermined time later, the cam **141** releases latch **135**, opening switch T-4*b* which deenergizes heater bank **177**. The switch T-3*b* will remain closed for an additional period of time to maintain the blower in operation for dissipating the heat from the furnace. Just before the end of the cycle the switch T-3*b* opens which deenergize the blower and also the timer solenoid **175**. At the end of the cycle, switch T-1*b* shifts back to the Standby position shown in FIGS. **24** and **25**. This breaks the maintaining circuit for the timer motor and also places the timer motor back under the control of the room thermostat switch **173**.

It is desirable to open the motor cycling switch T-2*b* before opening of the load switches T-6, T-5 and T-4. Unless this is done, there is a possibility that the room thermostat might reclose and stop the timing mechanism in mid position where one or all of the load switches are open. One way to achieve this result is by the use of a special cam **121***a* having a notch **181** just sufficient to allow switch T-2*b* to close with the latch **139** in place. Thus just as soon as the timer is restarted, the blades of switch T-2*b* are raised off the latch **139** and the contacts of switch T-2*b* open. An alternative method is to use a latch such as **138** operated by a cam such as cam **120** of switch T-6*b*.

The above operation as charted in FIG. **37** occurs on a normal cycle where no overheating occurs. If for some reason, overheating does occur, the limit control switch **180** will open. This will deenergize the timer solenoid **175** and also break the power circuit to the transformer primary **170** thus preventing the timer motor **172** from operating. Deenergizing solenoid **175** releases the latch **135** causing opening of switch T-4*b*. The movement imparted to the latch by the opening of switch T-4*b* releases latch **137** opening switch T-5*b* which in turn releases latch **138** opening switch T-6*b*. This same action also releases the latch **139** opening the motor switch T-2*b*. This operation is charted in FIG. **38**. It will be noted that the load switches open instantly in response to overheating and that the short circuit for the transformer primary is broken so that the timer motor can operate when the limit control again applies power to the transformer primary. Switch T-3*b* at this time remains closed maintaining the blower in operation for dissipating the overheated air.

When the temperature in the condition changing system is reduced to an acceptable value, the limit control switch **180** will reclose thus reapplying power to the timer solenoid and to the timer motor. The timer will now run back to the starting point or Standby position with the heater load switches open. If the room thermostat **173** is still calling for heat at this time, the timer will start a new cycle bringing on the heaters in sequence as previously described.

From the foregoing it will be apparent that the control system described on call for heat first starts the blower and then energizes the heater banks in sequence. Unless overheating occurs, the blowers and heaters will operate as long as the room thermostat calls for heat. When the thermostat is satisfied, the timer is restarted and turns off the heater banks in sequence. The system also allows the blower to operate for an additional period for dissipating the heated air and then stops the blower until the next cycle. If overheating should occur, the load switches are opened instantly instead of in sequence. Also, the timer is prevented from operating until the overheating is dissipated, thus maintaining the blower in operation for dissipating the heat. Once the limit control switch recloses the timer resumes operation back to the starting point with all of the load switches being maintained open. If the room thermostat is still calling for heat when the timing mechanism reaches the starting point, the blower and heater banks will be again energized in sequence.

CASCADE ON-CASCADE OFF OPERATION FOR MULTIPLE COMPRESSOR REFRIGERATION SYSTEMS

FIG. **31** is a schematic wiring diagram showing the application of the cascade on-cascade off system to a refrigeration system having three separate compressors or condition changing units. This system utilizes the same mechanism shown schematically in FIG. **25** excepting that the time cycle is lengthened and the cams are arranged on a cam shaft to give the sequence charted in FIG. **39**. On call for cooling, by the room thermostat **185**, the timer motor **172** is energized through contacts **157** and **158** of timer motor switch T-1*b*. Shortly thereafter switch T-1*b* transfers opening contacts **157** and **158** and closing contacts **158—161**, establishing the maintaining circuit for the timer motor. Also switch T-3*b* closes which energizes the blower motor **186** for cooling the refrigerator condenser or evaporator or both. This closure of switch T-3*b* also energizes the timer solenoid **175** which pulls in for allowing the timer load switches to close in sequence by action of the timer cams. Shortly after switch T-3*b* closes, switch T-4*b* closes energizing contactor coil C-1 which closes its double pole switches C-1*c* energizing the compressor **187**. A predetermined time later, such as 10 seconds, switch T-5*b* closes energizing contactor coil C-2 which closes double pole switches C-2*c* energizing compressor **188**. A predetermined time later switch T-6*b* closes energizing contactor coil C-3 which closes switches C-3*c* energizing compressor **189**. As shown in the chart of FIG. **39** the timer motor will continue running through the "Short Cycle Adder" period which may be an additional 2 minutes 30 seconds. At this point switch T-2*b* closes short circuiting the transformer secondary and thus stopping the timer motor **172**.

On a normal cycle the compressors and blower will remain in operation until the room thermostat **185** becomes satisfied. At this time the thermostat breaks the shunt circuit thus applying power to the timer motor and causing it to continue operation. The timer will now proceed through the "Off-Delay" period opening switches T–6*b*, T–5*b*, T–4*b* and T–3*b* in the sequence stated. Thus the compressors and blower motor are deactivated in sequence. At the end of this "Off-Delay" the timer continues running through the "Equalize Delay" period. This equalizing period may be as long as 5 minutes. After the timer has run through this pressure equalizing period, it returns to the Standby position where switch T–1*b* assumes the position shown in FIG. **31**. The system is thus at rest and a new cycle will be started on call for cooling by the thermostat **185**.

If a short cycle should occur as by opening of the high-low pressure cutout **190**, it will break the circuit to the transformer primary **170** and also to the timer solenoid **175**. The solenoid will drop out causing immediate opening of the load switches T–4*b*, T–5*b* and T–6*b*. This drops out the compressor contactors which in turn deactivates the compressors. Switch T–3*b* is not affected by dropping out of the solenoid and remains closed. Thus power is maintained to the blower. However, as the high-low pressure cutout **190** has broken the circuit to the transformer primary, the timer motor will not run even though switch T–2*b* opened from dropping out of the solenoid. This deenergization of the timer motor by the high-low pressure cutout adds an indefinite delay period to the delay provided by the timer. Once the undesirable condition in the refrigeration system is dissipated, the safety switch **190** will reclose thus reapplying power to the timer solenoid and also energizing the timer motor so that it can begin timing for the balance of the delay. As shown in the chart of FIG. **40** the delay provided by the timer at this time is the sum of the unused portion of the short cycle adder and the regular pressure equalizing period built into the timer. The load switches T–4*b*, T–5*b* and T–6*b* will remain open until the timer recycles back to the starting point and recloses the switches in the proper sequence. Switch T–3*b* will remain closed until the timer has entered the equalizing delay portion of the cycle. At this time the timer solenoid and the blower motor are deenergized and they will not again be energized until the start of a new cycle.

From the foregoing description it will be apparent that my cascade on-cascade off controller when applied to a multiple compressor refrigeration system provides for starting and stopping the compressors in sequence during a normal cycle and also provides a pressure equalization period following the compressor stopping on one cycle before the compressors can be restarted in the next cycle. It will also be apparent that my control system provides for starting the blower in advance of compressor operation and also for maintaining the blower in operation for a period of time after the compressors are stopped on a normal cycle. In the event of a short cycle which is terminated by the high-low pressure cutout, the compressors are stopped simultaneously and immediately. The timer motor is deenergized maintaining the blower switch closed as long as the undesirable condition occurs. In addition, the timer mechanism itself provides an extra delay in addition to the regular equalizing delay. These features thus provide a substantial longer delay between stopping and restarting of the compressors when the system is malfunctioning than occurs when the system is operating normally. This increase in delay time in response to malfunctioning, of course, adds considerable more protection for the compressors.

In addition, the arrangement of the switch T–3*b* controlling the blower and the location of the high-low pressure cutout in the timer motor circuit serve to maintain the blower in operation during the entire time that the high-low pressure cutout switch is open. Thus this arrangement both prolongs the delay period in response to malfunctioning and also ensures operation of the blower for dissipating the high or low pressure causing the stoppage. It should also be noted that the switch T–3 also serves to deenergize the solenoid when the compressors are out of operation.

FIGS. **26** and **27** show a modification in which switches T–1*b* and T–3*b* are operated simultaneously by a single cam. As shown in FIG. **26**, switch T–3*b* is of the same construction as shown in FIG. **22** and includes an upper switch blade **145'** and a lower switch blade **146'**. Switch T–1*b* consists of an upper switch blade **156'**, a middle switch blade **159'** and a lower switch blade **160'**. These switch blades are anchored to the terminal panel **10** in the same plane as switch blades **145'** and **146'** of switch T–3*b*. The switch blades of switch T–3*b* are biased downwardly toward the cam **152**. The switch blades **156'**, **159'** and **160'** of switch T–1*b* are biased upwardly toward cam **152**. A spacer **195** is loosely mounted in suitable holes in the switch blades **145'** and **159'** and serves to cause these switch blades to move in unison. A spacer **196** extends between the switch blade **146'** and the switch blades **156'** and **160'**. As shown in FIG. **27**, this spacer **196** passes freely through an opening **197** in switch blade **159'** and has no effect on the position of blade **159'**. The spacer **196** however, bears against the switch blades **156'** and **160'**. This serves to maintain the spacing between these two blades and cause these blades to operate in unison with the cam operated switch blade **146** of switch T–3*b*.

In the positions shown, the switch T–3*b* is open and its lower switch blade **146'** has dropped off the cam **152**. Switch blade **145'** is now riding the cam and is in its upper position. As the switch blade **146'** is in its lower position, it has depressed through spacer **196** the switch blades **156'** and **160'**. This has caused engagement of contacts **157** and **158** and disengagement of contacts **158** and **161**.

When the cam **152** continues its rotation and drops off the blade **145'** this blade drops to cause engagement of the contacts **145** and **146** of switch T–3*b*. It also through spacer **195** depresses switch blade **159'** disengaging contacts **157** and **158** and engaging contacts **158** and **161**.

The arrangement above described using a single cam makes it possible to make the control package smaller and also ensures simultaneous actuation of two independent switches in cases where simultaneous action is necessary.

From the foregoing it will be apparent that the present invention provides a simple and compact unit for bringing on a number of condition changing units or motors in sequence. The invention also provides for either normal simultaneous off operation, or cascade off operation combined with simultaneous off operation in the event of a power interruption of malfunction. It will also be apparent that the invention provides for control of a system, directly by a sensitive low voltage thermostat or other condition responsive device and that no complicated circuitry including relays is involved. It will be further apparent that the invention as applied to refrigeration control not only provides sequence control for a number of compressors but also provides for pressure equalization between normal operations and a prolonged delay between operations in event of a malfunction.

While a preferred form of the invention has been shown and described, it will be apparent that many modifications, omissions, etc. may be made without departing from the spirit and scope of the invention.

I claim:

1. In a control system for a condition changing system having a plurality of condition changing units, the combination of, a condition responsive device, motor driven actuating means, means for starting said actuating means in response to a predetermined condition at said condition responsive device, a plurality of load switches connected to different condition changing units, means operated by said motor driven actuating means for mechanically actuating said load switches in sequence thereby activating the condition changing units in sequence when the condition responsive device calls for a condition change, control means for stopping said motor driven actuating means after it has operated the load switches to activate the condition changing units, a control device, means mechanically connecting said control device with said load switchs for actuating said load switches independently of

said motor driven actuating means in a manner to deactivate the condition changing units when the control device is moved in one direction, means mechanically actuated by movement of the control device in said one direction for actuating said control means in a manner permitting continued operation of the motor driven actuating means, and means for actuating said control device in said one direction in response to a predetermined condition.

2. The combination as set forth in claim 1 in which the control means for the motor driven actuating means consists of a motor switch connected in circuit with the motor, said motor switch being operated in one direction by the motor driven actuating means after the load switches are actuated in sequence, said motor switch also being operated in the opposite direction by the control device substantially simultaneously with actuation of the load switches by said control device.

3. The combination as set forth in claim 2 in which the motor driven actuating means closes the load switches and opens the motor switch in sequence and in which the control device is an electric magnet which on deenergization opens the load switches and recloses the motor switch substantially simultaneously.

4. The combination as set forth in claim 1 in which the control device is an electromagnet and in which a single condition responsive device controls both the electromagnet and the motor driven actuating means, the load switches being closed in sequence in response to one condition at the condition responsive device, and being opened substantially simultaneously in response to another condition at the condition responsive device.

5. The combination as set forth in claim 1 in which the condition responsive device controls only the motor driven actuating means, and the control device is actuated by a separate condition responsive device responsive to a condition of the condition changing system.

6. In a control system for a condition changing system having a plurality of condition changing units, the combination of a condition responsive device, motor driven actuating means, means for starting said actuating means in response to a call for condition change by said condition responsive device, a plurality of load switches connected to different condition changing units, means operated by said actuating means for mechanically actuating said load switches in sequence, thereby activating the condition changing units in sequence when the condition responsive means calls for a condition change, means for stopping said actuating means when the load switches have been actuated for activating the condition changing units, said motor driven actuating means also being arranged to mechanically operate said load switches in sequence for deactivating the condition changing units in sequence upon continued movement of said actuating means, means for restarting the actuating means in response to the condition responsive means becoming satisfied, thereby deactivating the condition changing units in sequence, a control device, means actuated by said control device for mechanically operating said switches in a manner to deactivate the condition changing units substantially simultaneously and independently of said motor driven actuating means, and means for actuating said control device in response to a predetermined condition for causing simultaneous deactivation of said condition changing units.

7. The combination as set forth in claim 6 in which the control means for the motor driven actuating means consists of a motor switch connected in circuit with the motor, said motor switch being actuated in one direction by the motor driven actuating means after the load switches are actuated in sequence, said motor switch also being operated in the opposite direction by the control device substantially simultaneously with operation of the load switches by said control device.

8. The combination as set forth in claim 7 in which the load switches are closed to activate the condition changing units and the motor switch is closed to stop the motor by shunting the same and in which the control device is an electromagnet which upon deenergization opens the load switches and the motor switch.

9. In a control system for a condition changing system having a plurality of condition changing units, the combination of, a condition responsive device having a switch which closes upon call for condition change and which opens when satisfied, control means including a moor driven actuator having a drive motor and a plurality of switches connected to different condition changing units, said actuator being arranged to actuate said switches in sequence as the actuator moves from an "off" position to a "run" position, said actuator also being arranged to open said switches when the actuator returns from the "run" position to the "off" position, a power source for the drive motor capable of being shunted without damage, first circuit means including a first motor control switching means controlling power to the drive motor, said first motor control switching means being actuated by the actuator and said circuit means and switching means being connected and arranged to place the drive motor in circuit with the condition responsive device switch when the actuator is in the "off" position, and to provide an independent circuit for the drive motor when the actuator is away from the "off" position, second circuit means including a second motor control switching means, said second circuit means being connected and arranged to shunt the power source in series with the condition responsive device switch, said second motor control switch being operated by the actuator and arranged to close when the actuator is in the "run" position.

10. In a control system for a condition changing system having a plurality of condition changing units, the combination of, a condition responsive device, motor driven actuating means, said actuating means comprising a plurality of actuators and a motor for driving same, a plurality of load switches connected to different condition changing units, said load switches being operated by different actuators and individually comprising a first switch blade, a second switch blade, cooperating contacts carried by the switch blades, the first switch blade being biased toward the second switch blade tending to cause engagement of the contacts, the second switch blade being biased in the same direction tending to cause disengagement of the contacts, means including one of said actuators for moving both of said switch blades against their bias with the contacts separated to predetermined position and then releasing the blades, a plurality of latches, said latches being arranged to support the second switch blade of different load switches after release by the corresponding actuator for causing engagement of the load switch contacts, control means controlled by the condition responsive device for starting said motor driven actuating means in response to a predetermined condition thereby activating said condition changing units, control means for stopping said motor driven actuating means after it has operated the load switches to activate the condition changing units, and means including a latch actuator for actuating said latches to release said latches in response to a predetermined condition, thereby opening said load switches.

11. The combination as set forth in claim 10 in which the control means for the motor driven actuating means consists of a motor switch connected in circuit with the motor, said motor switch being operated in one direction by the motor driven actuating means after the load switches are actuated, said motor switch also being operated in the opposite direction by the latch actuator when it releases the latches.

12. The combination as set forth in claim 11 in which the motor driven actuating means closes the load switches and opens the motor switch in sequence, and in which the latch actuator is operated by an electromagnet which on deenergization releases the latches and recloses the motor switch.

13. The combination as set forth in claim 11 in which an electromagnet operates the latch actuator and in which the condition responsive device controls both the electromagnet and the motor driven actuating means, the load switches being

closed in sequence in response to one condition at the condition responsive device and being opened substantially simultaneously in response to another condition at the condition responsive device.

14. The combination as set forth in claim 10 in which the condition responsive device controls only the motor driven actuating means, and the latch actuator is actuated by a separate condition responsive device responsive to a condition of the condition changing system.

15. In a controller for sequentially controlling a plurality of loads, the combination of, a plurality of load switches, motor driven actuating means for actuating said load switches, said actuating means comprising a plurality of actuators and a motor for driving the same, said load switches being operated by different actuators and individually comprising a first switch blade, a second switch blade, cooperating contacts carried by the switch blades, the first switch blade being biased toward the second switch blade, said second switch switch blade being biased in the same direction, means including one of the actuators for moving both of the switch blades against their bias to predetermined positions and then releasing said blades, a plurality of latches, said latches being arranged to support one of the switch blades of different switches after release by the corresponding actuator, control means for stopping the motor driven actuating means after it has released said switches, and means for releasing said latches and operating said control means to permit continued operation of said motor driven actuating means.

16. The combination defined in claim 15 in which the control means for stopping the motor is a switch in circuit with the motor and having a latch for maintaining it closed, said last mentioned latch being released with the other latches.

17. In a multiple switch controller, the combination of, a plurality of switches, motor driven actuating means arranged to mechanically actuate said switches, a series of separate and independently mounted latches arranged to hold said switches in actuated position, means for releasing one of said latches, and means actuated by releasing motion of said one latch for engaging and releasing another of said latches.

18. The combination as set forth in claim 17 in which the first latch is provided with a camming surface arranged to cause additional movement of the latch after movement to releasing position, said additional movement being imparted by the switch it released and causing movement of said other latch in releasing direction.

19. In a timing device, a cam, first and second switch blades carrying cooperating contacts and each biased toward said cam, means providing a first cam follower surface carried by the first switch blade and riding the cam, means providing a second cam follower surface carried by the second switch blade and riding the cam, said cam having a main camming surface and a dropoff section, the cam follower surfaces and the switch blades being arranged to provide a gap between the contacts when both cam follower surfaces are riding the main camming surface of the cam, a latch arranged to support one of the switch blades in a manner to cause and maintain engagement of the contacts after the cam follower surfaces have been passed by the dropoff section of the cam, and means for releasing said latch to cause disengagement of said contacts.

20. The combination defined in claim 19 in which the means for releasing the latch is actuated with the cam and releases the latch at a predetermined position of the cam.

21. The combination set forth in claim 19 in which the means for releasing the latch consists of an electromagnet arranged to release the latch upon actuation thereof.

22. The combination set forth in claim 20 in which an electromagnet is arranged to release the latch independently of the first named latch releasing means.

23. In a control system for a condition changer, circuit means including a load switch for controlling the condition changer, operating means for the switch including a motor driven actuator, said operating means including actuated means raised by motion of the motor driven actuator and lowered when the actuator reaches a predetermined position, said operating means also including a latch movable from latching to releasing position and vice versa, the latch and actuated means being constructed and arranged to cause operation of the switch to start the condition changer when the actuated means is lowered with the latch in latching position and to stop the condition changer when latch is moved to releasing position, means including condition responsive device arranged to start the motor driven actuator from a first position in response to a predetermined condition, means for stopping the motor driven actuator in a second position after it has started the condition changer, means for releasing the latch and restarting the motor driven actuator in response to a predetermined condition and means for stopping said motor driven actuator at said first position.

24. The combination as set forth in claim 23 in which the means for stopping the motor driven actuator consists of a motor switch controlling the motor of the motor driven actuator, said switch being held open by a latching means released substantially simultaneously with the load switch latch.

25. In a control system for a refrigeration system having a compressor, the combination of, a power circuit for the compressor, control means for said power circuit including a condition responsive device, a timing device, and an electromagnet, control circuit means including the condition responsive device, the timing device and the electromagnet for causing closure of said power circuit to start the compressor in response to a call for condition change, the control circuit means also being arranged to open the power circuit in response to the condition responsive device becoming satisfied, the timing device being arranged to interpose an equalization delay between opening and closure of the power circuit sufficient to allow suitable pressure equalization in the system and to provide an additional delay in event of a short cycle, the overall time cycle of the timing device including both delays, means for causing operation of the timing device through the additional delay period when the compressor starts and for stopping the timing device at the end of this period if the compressor is still in operation, means for restarting the timing device when the compressor is stopped, and means for stopping the timing device when the equalizing period is substantially consumed.

26. In a control system for a refrigeration system having a compressor, the combination of, a power circuit for the compressor, control means for said power circuit including a condition responsive device a timing device, and an electromagnet, control circuit means including the condition responsive device, the timing device and the electromagnet for causing closure of said power circuit to start the compressor in response to a call for condition change, the control circuit means also being arranged to open the power circuit in response to the condition responsive device becoming satisfied, the timing device being arranged to provide an initial delay period between call for condition change and starting of the compressor, an equalization delay period between opening and closure of the power circuit sufficient to allow suitable pressure equalization in the system, and an additional delay period in the event of a short cycle, the overall time cycle of the timing device including all three delay periods, the condition responsive device being arranged to start the timing device on call for refrigeration and the timing device initiating said closure of the power circuit for the compressor at the end of said initial delay period, means for causing operation of the timing device through the additional delay period when the compressor starts and for stopping the timing device at the end of this additional delay period if the compressor is still in operation, means for restarting the timing device when the compressor is stopped, and means for stopping the timing device when the equalizing period is substantially consumed if the condition responsive device is not calling for refrigeration.

27. In a control system for a condition changing system having a plurality of condition changing units, the combination of, a plurality of switches connected to different condition chang-

ing units, an electric motor driven actuating means arranged when started from a first predetermined position to actuate said switches in sequence thereby activating the condition changing units in sequence, an operating condition responsive controller responsive to the load on the system, means controlled by said operating condition responsive controller for causing the motor driven actuating means to run from the first position and activate the condition changing units in sequence when the operating condition responsive controller calls for condition change, means controlled by said controller for stopping the actuating means in a second predetermined position allowing continued operation of the condition changing units, means for restarting the motor driven actuator and actuating the switches to terminate operation of the condition changing units when the operating condition responsive controller becomes satisfied, means controlled by the condition responsive controller for stopping the motor driven actuating means at the first predetermined position, protective means including an electromagnet for operating said switches to terminate operation of the condition changing units independently of said motor driven actuator means, a protective condition responsive controller in circuit with both the electromagnet and the motor of said motor driven actuating means, said protective controller acting to terminate operation of the condition changing units and prevent running of the actuating means when an undesirable condition occurs in the system.

28. In a control system for a condition changing system, the combination of a power circuit for said condition changing system, control means for said power circuit, said control means including an operating condition responsive device responsive to the load on the system, a protective condition responsive means responsive to a condition in the condition changing system, a timing device, and an electromagnet, control circuit means including the operating condition responsive device, the timing device and the electromagnet for causing closure of said power circuit to start the condition changer in response to a call for condition change, and to open the power circuit in response to the operating condition responsive device becoming satisfied, means in said control circuit means whereby the timing device interposes a delay between opening and closure of said power circuit, means in the control circuit means to start the timing device when the operating condition responsive device becomes satisfied if the protective condition responsive device indicates a satisfactory condition in the system, means in the control circuit means whereby said protective condition responsive means operates the electromagnet to open the power circuit independently of the operating condition responsive device in response to an unfavorable condition in the system, and means in the control circuit means to render the timing device inoperative to begin a timing cycle as long as the condition is unfavorable and render the timing device operable when the condition becomes favorable, whereby the duration of the unfavorable condition is added to the delay provided by the timing device.

29. In a control circuit for a condition changing system including a condition changer and fluid moving means associated therewith, the combination of, a first power circuit for the condition changer, a second power circuit for the fluid moving means, control circuit means for the power circuits including an operating condition responsive device responsive to the load on the system, a protective condition responsive means responsive to a condition in the condition changing system, and a timing device, said control circuit means being arranged to close both power circuits to start the condition changer and fluid moving means in response to a call for condition change by the first condition responsive device and to open the first power circuit to stop the condition changer in response to said first condition responsive device becoming satisfied, the timing device being arranged to control the second power circuit to maintain it closed for operating the fluid moving means a period of time after the condition changer is stopped, control circuit means arranged to start the timing device when the operating condition responsive device becomes satisfied if the protective condition responsive device indicates a satisfactory condition in the system, the protective condition responsive means being arranged to cause opening of the first power circuit to stop the condition changer, and to prevent the timing device from operating in response to an unfavorable condition, whereby the fluid moving means is maintained in operation as long as the unfavorable condition exists.

30. The combination set forth in claim **29** in which the timing device is also arranged to interpose a delay between stopping and restarting of the condition changer.

31. In a control system for a condition changer, a condition responsive device, a power circuit for the condition changer, a control system for the power circuit including said condition responsive device, a timing device and an electromagnet, means whereby said timing device causes closure of the power circuit at the command of the condition responsive device, and the electromagnet causes opening of the power circuit independently of the timing device when said electromagnet is deenergized, means including a condition responsive device and circuit means connecting said condition responsive device and electromagnet are arranged to deenergize the same in response to an unfavorable condition associated with the condition changer, switching means actuated by said timing device also in circuit with the electromagnet, said switching means being connected and arranged to deenergize said electromagnet independently of said second condition responsive device during periods when the power circuit is open, and means whereby said timing device operates the switching means to energize the electromagnet for allowing continued closure of the power circuit under the command of the first condition responsive means when the second condition responsive means indicate a favorable condition.

32. In a motor driven switching mechanism, a motor, a cam shaft driven by said motor, said cam shaft carrying a plurality of cams, a plurality of switches operated from one contact position to another by said cams, said cams being arranged to operate said switches in sequence, starting from a predetermined angular starting point of the cam shaft, means other than the cam shaft for returning at least one of the switches to said one position, mechanical interlocking means between said switches, said mechanical interlocking means being arranged to prevent one of said switches from being operated to its other contact position if a switch ahead of it is not in its other contact position, whereby the cam shaft must return to the starting position before said one switch can be actuated to its other contact position.

33. The combination set forth in claim **32** in which the switches are provided with separate control elements having active and inactive positions and arranged to require the control element of a given switch to be in active position in order for such switch to be in its other contact position, the mechanical interlocking means extending between said control elements.

34. The combination set forth in claim **33**, in which the control elements are latches which must be in latching position in order for the corresponding switch to assume its other contact position.

35. In a control system for a condition changer having a plurality of condition changing units, the combination of, a plurality of switches connected to different condition changing units, electric actuating means for actuating said switches, an operating condition responsive controller, means controlled by said operating condition responsive controller for causing said electric actuating means to operate said switches to start the condition changing units in response to call for condition change, said electric actuating means being arranged to stop said condition changing units in sequence in response to the condition responsive controller becoming satisfied, and protective means including an electromagnet arranged to actuate said switches simultaneously to stop operation of said condition changers, said electromagnet being operated in response to a malfunction and actuating said switches independently of said electric actuating means.