

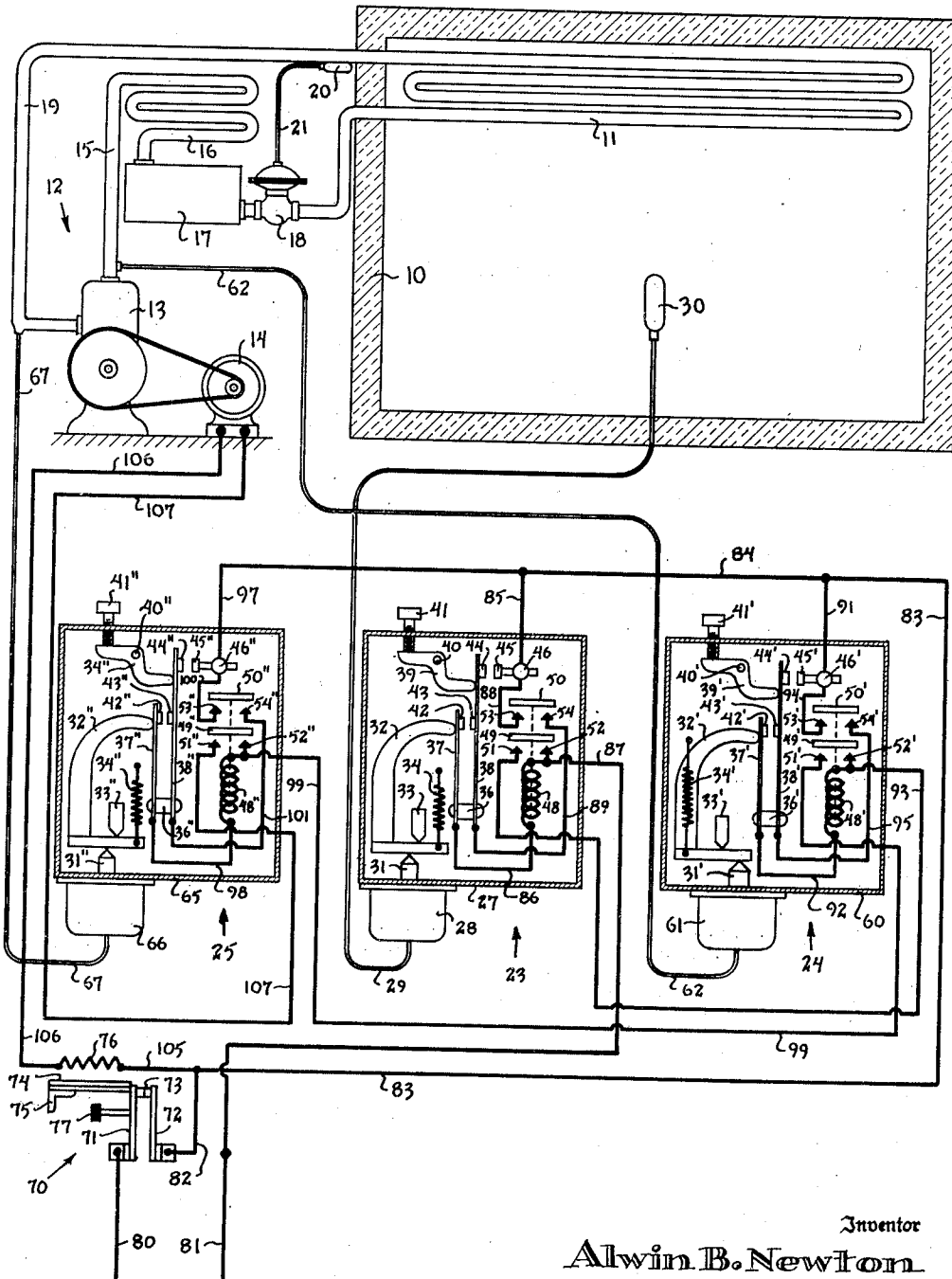
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A. B. NEWTON

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REFRIGERATION CONTROL SYSTEM

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Inventor

Alwin B. Newton

By

George H. Fisher

Attorney

UNITED STATES PATENT OFFICE

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REFRIGERATION CONTROL SYSTEM

Alwin B. Newton, Minneapolis, Minn., assignor to
Minneapolis-Honeywell Regulator Company,
Minneapolis, Minn., a corporation of Delaware

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This invention relates to control systems in general and more particularly to control systems for controlling the operation of a refrigerating apparatus.

An object of this invention is to provide a novel control arrangement for an electrically operated device wherein a plurality of control switches control individually the operation of a plurality of relays and wherein the electrically operated device can be operated only when all of the relays are pulled in.

A further object of this invention is to utilize this control arrangement for controlling the operation of a compressor of a refrigerating apparatus wherein the control switches are operated in accordance with refrigerating conditions, such as pressure on the high pressure side of the refrigerating apparatus, evaporator temperature, compressor overload conditions and the temperature of the medium being cooled by the refrigerating apparatus. With such a control arrangement, it is possible to require the pressure on the high pressure side to reduce to a predetermined low value and the evaporator temperature to rise to a defrosting value before the compressor can be placed in operation upon a call for cooling by the medium temperature responsive switch. This insures defrosting of the evaporator during each cycle of operation and prevents the starting of the compressor against high head pressures.

Other objects and advantages will become apparent to those skilled in the art upon reference to the accompanying specification, claims and drawing.

The single sheet of drawings illustrates the preferred form of this invention.

Referring now to the drawing, an enclosure containing a medium to be cooled is designated at 10. For purposes of illustration, this enclosure is shown as being a storage chamber such as a walk-in box. The storage chamber is cooled by an evaporator 11 suitably connected to a refrigerating apparatus generally designated at 12, which may comprise a compressor 13 operated by a compressor motor 14. Refrigerant is delivered from the compressor 13 through a high pressure line 15 to a condenser 16 and the condensed refrigerant is collected in a receiver 17. Condensed refrigerant flows from the receiver 17 through an expansion valve 18 into the evaporator 11 wherein it is evaporated and performs cooling functions. Evaporated refrigerant is drawn from the evaporator 11 through a suction line 19 by the compressor 13. The expansion valve 18 may be of the thermostatic type having a bulb 20 lo-

cated at the discharge side of the evaporator 11 connected by a capillary tube 21 to the expansion valve 18. Since such a construction is old in the art, a further description thereof is not considered necessary.

The compressor motor 14 and hence the refrigerating apparatus is illustrated as being controlled by three controllers. A controller responsive to the condition of the medium being cooled is generally designated at 23 and this controller may take the form of a temperature responsive controller responsive to the temperature of the air within the enclosure 10. A controller responsive to the pressure on the high pressure side of the refrigerating apparatus is generally designated at 24. A controller responsive to a condition indicative of evaporator temperature is generally designated at 25 and may take the form of a pressure responsive controller responsive to the pressure on the low pressure side of the refrigerating apparatus. Inasmuch as suction pressure and evaporator temperature are proportional, the suction pressure controller 25 in responding to variations in suction pressure also responds to the temperature of the evaporator means 11.

The temperature responsive controller 23 may comprise a casing 27 to which is secured a bellows chamber 28. The bellows chamber 28 is connected by a capillary tube 29 to a bulb 30 located within the enclosure 10. The bellows chamber 28 and bulb 30 are charged with a volatile fluid so that a plunger 31 is operated in accordance with variations in temperature within the enclosure 10. The plunger 31 operates a lever 32 pivoted on a fulcrum 33 against the action of an adjustable tension spring 34. Upon an increase in temperature, the lever 32 is rotated in a clockwise direction, and upon a decrease in temperature the spring 34 rotates the lever 32 in a counter-clockwise direction. A bracket 36 carries resilient arms 37 and 38, the arms being urged toward the lever 32 by their own resiliency. The arm 37 abuts against the lever 32, and the arm 38 abuts against a lever 39 pivoted at 40 and adjustably positioned by a screw 41. Contacts 42 and 43 are carried by the arms 37 and 38, respectively, and upon an increase in temperature the lever 32 moves the contact 42 into engagement with the contact 43. The arm 38 also carries a contact 44 which is adapted to engage an adjustable contact 45 carried by a post 46. After the contacts 42 and 43 have been engaged and a further temperature rise occurs, the contact 44 is moved into engagement with the

contact 45. For purposes of illustration, it is assumed that upon a rise in temperature contact 42 first engages contact 43 at 40° and then contact 44 engages contact 45 at 42°. Upon a decrease in temperature, contact 44 first disengages contact 45 at 42° and then contact 42 disengages contact 43 at 40°.

The temperature responsive controller 23 also includes a relay having an operating coil 48 for moving switch arms 49 and 50 into engagement with contacts 51, 52, 53, and 54 when the operating coil is energized. When the operating coil is deenergized, the switch arms 49 and 50 are moved out of engagement with their respective contacts 51, 52, 53, and 54 by means of springs, gravity, or other means, not shown.

The high pressure responsive controller 24 may comprise a casing 60 to which is secured a bellows chamber 61 connected by a pipe 62 to the high pressure line 15 of the refrigerating apparatus. The operating parts within the casing 60 are the same as the operating parts within the casing 27 of the temperature responsive controller 23 with one exception, and accordingly, like reference characters primed have been utilized for these parts. The location of the spring 34' and the plunger 31' of the pressure responsive controller 24 is just the opposite of the location of the plunger 31 and spring 34 of the temperature responsive controller 23. Accordingly, upon an increase in high pressure the lever 32' is rotated in a counter-clockwise direction, while upon a decrease in high pressure the lever 32' is rotated in a clockwise direction. For purposes of illustration, it is assumed that upon a decrease in high pressure contact 42' first engages contact 43' at 185 pounds and then contact 44' engages contact 45' at 140 pounds. Upon an increase in high pressure, contact 44' first disengages from contact 45' at 140 pounds and then contact 42' disengages contact 43' at 185 pounds.

The low pressure controller 25 may comprise a casing 65 to which is secured a bellows chamber 66 which, in turn, is connected by a pipe 67 to the low pressure or suction line 19 of the refrigerating apparatus. The operating parts contained within the casing 65 are exactly the same as the operating parts contained within the casing 27 of the temperature responsive controller 23 and therefore like reference characters double primed have been utilized for like parts. For purposes of illustration, it is assumed that upon an increase in suction pressure the contacts 42'' and 43'' engage at 20 pounds and then contacts 44'' and 45'' engage at 35 pounds. Upon a decrease in suction pressure, contacts 44'' and 45'' separate at 35 pounds and then contacts 42'' and 43'' separate at 20 pounds. It is also assumed that the suction pressure value of 35 pounds at which contacts 44'' and 45'' engage represents a temperature above the defrosting temperature of the evaporator 11 so that the contacts 44'' and 45'' only engage after the evaporator means 11 has defrosted.

An overload cut-out switching mechanism may be utilized with the control apparatus of this invention, and this overload cut-out switching mechanism is generally designated at 70. It may comprise arms 71 and 72 carrying contacts 73. The arm 71 is so arranged that it tends to separate the contacts 73 by its own resiliency. The arm 71 may be held into contact making position by means of a bimetallic element 74 suitably mounted on a bracket 75. The bimetallic ele-

ment 74 is influenced by a heater 76 located in the compressor load circuit. Upon the occurrence of an overload condition in the compressor load circuit, the bimetallic element 74 is flexed upwardly to allow the arm 71 to separate the contacts 73, whereupon the circuit through the contacts 73 is broken. A manual operator 77 may be utilized for reclosing the contacts 73 so that they may be held in engagement by the bimetallic element 74 after the same has cooled down following the occurrence of an overload condition. Power is supplied to the compressor motor 14 and to the control system by means of line wires 80 and 81 leading from some source of power, not shown.

Assume now that the temperature within the enclosure 10 has risen to 40° to cause contacts 42 and 43 and contacts 44 and 45 to be closed. A circuit is thereupon completed from the line wire 80 through arm 71, contacts 73, arm 72, wires 82, 83, 84, and 85, contacts 45 and 44, arm 38, contacts 43 and 42, arm 37, wire 86, operating coil 48, and wire 87 back to the other line wire 81. Completion of this circuit energizes the operating coil 48 to move the switch arms 49 and 50 into engagement with their respective contacts. Movement of the switch arm 50 into engagement with contacts 53 and 54 completes a maintaining circuit for the operating coil 48 which is independent of the contacts 44 and 45 and this circuit may be traced from the overload cut-out 70 through wires 82, 84, 84, and 85, post 46, wire 88, contact 53, switch arm 50, contact 54, wire 89, arm 38, contacts 43 and 42, arm 37, wire 86, operating coil 48, and wire 87 back to the line wire 81. Completion of this circuit maintains the operating coil 48 energized until such time as the contacts 42 and 43 separate.

When the high pressure decreases to 140 pounds, contacts 42' and 43' and contacts 44' and 45' are in engagement to complete a circuit from the overload cut-out 70 through wires 82, 83, and 91, contacts 45' and 44', arm 38', contacts 43' and 42', arm 37', wire 92, operating coil 48', wire 93, contact 51, switch arm 49, contact 52, and wire 87 back to the line wire 81. Completion of this circuit energizes the operating coil 48' when the high pressure decreases to 140 pounds providing the relay of the temperature responsive controller 23 is pulled in.

Energization of the operating coil 48' moves the switch arms 49' and 50' into engagement with their respective contacts. Movement of the switch arm 50' into engagement with the contacts 53' and 54' completes a maintaining circuit for the operating coil 48' which is independent of the contacts 44' and 45'. This circuit may be traced from the overload cut-out 70 through wires 82, 83, and 91, post 46', wire 94, contact 53', switch arm 50', contact 54', wire 95, arm 38', contacts 43' and 42', arm 37', wire 92, operating coil 48', wire 93, contact 51, switch arm 49, contact 52, and wire 87 back to the other line wire 81. Completion of this circuit maintains the operating coil 48' energized until the high pressure increases to 185 pounds to separate the contacts 42' and 43', or until the relay of the temperature responsive controller 23 drops out.

When the suction pressure rises to 35 pounds, the contacts 44'' and 45'' and the contacts 42'' and 43'' are moved into engagement. This completes a starting circuit for the operating coil 48'' which may be traced from the overload

cut-out 70 through wires 82, 83, 84, and 97, contacts 45" and 44", arm 38", contacts 43" and 42", arm 37", wire 98, operating coil 48", wire 99, contact 51', switch arm 49', contact 52', wire 93, contact 51, switch arm 49, contact 52, and wire 87 back to the line wire 81. Completion of this circuit energizes the operating coil 48" to move the switch arms 49" and 50" into engagement with their respective contacts. Movement of the switch arm 50" into engagement with the contacts 53" and 54" completes a maintaining circuit for the operating coil 48" which is independent of the contacts 44" and 45". This circuit may be traced from the overload cut-out 70 through wires 82, 83, 84, and 97, post 46", wire 100, contact 53", switch arm 50", contact 54", wire 101, arm 38", contacts 43" and 42", arm 37", wire 98, operating coil 48", wire 99, contact 51', switch arm 49', contact 52', wire 93, contact 51, switch arm 49, contact 52, and wire 87 back to the other line wire 81. Completion of this circuit maintains the operating coil 48" energized until the suction pressure decreases to 20 pounds to separate the contacts 42" and 43", or until the relay of the temperature responsive controller 23 drops out or until the relay of the high pressure responsive controller 24 drops out.

When all of the relays of the temperature responsive controller 23, the high pressure responsive controller 24, and the suction pressure responsive controller 25 are pulled in, a circuit for the compressor is completed which may be traced from the line wire 80 through the overload cut-out 70, wires 82 and 105, heater element 76, wire 106, compressor motor 14, wire 107, contact 51", switch arm 49", contact 52", wire 99, contact 51', switch arm 49', contact 52', wire 93, contact 51, switch arm 49, contact 52, and wire 87 back to the other line wire 81. Accordingly, it is seen that the load switches of the relays of the three controllers are connected in series with the compressor motor 14 so that the compressor motor 14 can be operated only when all three relays are pulled in.

When the temperature of the enclosure rises to 42°, when the high pressure decreases to 140 pounds, and the suction pressure increases to 35 pounds, all of the relays are pulled in to complete the compressor motor circuit and place the refrigerating apparatus in operation. If the suction pressure should decrease to 20 pounds, the relay of the suction pressure responsive controller 25 drops out to stop operation of the refrigerating apparatus, the relays of the temperature responsive controller 23 and the high pressure responsive controller 24 still remaining in. The relay of the suction pressure responsive controller cannot again be pulled in until the suction pressure rises to 35 pounds and accordingly defrosting of the evaporator 11 must occur before the refrigerating apparatus can be placed in operation.

Assume now that the high pressure increases to 185 pounds to drop out the relay of the high pressure responsive controller 24. This not only interrupts the circuit to the compressor motor 14 but also drops out the relay of the suction pressure responsive controller 25, the relay of the temperature responsive controller 23 still remaining in. Accordingly, the relay of the high pressure responsive controller cannot again be pulled in until the high pressure decreases to 140 pounds and the relay of the suction pressure responsive controller 25 cannot be pulled in until

both defrosting of the evaporator 11 has occurred and the high pressure responsive controller relay is pulled in. Hence when the compressor is cut off by the occurrence of a high pressure condition on the high pressure side of the refrigerating apparatus, the refrigerating apparatus cannot again be placed in operation until both the high pressure decreases to a predetermined low value and the evaporator 11 has defrosted.

Assume now that the temperature within the enclosure 10 decreases to 40°, the relay of the temperature responsive controller 23 will then drop out. In addition to interrupting the load circuit to the compressor motor 14, dropping out of the relay of the temperature responsive controller 23 also drops out the relays of the high pressure responsive controller 24 and the suction pressure responsive controller 25 so that the refrigerating apparatus cannot again be placed in operation until the temperature within the enclosure 10 rises to 42°, the high pressure decreases to 140 pounds, and the evaporator 11 is defrosted.

If an overload condition in the compressor motor circuit occurs, the overload cut-out 70 trips open and all of the relays are dropped out. Hence following an overload condition the compressor cannot be restarted even though the overload cut-out is reset until the temperature within the enclosure 10 increases to 42°, the high pressure decreases to 140 pounds and the suction pressure increases to 35 pounds. Upon a momentary power failure condition the same sequence of operation is required to place the refrigerating apparatus back into operation.

Summing up, if after the refrigerating apparatus has been placed in operation it is stopped by the occurrence of a low suction pressure, the refrigerating apparatus cannot be replaced in operation until the evaporator 11 has defrosted. If the refrigerating apparatus has been stopped upon the occurrence of a high head pressure, it cannot be restarted until the head pressure decreases to a low value and the evaporator has defrosted. If the refrigerating apparatus has been stopped upon the occurrence of a low temperature condition within the enclosure 10, or if it is stopped upon the occurrence of an overload condition in the compressor motor circuit, it cannot be restarted until the temperature within the enclosure rises to a predetermined value, the high pressure decreases to a predetermined value, and the evaporator 11 has defrosted. Accordingly, this system insures that the evaporator 11 is defrosted before the refrigerating apparatus is placed in operation regardless of how operation of the refrigerating apparatus was stopped.

If it be desirable to insure that the refrigerating apparatus cannot be placed in operation until the pressure on the high pressure side of the refrigerating apparatus has decreased to a predetermined low value regardless of how the refrigerating apparatus was stopped, the location of the suction pressure responsive controller 25 and the high pressure responsive controller 24 in the circuit may be reversed. With such a revised arrangement the refrigerating apparatus could not be started under any conditions until the pressure on the high pressure side of the refrigerating apparatus decreased to, illustratively, 140 pounds. Likewise, if it be desirable to prevent restarting of the refrigerating apparatus until the temperature within the enclosure 10 increases to 42° regardless of how the refrigerating

erating apparatus was stopped, the temperature responsive controller 23 and the suction pressure responsive controller may be reversed in the circuit. With such an arrangement, it would be impossible to restart the refrigerating apparatus until the temperature within the enclosure 10 increases to 42° regardless of how the refrigerating apparatus was shut down. Hence this invention contemplates various locations of the various controllers in the circuit arrangement so that any desired sequence of operation may be obtained.

If, as shown, the starting circuit of the operating coil 48' of the high pressure responsive controller passes through the switch means of the temperature responsive controller 23 and if the starting circuit of the operating coil 48'' of the suction pressure controller 25 passes through the switch means of the relay of the high pressure responsive controller 24 and the switch means of the relay of the temperature responsive controller 23, it is not necessary to pass the load circuit of the compressor motor 14 through the three relays. The compressor motor 14 could be controlled solely by the switch means of the relay of the suction pressure controller 25 and substantially the same results would be obtained. This is predicated on the fact that the energization of the operating coil 48'' of the suction pressure controller 25 is controlled by the switch means of the relays of the temperature responsive controller 23 and the high pressure responsive controller 24. Such a modified control arrangement is also within the contemplation of this invention.

If the load circuit for the compressor motor 14 passes serially through the switch means of all of the relays as illustrated in the drawing, it is not necessary to pass the starting circuit of the relay 48' of the high pressure responsive controller through the switch means of the relay of the temperature responsive controller 23 or to pass the starting circuit of the operating coil 48'' of the suction pressure controller 25 through the switch means of the relays of the temperature responsive controller 23 and the high pressure responsive controller 24. Substantially the same mode of operation would be obtained by this revised arrangement and this revised arrangement is also within the contemplation of this invention.

By passing the load circuit serially through the three relays and by passing the starting circuits of the relays through the other relays as is shown in the drawing, shutting down of the refrigerating apparatus is absolutely assured even though one of the relays should stick to prevent shutting down of the refrigerating apparatus.

Although for purposes of illustration, one form of this invention has been disclosed other forms thereof may become apparent to those skilled in the art upon reference to this disclosure and therefore this invention is to be limited only by the scope of the appended claims and prior art. I claim as my invention:

1. In a control system for an electrically operated device, the combination of, a first switch, first relay means including an operating coil and switch means closed upon energization thereof, wiring connections for completing a circuit through the first switch and the operating coil of the first relay means to energize the same, second and third switches, means for closing the second and third switches in sequence and for

opening the same in the opposite order, second relay means including an operating coil and switch means closed upon energization thereof, circuit connections for completing a circuit through the second switch and the operating coil of the second relay means to energize the same, circuit connections for completing a circuit through the third switch, the switch means of the first relay means, the switch means of the second relay means and the operating coil of the second relay means to maintain the operating coil of the second relay means energized until the third switch is opened or the operating coil of the first relay means is deenergized whereupon the operating coil of the second relay means is deenergized, and a circuit for connecting the switch means of both relay means in series with the electrically operated device to operate the electrically operated device only when the operating coils of both relay means are energized.

2. In a control system for an electrically operated device, the combination of, a first switch, first relay means including an operating coil and switch means closed upon energization thereof, wiring connections for completing a circuit through the first switch and the operating coil of the first relay means to energize the same, second and third switches, means for closing the second and third switches in sequence and for opening the same in the opposite order, second relay means including an operating coil and switch means closed upon energization thereof, wiring connections for completing a circuit through the second switch, the switch means of the first relay means and the operating coil of the second relay means to energize the same when the operating coil of the first relay means is energized, wiring connections for completing a circuit through the third switch, the switch means of the first relay means, the switch means of the second relay means and the operating coil of the second relay means to maintain the operating coil of the second relay means energized until the third switch is opened or the operating coil of the first relay means is deenergized whereupon the operating coil of the second relay means is deenergized, and wiring connections for controlling the electrically operated device by the switch means of the second relay means to operate the electrically operated device only when both relay means are energized.

3. In a control system for an electrically operated device, the combination of, first and second switches, means for closing the first and second switches in sequence and for opening the same in the opposite order, first relay means including an operating coil and switch means closed upon energization thereof, means for completing a circuit through the second switch and the operating coil of the first relay means to energize the same, means for completing a circuit through the first switch, the switch means of the first relay means and the operating coil of the first relay means to maintain the same energized until the first switch is opened whereupon the operating coil of the first relay means is deenergized, third and fourth switches, means for closing the third and fourth switches in sequence and for opening the same in the opposite order, second relay means including an operating coil and switch means closed upon energization thereof, means for completing a circuit through the fourth switch and the operating coil of the second relay means to energize the same, means for

completing a circuit through the third switch, the switch means of the first relay means, the switch means of the second relay means and the operating coil of the second relay means to maintain the same energized until the third switch means is opened or the operating coil of the first relay means is deenergized whereupon the operating coil of the second relay means is deenergized, and means for connecting the switch means of both relay means in series with the electrically operated device to operate the electrically operated device only when the operating coils of both relay means are energized.

4. In a control system for an electrically operated device, the combination of, first and second switches, means for closing the first and second switches in sequence and for opening the same in the opposite order, first relay means including an operating coil and switch means closed upon energization thereof, means for completing a circuit through the second switch and the operating coil of the first relay means to energize the same, means for completing a circuit through the first switch, the switch means of the first relay means and the operating coil of the first relay means to maintain the same energized until the first switch is opened whereupon the operating coil of the first relay means is deenergized, third and fourth switches, means for closing the third and fourth switches in sequence and for opening the same in the opposite order, second relay means including an operating coil and switch means closed upon energization thereof, means for completing a circuit through the fourth switch, the switch means of the first relay means and the operating coil of the second relay means to energize the same when the operating coil of the first relay means is energized, means for completing a circuit through the third switch, the switch means of the second relay means and the operating coil of the second relay means to maintain the same energized until the third switch means is opened or the operating coil of the first relay means is deenergized whereupon the operating coil of the second relay means is deenergized, and means for controlling the electrically operated device by the switch means of the second relay means to operate the electrically operated device only when both relay means are pulled in.

5. In a control system for an electric motor, the combination of, a first switching means having starting, intermediate and stopping positions, first relay means including operating means and switch means operated thereby, circuit connections controlled by the first switching means for initially energizing the operating means of the first relay means to close the switch means thereof when the first switching means moves to its starting position, circuit connections controlled by said first switching means and the switch means of the first relay means to maintain the switch means of the first relay means in closed position when the first switching means moves to its intermediate position and until it moves to its stopping position, second switching means also having starting, intermediate, and stopping positions, second relay means including operating means and switch means operated thereby, circuit connections controlled by the switch means of the first relay and by said second switching means when in its starting position to initially energize the operating means of the second relay means, circuit connections controlled by the

switching means of both the first and second relay means and by the second switching means to maintain the switch means of the second relay means closed upon movement of the second switching means to its intermediate position and until it moves to its stopping position, a circuit for the motor controlled by the switch means of the second relay means, and an overload cut-out mechanism responsive to overload conditions on the motor and including a switch in circuit with the operating means of each of said relay means whereby upon opening of said switch both the first and second switching means must return to their starting positions before their associated relay means can again be energized.

6. In a refrigeration system including a refrigeration apparatus having a compressor and evaporator means, the combination with said apparatus of, a first switching means having starting, intermediate and stopping positions, first relay means including operating means and switch means operated thereby, circuit connections controlled by the first switching means for initially energizing the operating means of the first relay means to close the switch means thereof when the first switching means moves to its starting position, circuit connections controlled by said first switching means and the switch means of the first relay means to maintain the switch means of the first relay means in closed position when the first switching means moves to its intermediate position and until it moves to its stopping position, second switching means also having starting, intermediate and stopping positions, second relay means including operating means and switch means operated thereby, circuit connections controlled by the switch means of the first relay and by said second switching means when in its starting position to initially energize the operating means of the second relay means, circuit connections controlled by the switching means of both the first and second relay means and by the second switching means to maintain the switch means of the second relay means closed upon movement of the second switching means to its intermediate position and until it moves to its stopping position, a circuit for the compressor controlled by the switching means of the second relay means, means responsive to the pressure on the high pressure side of the refrigerating apparatus for operating one of the switching means, means responsive to a condition which is a measure of evaporator temperature for operating the other of the switching means, and an overload cutout mechanism responsive to overload conditions of the compressor and including a switch in circuit with the operating means of each of said relay means whereby upon opening of said switch both the first and second switching means must return to their starting positions before their associated relay means can again be energized.

7. In a control system for an electrically operated device, the combination of, first switching means, first relay means including operating means and switch means operated thereby, circuit connections controlled by the first switching means for energizing the operating means of the first relay means to close the switch means thereof when the first switching means is moved to closed circuit position, second switching means having a starting position and an off position and an intermediate position, second relay means including operating means and switch means operated thereby, circuit connections controlled by

the second switching means and the switch means of the first relay means for energizing the operating means of the second relay means to close the switch means thereof when the second switching means is moved to the starting position and the switch means of the first relay means is closed, circuit connections controlled by the second switching means, the switch means of the first relay means and the switch means of the second relay means for maintaining energization of the operating means of the second relay means to maintain the switch means of the second relay means closed while the second switching means moves from its starting position and through its intermediate position whereupon opening of the switch means of the first relay means or movement of the second switching means to its off position opens the switch means of the second relay means, and a circuit for controlling the electrically operated device by the switch means of the second relay means to operate the electrically operated device only when the switch means of both relay means are closed.

8. In a control system for an electrically operated device, the combination of, first switching means, first relay means including operating means and switch means operated thereby, circuit connections controlled by the first switching means for energizing the operating means of the first relay means to close the switch means thereof when the first switching means is moved to closed circuit position, second switching means having a starting position and an off position and an intermediate position, second relay means including operating means and switch means operated thereby, circuit connections controlled by the second switching means for energizing the operating means of the second relay means to close the switch means thereof when the second switching means is moved to the starting position, circuit connections controlled by the switch means of the first relay means and the switch means of the second relay means for maintaining energization of the operating means of the second relay means to maintain the switch means of the second relay means closed, whereupon opening of the switch means of the first relay means opens the switch means of the second relay means, circuit connections controlled by the second switching means in control of the energization of the operating means of the second relay means to open the switch means thereof when the second switching means is moved through its intermediate position to the off position, and a circuit connecting the switch means of both relay means in series with the electrically operated device to operate the device only when the switch means of both relay means are closed.

9. In a refrigeration system including a refrigerating apparatus having a compressor and evaporator means, the combination with said apparatus of, a first relay including operating means and switch means operated thereby, a second relay including operating means and switch means operated thereby, first switching means, circuit connections controlled by the first switching means to energize the operating means of the first relay for closing the switch means thereof, second switching means, circuit connections controlled by the second switching means and the switch means of the first relay to energize the operating means of the second relay for closing the switch means thereof providing the switch means of the first relay is closed, whereupon opening of the switch means of the first relay opens the switch

means of the second relay, means responsive to pressure on the high pressure side of the refrigerating apparatus for operating one of the switching means, means responsive to a condition which is a measure of evaporator temperature for operating the other switching means, and circuit connections controlled by the switch means of the second relay for operating the compressor only when the switch means of both relays are closed.

10. In a refrigeration system including a refrigerating apparatus having a compressor and evaporator means, the combination with said apparatus of a first relay including operating means and switch means operated thereby, a second relay including operating means and switch means operated thereby, first switching means, circuit connections controlled by the first switching means to energize the operating means of the first relay for closing the switch means thereof, second switching means, circuit connections controlled by the second switching means and the switch means of the first relay to energize the operating means of the second relay for closing the switch means thereof providing the switch means of the first relay is closed, whereupon opening of the switch means of the first relay opens the switch means of the second relay, means responsive to pressure on the high pressure side of the refrigerating apparatus for operating one of the switching means, means responsive to the temperature of the medium being controlled by the evaporator means for operating the other switching means, and circuit connections controlled by the switch means of the second relay for operating the compressor only when the switch means of both relays are closed.

11. In a refrigeration system including a refrigerating apparatus having a compressor and evaporator means, the combination with said apparatus of, a first relay including operating means and switch means operated thereby, a second relay including operating means and switch means operated thereby, first switching means, circuit connections controlled by the first switching means to energize the operating means of the first relay for closing the switch means thereof, second switching means, circuit connections controlled by the second switching means and the switch means of the first relay to energize the operating means of the second relay for closing the switch means thereof providing the switch means of the first relay is closed, whereupon opening of the switch means of the first relay opens the switch means of the second relay, means responsive to a condition which is a measure of evaporator temperature for operating one of the switching means, means responsive to the temperature of the medium being controlled by the evaporator means for operating the other switching means, and circuit connections controlled by the switch means of the second relay for operating the compressor only when the switch means of both relays are closed.

12. In a refrigeration system including a refrigerating apparatus having a compressor and evaporator means, the combination with said apparatus of, a first relay including operating means and switch means operated thereby, a second relay including operating means and switch means operated thereby, first switching means, circuit connections controlled by the first switching means to energize the operating means of the first relay for closing the switch means thereof, second switching means having a starting, a stop-

ping and an intermediate position, circuit connections controlled by the second switching means when in its starting position and the switch means of the first relay to initially energize the operating means of the second relay for closing the switch means thereof providing the switch means of the first relay is closed, whereupon opening of the switch means of the first relay opens the switch means of the second relay, additional circuit connections controlled by the switch means of both the first and second relays and by said second switching means for maintaining energization of the operating means upon movement of said second switching means from its starting to its intermediate position, means responsive to the temperature of the medium being controlled by the evaporator means for controlling one of said switching means, means responsive to the pressure on the high pressure side of the refrigerating apparatus for controlling the other of said switching means, and a circuit controlled by the switch means of the second relay for operating the compressor only when the switch means of both relays are closed.

13. In a refrigeration system including a refrigerating apparatus having a compressor and evaporator means, the combination with said apparatus of, a first relay including operating means and switch means operated thereby, a second relay including operating means and switch means operated thereby, first switching means, circuit connections controlled by the first switching means to energize the operating means of the first relay for closing the switch means thereof, second switching means having a starting, a stopping and an intermediate position, circuit connections controlled by the second switching means when in its starting position and the switch means of the first relay to initially energize the operating means of the second relay for closing the switch means thereof providing the switch means of the first relay is closed, whereupon opening of the switch means of the first relay opens the switch means of the second relay, additional circuit connections controlled by the switch means of both the first and second relays and by said second switching means for maintaining energization of the operating means upon movement of said second switching means from its starting to its intermediate position, means responsive to the temperature of the medium being controlled by the evaporator means for controlling one of said switching means, means responsive to a condition which is a measure of evaporator temperature for controlling the other of said switching means, and a circuit controlled by the switch means of the second relay for operating the compressor only when the switch means of both relays are closed.

14. In a refrigeration system including a refrigerating apparatus having a compressor and evaporator means, the combination with said apparatus of, a first relay including operating means and switch means operated thereby, a second relay including operating means and switch means operated thereby, first switching means, circuit connections controlled by the first switching means to energize the operating means of the first relay for closing the switch means thereof, second switching means having a starting, a stopping and an intermediate position, circuit connections controlled by the second switching means when in its starting position and the switch means of the first relay to initially energize the operating means of the second relay for

closing the switch means thereof providing the switch means of the first relay is closed, whereupon opening of the switch means of the first relay opens the switch means of the second relay, additional circuit connections controlled by the switch means of both the first and second relays and by said second switching means for maintaining energization of the operating means upon movement of said second switching means from its starting to its intermediate position, means responsive to the pressure on the high pressure side of the refrigerating apparatus for controlling one of said switching means, means responsive to a condition which is a measure of evaporator temperature for controlling the other of said switching means, and a circuit controlled by the switch means of the second relay for operating the compressor only when the switch means of both relays are closed.

15. In a refrigeration system including a refrigerating apparatus having a compressor and evaporator means, the combination with said apparatus of, a first relay including operating means and switch means operated thereby, a second relay including operating means and switch means operated thereby, a third relay including operating means and switch means operated thereby, first switching means, circuit connections controlled by the first switching means to energize the operating means of the first relay for closing the switch means thereof, second switching means, circuit connections controlled by the second switching means and the switch means of the first relay to energize the operating means of the second relay for closing the switch means thereof providing the switch means of the first relay is closed, whereupon opening of the switch means of the first relay opens the switch means of the second relay, third switching means, circuit connections controlled by the third switching means and the switch means of the first and second relays to energize the operating means of the third relay for closing the switch means thereof providing the switch means of the first and second relays are closed, whereupon opening of the switch means of the first or second relay opens the switch means of the third relay, means responsive to the pressure on the high pressure side of the refrigerating apparatus for operating one of the switching means, means responsive to a condition which is a measure of evaporator temperature for operating another of the switching means, means responsive to the temperature of the medium being controlled by the evaporator means for operating the other switching means, and a circuit controlled by the switch means of the third relay for operating the compressor only when the switch means of all of the relays are closed.

16. In a refrigeration system including a refrigerating apparatus having a compressor and evaporator means, the combination with said apparatus of, a first relay including operating means and switch means operated thereby, a second relay including operating means and switch means operated thereby, a third relay including operating means and switch means operated thereby, first switching means, circuit connections controlled by the first switching means to energize the operating means of the first relay for closing the switch means thereof, second switching means, circuit connections controlled by the second switching means and the switch means of the first relay to energize the operat-

ing means of the second relay for closing the switch means thereof providing the switch means of the first relay is closed, whereupon opening of the switch means of the first relay opens the switch means of the second relay, third switching means, circuit connections controlled by the third switching means and the switch means of the first and second relays to energize the operating means of the third relay for closing the switch means thereof providing the switch means of the first and second relays are closed, whereupon opening of the switch means of the first or second relay opens the switch means of the third relay, means responsive to the temperature of the medium being controlled by the evaporator means for operating the one of said switching means, means responsive to the pressure on the high pressure side of the refrigerating apparatus for operating another of the switching means, means responsive to a condition which is a measure of evaporator temperature for operating the remaining switching means, a circuit controlled by the switch means of the third relay for operating the compressor only when the switch means of all of the relays are closed, one of said switching means having a starting, a stopping and an intermediate position, and circuit connections controlled by said one of the switching means and the switching means of its relay to maintain energization of the operating means of such relay when the switching means moves from its starting to its intermediate position.

17. In a refrigeration system including a refrigerating apparatus having a compressor and evaporator means, the combination with said apparatus of, a first relay having operating means and switch means operated thereby, a second relay having operating means and switch means operated thereby, first switching means having a starting position, an intermediate position and an off position, second switching means having a starting position, an intermediate position, and an off position, circuit connections controlled by the first switching means to energize the operating means of the first relay to close the switch means of the first relay when the first switching means is moved to the starting position, circuit connections controlled by the switch means of the first relay in control of the operating means of the first relay to maintain the switch means of the first relay closed when the first switching means moves to its intermediate position and until it moves to its off position, circuit connections controlled by the second switching means and the switch means of the first relay to energize the operating means of the second relay to close the switch means of the second relay when the second switching means is moved to the starting position and the switch means of the first relay is closed, circuit connections controlled by the switch means of the first relay and the switch means of the second relay in control of the operating means of the second relay to maintain the switch means of the second relay closed when the second switching means moves to its intermediate position and until it moves to its off position, a circuit controlled by the switch means of the second relay for operating the compressor when the switch means of both relays are closed, means responsive to the pressure on the high pressure side of the refrigerating apparatus for moving one of the switching means to the starting position upon a decrease in pressure and to its intermediate position and then to the off position upon an increase in pressure, and means

responsive to a condition which is a measure of evaporator temperature to move the other switching means to the starting position upon an increase in evaporator temperature and to its intermediate position and then to the off position upon a decrease in evaporator temperature.

18. In a refrigeration system including a refrigerating apparatus having a compressor and evaporator means, the combination with said apparatus of, a first relay having operating means and switch means operated thereby, a second relay having operating means and switch means operated thereby, first switching means having a starting position, an intermediate position and an off position, second switching means having a starting position, an intermediate position and an off position, circuit connections controlled by the first switching means to energize the operating means of the first relay to close the switch means of the first relay when the first switching means is moved to the starting position, circuit connections controlled by the switch means of the first relay in control of the operating means of the first relay to maintain the switch means of the first relay closed when the first switching means moves to its intermediate position and until it moves to its off position, circuit connections controlled by the second switching means and the switch means of the first relay to energize the operating means of the second relay to close the switch means of the second relay when the second switching means is moved to the starting position and the switch means of the first relay is closed, circuit connections controlled by the switch means of the first relay and the switch means of the second relay in control of the operating means of the second relay to maintain the switch means of the second relay closed when the second switching means moves to its intermediate position and until it moves to its off position, a circuit controlled by the switch means of the second relay for operating the compressor when the switch means of both relays are closed, means responsive to the pressure on the high pressure side of the refrigerating apparatus for moving one of the switching means to the starting position upon a decrease in pressure and to its intermediate and then to the off position upon an increase in pressure, and means responsive to the temperature of the medium being controlled by the evaporator means to move the other switching means to the starting position upon an increase in temperature and to its intermediate and then to the off position upon a decrease in temperature.

19. In a refrigeration system including a refrigerating apparatus having a compressor and evaporator means, the combination with said apparatus of, a first relay having operating means and switch means operated thereby, a second relay having operating means and switch means operated thereby, first switching means having a starting position, an intermediate position and an off position, second switching means having a starting position, an intermediate position and an off position, circuit connections controlled by the first switching means to energize the operating means of the first relay to close the switch means of the first relay when the first switching means is moved to the starting position, circuit connections controlled by the switch means of the first relay in control of the operating means of the first relay to maintain the switch means of the first relay closed when the first switching means

moves to its intermediate position and until it moves to its off position, circuit connections controlled by the second switching means and the switch means of the first relay to energize the operating means of the second relay to close the switch means of the second relay when the second switching means is moved to the starting position and the switch means of the first relay is closed, circuit connections controlled by the switch means of the first relay and the switch means of the second relay in control of the operating means of the second relay to maintain the switch means of the second relay closed when the second switching means moves to its intermediate position and until it moves to its off position, a circuit controlled by the switch means

of the second relay for operating the compressor when the switch means of both relays are closed, means responsive to the temperature of the medium being controlled by the evaporator means to move one of the switching means to the starting position upon an increase in temperature and to its intermediate and then to the off position upon a decrease in temperature, and means responsive to a condition which is a measure of evaporator temperature to move the other switching means to the starting position upon an increase in evaporator temperature and to its intermediate and then to the off position upon a decrease in evaporator temperature.

ALWIN B. NEWTON.