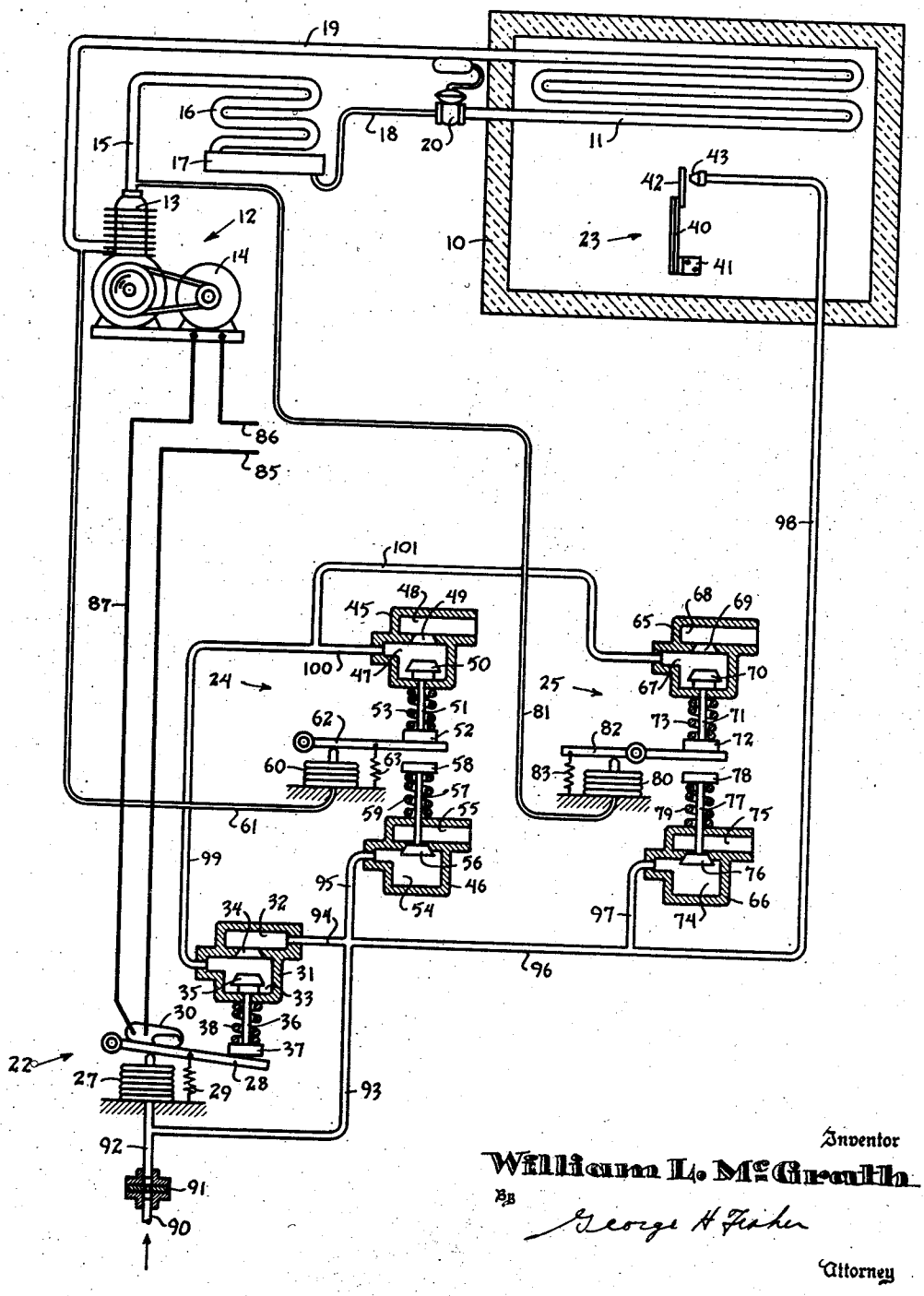
June 10, 1941. W. L. McGRATH 2,244,890

REFRIGERATION CONTROL SYSTEM

Filed Dec. 31, 1938




Inventor

William L. McGrath

By George H. Fisher

Attorney

Patented June 10, 1941

2,244,890

# UNITED STATES PATENT OFFICE

2,244,890

## REFRIGERATION CONTROL SYSTEM

William L. McGrath, St. Paul, Minn., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

Application December 31, 1938, Serial No. 248,681

24 Claims. (Cl. 62—4)

This invention relates to control systems in general and particularly to control systems for a refrigerating apparatus.

It is the prime object of this invention to provide a fluid operated control system for controlling an apparatus to cause operation of the apparatus only when a plurality of conditions have reached predetermined values and to stop operation of the apparatus when any of the conditions reach other predetermined values.

Another object of this invention is to provide a fluid operated control system for a refrigerating apparatus to cause operation of the compressor of the refrigerating apparatus only when the temperature being controlled increases to a predetermined high value, the suction pressure increases to a predetermined high value and the head pressure decreases to a predetermined low value and to continue the compressor in operation until either the temperature being controlled decreases to a predetermined low value or the suction pressure decreases to a predetermined low value or the head pressure increases to a predetermined high value.

Other objects of this invention reside in the particular manner in which the fluid operated control system carries out this sequence of operation.

The fluid supplied to the control system may be refrigerant of the refrigerating apparatus or may be air under pressure. For purposes of illustration the fluid is shown and described as air under pressure.

For a more thorough understanding of this invention reference is made to the accompanying drawing in which is diagrammatically illustrated the preferred form of this invention.

For purposes of illustration it is assumed that the refrigerating apparatus of this invention is utilized for cooling a fixture 10 which may be a room, walk-in box, storage compartment, soda fountain, or the like in which it is desired to maintain substantially constant temperatures. The fixture 10 is cooled by a cooling coil 11 preferably in the form of an evaporator. Refrigerant is supplied to and withdrawn from the evaporator 11 by means of a refrigerating apparatus generally designated at 12 which may comprise a compressor 13 operated by an electric motor 14. Compressed refrigerant flows from the compressor 13 through a high pressure line 15 into a condenser 16 and condensed refrigerant is collected in a receiver 17. Liquid refrigerant flows from the receiver 17 through a liquid line 18 into the evaporator 11 and evaporated refrigerant is withdrawn from the evaporator 11 through a suction line 19 by the compressor 13. The flow of refrigerant into the evaporator 11 may be regulated by an expansion valve 20 shown to be of the thermostatic type. Since the above construction is conventional in the art, a further description is not considered necessary it being sufficient to state that when the compressor 13 is placed in operation the evaporator 11 performs a cooling function.

The compressor motor 14 and hence the compressor 13 are controlled by a starter generally designated at 22 and this starter is in turn controlled by a temperature responsive controller generally designated at 23 responsive to the temperature within the fixture 10, a controller generally designated at 24 responsive to a condition indicative of evaporator temperature such as suction pressure and a pressure responsive controller generally designated at 25 responsive to the head pressure.

The starter 22 may comprise a bellows 27 for operating an arm 28 against the action of an adjustable tension spring 29. The arm 28 in turn operates a mercury switch 30, the arrangement being such that when the pressure in the bellows 27 increases to, say 10 lbs., the mercury switch 30 is tilted to a closed position and when the pressure decreases below this value the mercury switch 30 is tilted to the open position as shown in the drawing. Associated with the starter 22 is a valve casing 31 having an inlet chamber 32 and an outlet chamber 33 connected by a valve port 34. A valve 35 is adapted to open and close the port 34 and is connected by a valve stem 36 to an abutment 37 adjustably mounted on the valve stem 36. A spring 38 located between the abutment 37 and the valve casing 31 urges the valve 35 away from the port 34 to the position shown in the drawing. The abutment 37 and hence the valve 35 are operated by the arm 28, the arrangement being such that when the pressure within the bellows 27 rises to 10 lbs., the valve 35 closes the port 34 and when the pressure decreases below this value the valve 35 opens the port 34.

The temperature responsive controller 23 responsive to the temperature within the fixture 10 may comprise a thermostatic element 40 suitably mounted on a bracket 41 for operating a flapper 42 with respect to a nozzle 43. The parts are so arranged that when the temperature within the fixture rises to 42°, the flapper 42 closes off the nozzle 43 and when the temperature decreases to 40°, the flapper 42 opens the nozzle 43.

The controller 24 responsive to changes in suction pressure and hence responsive to changes in evaporator temperature may comprise two valve casings 45 and 46. The valve casing 45 is provided with an inlet chamber 47 and an outlet chamber 48 connected by a valve port 49. A valve 50 is adapted to open and close the port 49 and is connected by a valve stem 51 to an abutment 52 adjustably mounted on the valve stem 51. A spring 53 located between the casing 45 and the adjustable abutment 52 urges the valve 50 to a position for opening the valve port 49. The valve casing 46 may comprise an inlet chamber 54 and an outlet chamber 55 and a valve 56 controls communication between the chambers 54 and 55. The valve 56 is connected by a valve stem 57 to an adjustable abutment 58 and a spring 59 located between the abutment 58 and the valve casing 46 urges the valve 56 to a position to interrupt communication between the inlet chamber 54 and the outlet chamber 55. In other words, the valve 50 of the valve casing 45 is normally urged to an open position and the valve 56 of the valve casing 46 is normally urged to a closed position. A bellows 60 is connected by a pipe 61 to the suction line 19 of the refrigerating apparatus so that the bellows 60 is expanded and contracted in accordance with changes in suction pressure and hence changes in evaporator temperature. The bellows 60 operates an arm 62 against the action of an adjustable tension spring 63 and the arm 62 engages abutments 52 and 58 for opening and closing the valves 50 and 56. For purposes of illustration it is assumed that the valve 50 is closed when the suction pressure increases to 35 lbs. and that the valve 56 is opened when the suction pressure decreases to 10 lbs. It is also assumed that a suction pressure of 35 lbs. corresponds to a temperature condition within the evaporator 11 above freezing so that the valve 50 is closed only when the evaporator 11 is defrosted.

The head pressure responsive controller 25 may comprise two valve casings 65 and 66, the valve casing 65 being divided into an inlet chamber 67 and an outlet chamber 68 connected by a valve port 69 and the valve casing 66 being divided into an inlet chamber 74 and an outlet chamber 75 connected together by a valve port. A valve 70 opens and closes the valve port 69 and is connected by a valve stem 71 to an adjustable abutment 72. A spring 73 interposed between the abutment 72 and the valve casing 65 urges the valve 70 towards an open position. A valve 76 controls communication between the inlet chamber 74 and the outlet chamber 75 of the valve casing 66 and is connected by a valve stem 77 to an adjustable abutment 78. A spring 79 interposed between the abutment 78 and the valve casing 66 urges the valve 76 to a closed position. A bellows 80 is connected by a pipe 81 to the high pressure line 15 of the refrigerating apparatus so that the bellows 80 is expanded and contracted in accordance with changes in head pressure. The bellows 80 operates an arm 82 against the action of an adjustable tension spring 83. The arm 82 engages the adjustable abutments 72 and 78 for opening and closing the valves 70 and 76. For purposes of illustration it is assumed that the parts are so arranged that when the head pressure decreases to 140 lbs., the valve 70 is moved to a closed position and that when the head pressure increases to 190 lbs., the valve 76 is opened.

Power is supplied to the compressor motor 14 by line wires 85 and 86 leading from some source of power (not shown). When the pressure in the bellows 27 of the starter 22 increases to 10 lbs., to close the mercury switch 30, a circuit is completed from the line wire 85 through mercury switch 30, wire 87, and compressor motor 14 back to the other line wire 86 to cause operation of the compressor motor 14 and hence operation of the compressor 13.

Air under pressure is supplied to the pneumatic control system through a supply pipe 90 leading from some source of air pressure (not shown). An orifice 91 regulates the supply of air to the pneumatic control system. The orifice 91 is connected to the bellows 27 of the starter 22 by a pipe 92 and is also connected by pipes 93, 94, 95, 96, and 97 to the inlet chambers 32, 54, and 74 and by pipe 98 to the nozzle 43 of the temperature responsive controller 23. The outlet chamber 33 of the starter 22 is connected by pipes 99, 100, and 101 to the inlet chambers 47 and 67 of the suction pressure responsive controller 24 and the head pressure responsive controller 25.

Assume now that the temperature within the fixture is 40° whereupon the flapper 42 is disengaging the nozzle 43, that the suction pressure is below 35 lbs. whereupon the valve 50 is open and that the head pressure is above 140 lbs. whereupon the valve 70 is open. Under these conditions the bellows 27 is vented through pipes 93, 96, and 98 and nozzle 43 and through pipes 93, 94, inlet chamber 32, port 34, outlet chamber 33, pipes 99 and 100, inlet chamber 47, port 49, and outlet chamber 48 and through pipe 101, inlet chamber 67, port 69, and outlet chamber 68. Hence the bellows 27 is contracted and the mercury switch 30 is open so that the compressor motor 14 is not operating. In other words, three parallel vent passages are provided for the bellows 27 to prevent the compressor 13 from operating.

When the suction pressure increases to 35 lbs., the valve 50 is closed to obstruct one of the vent passages, when the head pressure decreases to 140 lbs., the valve 70 is closed to obstruct another vent passage and when the temperature within the fixture 10 increases to 42°, the flapper 42 engages the nozzle 43 to obstruct the other vent passage. When all three vent passages are obstructed in the manner pointed out above the pressure within the bellows 27 rises to 10 lbs., to close the mercury switch 30 to cause operation of the compressor 13 and to close the valve 35 to obstruct two of the vent passages as long as the compressor remains in operation. Accordingly after the compressor has been placed in operation in the manner specified above it will remain in operation even though the suction pressure decreases below 35 lbs. or the head pressure increases above 140 lbs.

If now the temperature of the fixture 10 decreases to 40° to move the flapper 42 away from the nozzle 43 the bellows 27 is vented and therefore the pressure therein decreases below 10 lbs. to open the switch 30 and open the valve 35. Opening of the switch 30 stops operation of the compressor and opening of the valve 35 necessitates an increase in suction pressure to 35 lbs. and a decrease in head pressure to 140 lbs. before the refrigerating apparatus may again be placed in operation.

Assume now that the refrigerating apparatus is in operation and that the suction pressure decreases to 10 lbs., under these conditions bellows 27 is vented through pipes 93 and 95, inlet chamber 54, valve 56, and outlet chamber 55

to stop the compressor motor 14 and to open the valve 35. Accordingly, the refrigerating apparatus is stopped and cannot be restarted until the suction pressure again increases to 35 lbs. and the head pressure decreases to 140 lbs.

If during the operation of the compressor the head pressure should increase to 190 lbs., the valve 76 of the head pressure responsive controller is opened to vent the bellows 27 through the pipes 93, 96, and 97, inlet chamber 74, valve 76 and outlet chamber 75. The compressor is thereupon stopped and cannot again be restarted until the suction pressure increases to 35 lbs. and the head pressure decreases to 140 lbs.

By reason of the above control arrangement the compressor motor 14 and hence the compressor 13 can be placed in operation only when the suction pressure increases to 35 lbs., the head pressure increases to 142 lbs. and the fixture temperature increases to 42° and is maintained in operation until either the suction pressure decreases to 10 lbs., or the head pressure increases to 190 lbs., or the fixture temperature decreases to 40°. With such a control arrangement desired temperature conditions are maintained at all times within the fixture 10, defrosting of the refrigerating apparatus during each cycle of operation is at all times afforded and low and high pressure protection is additionally provided. Since the compressor cannot be started until the head pressure decreases to 142 lbs. the starting torque on the compressor motor 14 is at all times maintained at a minimum.

While the control system has been disclosed as applied to a refrigerating apparatus it is obvious that this control system could be applied to other types of apparatus and such an application of this control system is also contemplated in this invention. While for purposes of illustration certain pressure and temperature values have been utilized it is obvious that other values could be utilized within the scope of this invention. If refrigerant of the refrigating apparatus be utilized as the controlling fluid instead of air, the outlet chambers of the various valves and the fluid exhausted from the nozzle 43 would be connected into the suction line 19.

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 the accompanying disclosure and therefore this invention is to be limited only by the scope of the appended caims and prior art.

I claim as my invention:

1. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means for operating the control means, a source of fluid under pressure, first and second valve means for controlling the supply of fluid from the source to the pressure operated means, means responsive to a temperature condition produced by the evaporator means for controlling the first valve means to operate the compressor upon a call for cooling, and means responsive to suction pressure for operating the second valve means to prevent starting of the compressor until the suction pressure increases to a defrosting value.

2. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means for operating the control means, a source of fluid under pressure, first and second valve means for controlling the supply of fluid from the source to the pressure operated means, means responsive to a temperature condition produced by the evaporator means for controlling the first valve means to operate the compressor upon a call for cooling, and means responsive to suction pressure for operating the second valve means to prevent starting of the compressor until the suction pressure increases to a defrosting value and for stopping the compressor when the suction pressure decreases to a predetermined low value.

3. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means for operating the control means, a source of fluid under pressure, first and second valve means for controlling the supply of fluid from the source to the pressure operated means, means responsive to a temperature condition produced by the evaporator means for controlling the first valve means to operate the compressor upon a call for cooling, and means responsive to head pressure for operating the second valve means to prevent starting of the compressor until the head pressure decreases to a predetermined low value.

4. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means for operating the control means, a source of fluid under pressure, first and second valve means for controlling the supply of fluid from the source to the pressure operated means, means responsive to a temperature condition produced by the evaporator means for controlling the first valve means to operate the compressor upon a call for cooling, and means responsive to head pressure for operating the second valve means to prevent starting of the compressor until the head pressure decreases to a predetermined low value and for stopping the compressor when the head pressure increases to a predetermined high value.

5. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means for operating the control means, a source of fluid under pressure, first and second valve means for controlling the supply of fluid from the source to the pressure operated means, means responsive to suction pressure and means responsive to head pressure for operating the first and second valve means respectively to start the compressor only when the head pressure decreases to a predetermined low value and the suction pressure increases to a predetermined high value and to stop the compressor when either the head pressure increases to a predetermined high value or the suction pressure decreases to a predetermined low value.

6. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure oper-

ated means for operating the control means, a source of fluid under pressure, first, second and third valve means for controlling the supply of fluid from the source to the pressure operated means, means responsive to a temperature condition produced by the evaporator means for controlling the first valve means to operate the compressor upon a call for cooling, means responsive to suction pressure for operating the second valve means to prevent starting of the compressor until the suction pressure increases to a defrosting value, and means responsive to head pressure for operating the third valve means to stop operation of the compressor when the head pressure increases to a predetermined high value.

7. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means for operating the control means, a source of fluid under pressure, first, second and third valve means for controlling the supply of fluid from the source to the pressure operated means, means responsive to a temperature condition produced by the evaporator means for controlling the first valve means to operate the compressor upon a call for cooling, means responsive to suction pressure for operating the second valve means to prevent starting of the compressor until the suction pressure increases to a defrosting value and to stop operation of the compressor when the suction pressure decreases to a predetermined low value, and means responsive to head pressure for operating the third valve means to stop operation of the compressor when the head pressure increases to a predetermined high value.

8. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means for operating the control means, a source of fluid under pressure, first, second and third valve means for controlling the supply of fluid from the source to the pressure operated means, means responsive to a temperature condition produced by the evaporator means for controlling the first valve means to operate the compressor upon a call for cooling, means responsive to suction pressure for operating the second valve means to prevent starting of the compressor until the suction pressure increases to a defrosting value, and means responsive to head pressure for operating the third valve means to prevent starting of the ccmpressor until the head pressure decreases to a predetermined low value and to stop operation of the compressor when the head pressure increases to a predetermined high value.

9. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means for operating the control means, a source of fluid under pressure, first, second and third valve means for controlling the supply of fluid from the source to the pressure operated means, means responsive to a temperature condition produced by the evaporator means for controlling the first valve means to operate the compressor upon a call for cooling, means responsive to suction pressure for operating the second valve means to prevent starting of the compressor until the suction pressure increases to a defrosting value and to stop operation of the compressor when the suction pressure decreases to a predetermined low value, and means responsive to head pressure for operating the third valve means to prevent starting of the compressor until the head pressure decreases to a predetermined low value and to stop operation of the compressor when the head pressure increases to a predetermined high value.

10. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means having expanded and contracted positions for operating the control means, means for supplying fluid under pressure to the pressure operated means to cause the control means to move to a first position to cause operation of the compressor, first and second vent passages for venting fluid from the pressure operated means to cause the control means to move to a second position to stop operation of the compressor, valve means operated upon an increase in temperature being produced by the evaporator means for closing the first vent passage, valve means operated upon an increase in suction pressure for closing the second vent passage when the suction pressure increases to a defrosting value whereby the compressor is started upon a call for cooling only when the evaporator means is defrosted, and valve means operated upon operation of the compressor for closing the second vent passage to maintain the compressor in operation until the call for cooling is satisfied.

11. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means having expanded and contracted positions for operating the control means, means for supplying fluid under pressure to the pressure operated means to cause the control means to move to a first position to cause operation of the compressor, first and second vent passages for venting fluid from the pressure operated means to cause the control means to move to a second position to stop operation of the compressor, valve means operated upon an increase in temperature being produced by the evaporator means for closing the first vent passage, valve means operated upon an increase in suction pressure for closing the second vent passage when the suction pressure increases to a defrosting value whereby the compressor is started upon a call for cooling only when the evaporator means is defrosted, valve means operated upon operation of the compressor for closing the second vent passage to maintain the compressor in operation until the call for cooling is satisfied, a third vent passage for venting fluid from the pressure operated means, and valve means operated upon a decrease in suction pressure to a predetermined low value for opening the third vent passage to stop operation of the compressor.

12. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means having expanded and contracted positions for operating the control means, means for sup-

plying fluid under pressure to the pressure operated means to cause the control means to move to a first position to cause operation of the compressor, first and second vent passages for venting fluid from the pressure operated means to cause the control means to move to a second position to stop operation of the compressor, valve means operated upon an increase in temperature being produced by the evaporator means for closing the first vent passage, valve means operated upon a decrease in head pressure to a predetermined low value for closing the second vent passage whereby the compressor is started upon a call for cooling only when the head pressure decreases to the predetermined low value, and valve means operated upon operation of the compressor for closing the second vent passage to maintain the compressor in operation until the call for cooling is satisfied.

13. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means having expanded and contracted positions for operating the control means, means for supplying fluid under pressure to the pressure operated means to cause the control means to move to a first position to cause operation of the compressor, first and second vent passages for venting fluid from the pressure operated means to cause the control means to move to a second position to stop operation of the compressor, valve means operated upon an increase in temperature being produced by the evaporator means for closing the first vent passage, valve means operated upon a decrease in head pressure to a predetermined low value for closing the second vent passage whereby the compressor is started upon a call for cooling only when the head pressure decreases to the predetermined low value, valve means operated upon operation of the compressor for closing the second vent passage to maintain the compressor in operation until the call for cooling is satisfied, a third vent passage for venting fluid from the pressure operated means, and valve means operated upon an increase in head pressure to a predetermined high value for opening the third vent passage to stop operation of the compressor.

14. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means having expanded and contracted positions for operating the control means, means for supplying fluid under pressure to the pressure operated means to cause the control means to move to a first position to cause operation of the compressor, first, second and third vent passages for venting fluid from the pressure operated means to cause the control means to move to a second position for stopping operation of the compressor, valve means operated upon an increase in temperature being produced by the evaporator means for closing the first vent passage, valve means operated upon an increase in suction pressure to a predetermined high value for closing the second vent passage, valve means operated upon a decrease in head pressure to a predetermined low value for closing the third vent passage whereby the compressor is started upon a call for cooling only when the suction pressure increases to the predetermined high value and the head pressure decreases to the predetermined low value, and valve means operated upon operation of the compressor for closing the second and third vent passages to maintain the compressor in operation until the call for cooling is satisfied.

15. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for controlling the operation of the compressor, pressure operated means having expanded and contracted positions for operating the control means, means for supplying fluid under pressure to the pressure operated means to cause the control means to move to a first position to cause operation of the compressor, first, second and third vent passages for venting fluid from the pressure operated means to cause the control means to move to a second position for stopping operation of the compressor, valve means operated upon an increase in temperature being produced by the evaporator means for closing the first vent passage, valve means operated upon an increase in suction pressure to a predetermined high value for closing the second vent passage, valve means operated upon a decrease in head pressure to a predetermined low value for closing the third vent passage whereby the compressor is started upon a call for cooling only when the suction pressure increases to the predetermined high value and the head pressure decreases to the predetermined low value, valve means operated upon operation of the compressor for closing the second and third vent passages to maintain the compressor in operation until the call for cooling is satisfied, a fourth vent passage for venting fluid from the pressure operated means, valve means operated upon a decrease in suction pressure to a predetermined low value for opening the fourth vent passage to stop operation of the compressor, a fifth vent passage for venting fluid from the pressure operated means, and valve means operated upon an increase in head pressure to a predetermined high value for opening the fifth vent passage to stop operation of the compressor.

16. In a pneumatic control system, the combination of, a control device movable to first and second positions, pressure operated means having expanded and contracted positions for moving the control device, means for supplying air under pressure to the pressure operated means to cause the control device to move to the first position, first and second vent passages for venting air from the pressure operated means to cause the control device to move to the second position, normally closed valve means in the first vent passage, normally opened valve means in the second vent passage, means for closing the normally opened valve means to cause the control device to move to the first position, valve means in the second vent passage movable to a closed position upon movement of the control device to the first position to maintain the control device in the first position even though the normally opened valve means is subsequently opened, and means for opening the normally closed valve means to cause the control device to move to the second position.

17. In a pneumatic control system, the combination of, a control device movable to first and second positions, pressure operated means having expanded and contracted positions for moving the control device, means for supplying air under pressure to the pressure operated

means to cause the control device to move to the first position, first and second vent passages for venting air from the pressure operated means to cause the control device to move to the second position, first valve means for closing and opening the first vent passage and second valve means for closing and opening the second vent passage whereby the control device is moved to the first position only when both valve means close their respective vent passages, and third valve means for closing the second vent passage upon movement of the control device to the first position to maintain the control device in the first position regardless of the position of the second valve means until the first valve means opens the first vent passage.

18. In a pneumatic control system, the combination of, a control device movable to first and second positions, pressure operated means having expanded and contracted positions for moving the control device, means for supplying air under pressure to the pressure operated means to cause the control device to move to the first position, first and second vent passages for venting air from the pressure operated means to cause the control device to move to the second position, first valve means for closing and opening the first vent passage and second valve means for closing and opening the second vent passage whereby the control device is moved to the first position only when both valve means close their respective vent passages, third valve means for closing the second vent passage upon movement of the control device to the first position to maintain the control device in the first position regardless of the position of the second valve means until the first valve means opens the first vent passage, a third vent passage for venting air from the pressure operated means, and fourth valve means for opening the third vent passage to cause the control device to move to the second position regardless of the positions of the other valve means.

19. In a pneumatic control system, the combination of, a control device movable to first and second positions, pressure operated means having expanded and contracted positions for moving the control device, means for supplying air under pressure to the pressure operated means to cause the control device to move to the first position, first, second and third vent passages for venting air from the pressure operated means to cause the control device to move to the second position, first valve means for closing and opening the first vent passage, second valve means for closing and opening the second vent passage and third valve means for closing and opening the third vent passage whereby the control device is moved to the first position only when the first, second and third valve means close their respective vent passages, and fourth valve means for closing the second and third vent passages upon movement of the control device to the first position to maintain the control device in the first position regardless of the positions of the second and third valve means until the first valve means opens the first vent passage.

20. In a pneumatic control system, the combination of, a control device movable to first and second positions, pressure operated means having expanded and contracted positions for moving the control device, means for supplying air under pressure to the pressure operated means to cause the control device to move to the first position, first, second, third and fourth vent passages for venting air from the pressure operated means to cause the control device to move to the second position, first normally closed valve means in the first vent passage, second normally closed valve means in the second vent passage, third normally opened valve means in the third vent passage, fourth normally opened valve means in the fourth vent passage, means for closing the third and fourth normally opened valve means to cause the control device to move to the first position, valve means in the third and fourth vent passages movable to a closed position upon movement of the control device to the first position to maintain the control device in the first position even though the third or fourth normally opened valve means are subsequently opened, and means for opening either or both of the first and second normally closed valve means to cause the control device to move to the second position.

21. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for the compressor having compressor starting and stopping positions, pressure operated means for operating said control means to its two controlling positions dependent upon the amount of pressure to which said pressure operated means is subjected, a source of pressure for said pressure operated means, a first valve in control of the amount of pressure in said pressure operated means, means responsive to the temperature produced by said evaporator means operating said first valve to a position to change the pressure in said pressure operated means in a manner to move the control means to starting position when said temperature is high, a second valve, means responsive to the suction pressure in the system operating said second valve to permit such change in pressure in the pressure operated means by said first valve only when the suction pressure has risen to a predetermined value, and a third valve operated upon operation of the compressor to a position cooperating with said first valve to maintain said changed pressure in the pressure operated means irrespective of the position of said second valve so long as said temperature is high.

22. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for the compressor having compressor starting and stopping positions, pressure operated means for operating said control means to its two controlling positions dependent upon the amount of pressure to which said pressure operated means is subjected, a source of pressure for said pressure operated means, a first valve in control of the amount of pressure in said pressure operated means, means responsive to the temperature produced by said evaporator means operating said first valve to a position to change the pressure in said pressure operated means in a manner to move the control means to starting position when said temperature is high, a second valve, means responsive to the suction pressure in the system operating said second valve to permit such change in pressure in the pressure operated means by said first valve only when the suction pressure has risen to a predetermined value, a third valve operated upon operation of the compressor to a position cooperating with said first valve to maintain said changed pressure in the pressure operated means

irrespective of the position of said second valve so long as said temperature is high, and a fourth valve responsive to suction pressure in control of the pressure in said pressure operated means and operative to change said pressure in a manner to move said control means to stopping position of the compressor when the suction pressure is relatively low.

23. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for the compressor having compressor starting and stopping positions, pressure operated means for operating said control means to its two controlling positions dependent upon the amount of pressure to which said pressure operated means is subjected, a source of pressure for said pressure operated means, a first valve in control of the amount of pressure in said pressure operated means, means responsive to the temperature produced by said evaporator means operating said first valve to a position to change the pressure in said pressure operated means in a manner to move the control means to starting position when said temperature is high, a second valve, means responsive to the suction pressure in the system operating said second valve to permit such change in pressure in the pressure operated means by said first valve only when the suction pressure has risen to a predetermined value, a third valve operated upon operation of the compressor to a position cooperating with said first valve to maintain said changed pressure in the pressure operated means irrespective of the position of said second valve so long as said temperature is high, and a fourth valve responsive to discharge pressure of the compressor in control of the pressure in said pressure operated means and operative to change the pressure therein in a manner to move said control means to stopping position of the compressor when the discharge pressure is relatively high.

24. In a control system for a refrigerating apparatus having a compressor and evaporator means for performing a cooling function, the combination of, control means for the compressor having compressor starting and stopping positions, pressure operated means for operating said control means to its two controlling positions dependent upon the amount of pressure to which said pressure operated means is subjected, a source of pressure for said pressure operated means, a first valve in control of the amount of pressure in said pressure operated means, means responsive to the temperature produced by said evaporator means operating said first valve to a position to change the pressure in said pressure operated means in a manner to move the control means to starting position when said temperature is high, a second valve, means responsive to the suction pressure in the system operating said second valve to permit such change in pressure in the pressure operated means by said first valve only when the suction pressure has risen to a predetermined value, a third valve operated upon operation of the compressor to a position cooperating with said first valve to maintain said changed pressure in the pressure operated means irrespective of the position of said second valve so long as said temperature is high, a fourth valve responsive to suction pressure in control of the pressure in said pressure operated means and operative to change said pressure in a manner to move said control means to stopping position of the compressor when the suction pressure is relatively low, and a fifth valve responsive to discharge pressure of the compressor in control of the pressure in said pressure operated means and operative to change the pressure therein in a manner to move said control means to stopping position of the compressor when the discharge pressure is relatively high.

WILLIAM L. McGRATH.