

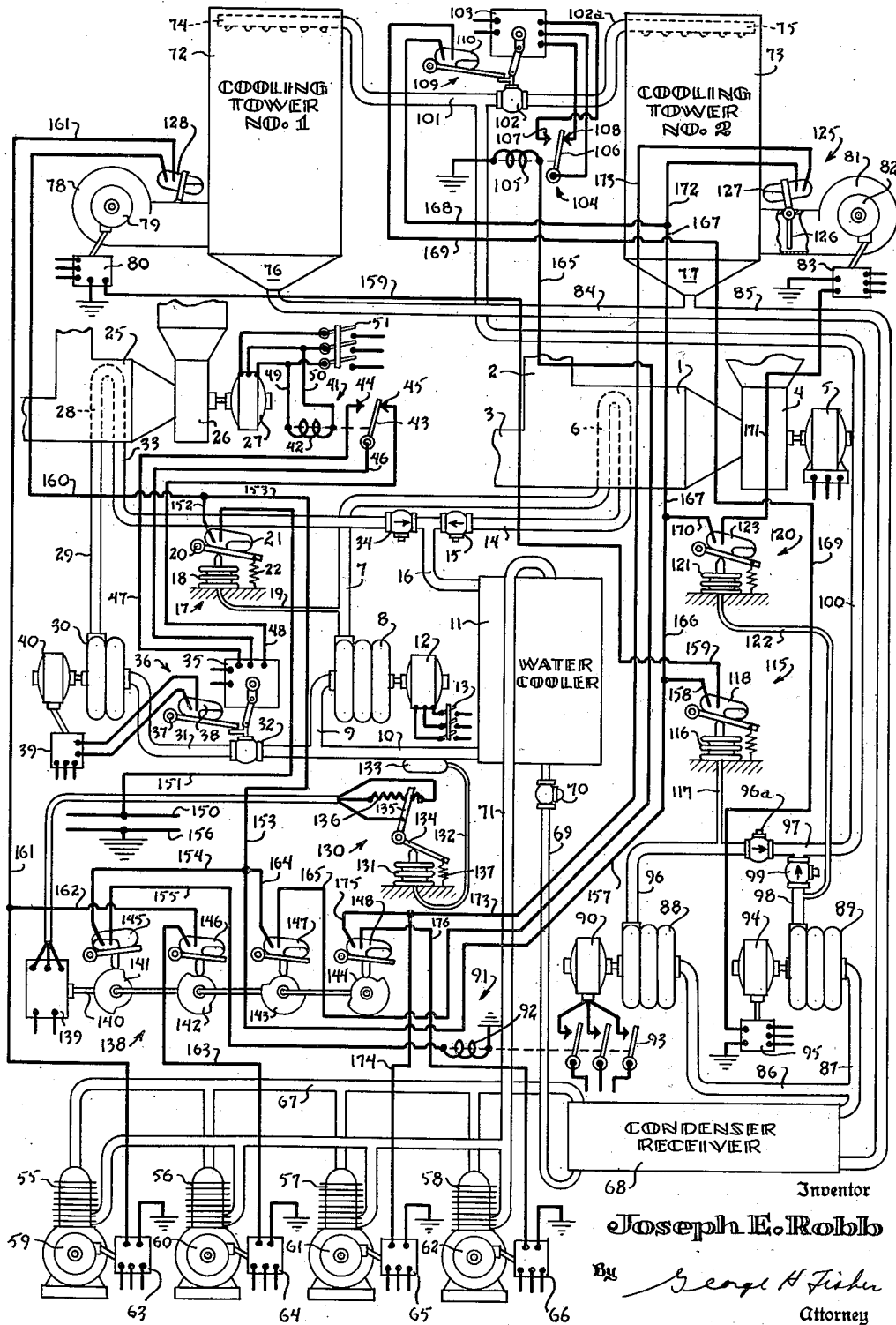
Nov. 26, 1940.

J. E. ROBB

2,222,989

REFRIGERATION CONTROL SYSTEM

Filed April 30, 1938



UNITED STATES PATENT OFFICE

2,222,989

REFRIGERATION CONTROL SYSTEM

Joseph E. Robb, Overland Park, Kans., assignor
to Minneapolis-Honeywell Regulator Company,
Minneapolis, Minn., a corporation of Dela-
ware

Application April 30, 1938, Serial No. 205,290

17 Claims. (Cl. 62—3)

This invention relates to refrigeration systems and is more particularly concerned with automatic controls therefor.

In refrigeration systems for providing refrigeration for air conditioning large buildings, it has been common to locate the heavy machinery such as compressors, pumps, and condensers in the basement of the building while locating the cooling towers on the roof of the building. In large systems it has also been customary to utilize a number of compressors and to vary the number of compressors in operation in accordance with the load. It has also been customary to utilize a plurality of cooling towers and to vary the number of cooling towers in operation in accordance with the load on the system. Heretofore where a plurality of cooling towers have been employed, it has been necessary to provide separate cooling tower pumps and conduits leading from the condenser to each cooling tower, in order to provide for independent operation of the cooling towers. The conduits between the cooling tower pumps and the cooling towers must necessarily be of relatively large diameter and must extend the entire height of the building. These long runs of large size pipes are quite expensive. It is an object of my invention to reduce the cost of installations utilizing a plurality of cooling towers by providing an arrangement by which the cooling towers may be served by a single supply conduit while at the same time providing for independent operation of the cooling towers.

It is a further object of my invention to provide a suitable control system for refrigeration systems which automatically varies the number of compressors and the number of cooling towers in operation in accordance with the load on the refrigeration system.

It is a further object of this invention to provide a control system for refrigeration systems which automatically places the cooling tower pump, the cooling tower fan, and compressor into operation and which prevents the compressor from operating unless both the cooling tower pump and fan are operating.

Still another object of this invention is to provide an automatic control system which acts to check the operation of the various pumps and fans and which prevents operation of a compressor in the event that the remainder of the refrigeration system is not operating properly.

A still further object of this invention is the provision of a control system of this type which not only checks the operation of the various

pumps and fans, but which also places these instrumentalities into operation in sequence to thereby avoid overloading of the power supply due to simultaneous starting of a plurality of motors.

Other objects consist of various combinations and subcombinations of control apparatus and will become apparent from the following description and the appended claims.

For a full disclosure of my invention, reference is made to the following detailed description and to the accompanying drawing, the single figure of which illustrates diagrammatically a refrigeration control system embodying the features of my invention.

Referring to the drawing, reference character 1 indicates an air conditioning chamber which may be provided with an inlet or return duct 2 which leads from a space to be conditioned, and a fresh air duct 3. The outlet of this chamber may be connected to a fan 4 which discharges the air through a suitable discharge duct to the space being conditioned. The fan 4 may be driven by means of a motor 5. Located within the condition chamber is a cooling coil 6 which may be connected by a pipe 7 to the discharge of a pump 8. The inlet of this pump 8 may be connected by pipes 9 and 10 to a water cooler 11. The pump 8 may be driven by means of an electric motor 12 under the control of a manual switch 13. The water cooler 11 may be an indirect heat exchanger for passing the water to be cooled into heat exchange relationship with evaporating refrigerant for thereby cooling the water. When the switch 13 is closed for placing the pump 8 into operation, water will be withdrawn from the water cooler 11 through pipe 10 and discharged through the pipe 7 to the cooling coil 6, this water then flowing through an outlet pipe 14 and check valve 15 to a pipe 16 which leads to the inlet of the water cooler 11. The pump 8 therefore acts to circulate water between the cooling coil 6 and the water cooler 11.

Attached to the discharge pipe 7 of the pump 8 is a pressure responsive device generally indicated at 17. This pressure controller may consist of a bellows 18 which is connected by a tube 19 to the pipe 7. The bellows 18 may actuate a pivoted mercury switch carrier 20 carrying a mercury switch 21. The bellows 18 may be loaded by means of a spring 22 for causing the bellows to collapse thereby tilting the mercury switch to open position as shown when the pressure in pipe 7 is at a value indicating that the pump 8 is not

in operation. When the pump 8 is started, however, the pressure in pipe 7 will increase thereby causing expansion of the bellows 18 against the action of spring 22 for tilting the mercury switch 21 to closed position. The purpose of the pressure responsive device 17 will become apparent as this description proceeds.

Reference character 25 indicates a second conditioning chamber which may be utilized for conditioning the air of another or auxiliary space. This conditioning chamber is shown as being connected to a fan 26 which is driven by means of a fan motor 27. Within the conditioning chamber 25 is a cooling coil 28, the inlet of this cooling coil being connected by pipe 29 to a circulating pump 30. The inlet of circulating pump 30 is connected by a pipe 31 to a valve 32, this valve being in turn connected to the pipe 10 which leads from the outlet of the water cooler 11. The outlet of the cooling coil 28 is connected by a pipe 33 through a check valve 34 to the pipe 16 leading to the inlet of the water cooler 11. Thus when the valve 32 is opened and the pump 30 is in operation the pump 30 will circulate water from the outlet of the water cooler through the cooling coil 28 back to the water cooler. The valve 32 may be actuated by means of a valve motor 35. This valve motor 35 may be of any suitable type and is herein shown as comprising a 180° movement type for either opening the valve 32 wide or closing this valve. This motor in addition to actuating the valve 32 may also actuate an auxiliary switch 36, this switch being indicated diagrammatically as comprising a pivoted switch carrier 37 actuated by the valve stem of valve 32. This switch carrier carries a mercury switch 38 which controls the starting box 39 for the motor 40 which drives the pump 30. When the valve 32 is closed, the mercury switch 38 is tilted to open position for causing the starting box 39 to place the pump motor 40 out of operation. When the motor 35 operates to open the valve 32, however, the switch 38 will be tilted to closed position for thereby causing the starting box 39 to place the pump motor 40 into operation. The valve motor 35 utilizes a three-wire control circuit and is controlled by means of a relay 41 which may consist of a relay coil 42 which actuates through a suitable armature (not shown), a switch arm 43 which cooperates with contacts 44 and 45. The switch arm 43 is connected by a wire 46 to the common motor control terminal while the contacts 44 and 45 are connected to the other two motor control terminals by wires 47 and 48. When the switch arm 43 engages contact 45 the motor 48 will assume a position for closing the valve 32 as shown. When the switch arm 43 engages contact 44 however, the motor will run to a position for opening the valve 32. The relay coil 42 is connected by wires 49 and 50 across one phase of the power circuit for the fan motor 27. Thus when the fan motor 27 is energized by closing the switch 51, the relay coil 42 will be energized which will cause the switch arm 43 to engage contact 44 thereby causing the valve motor 35 to open the valve, and to close mercury switch 38 for placing the pump motor 40 into operation. When the motor 27 is deenergized however as by opening the switch 51, the switch arm 43 of relay 41 will engage contact 45 thus causing the valve motor 35 to close the valve 32 and to open mercury switch 38 for placing the pump motor 40 out of operation. The auxiliary air conditioner may therefore be readily placed into or out of opera-

tion simply by actuating the switch 51 in the fan motor circuit.

Referring to the refrigerant circuit for the water cooler, reference characters 55, 56, 57, and 58 indicate refrigerant compressors which may be driven by electric motors 59, 60, 61, and 62, respectively, these motors in turn being provided with starting boxes 63, 64, 65, and 66. The discharge of each compressor is connected to a high pressure header 67 which in turn is connected to the refrigerant inlet of a condenser-receiver 68. It will be understood that the compressed refrigerant will be condensed in the condenser-receiver, the thereby liquified refrigerant passing through a liquid line 69 and expansion valve 70 into the water cooler 11 wherein it evaporates for cooling the water passing through the water cooler. The evaporated refrigerant leaves the water cooler through a suction line 71 which is connected to the inlets of the compressors 55, 56, 57, and 58, as shown.

In order to provide a source of cooled water for condensing the refrigerant in the condenser-receiver 68, a pair of cooling towers 72 and 73 are provided. These cooling towers may be of any desired type and are diagrammatically illustrated as being provided with spray pipes 74 and 75 and with sumps 76 and 77. The cooling tower 72 is provided with a fan 78 which may be driven by an electric motor 79 under the control of a starting box 80. The cooling tower 73 may be provided with a similar fan 81 driven by an electric motor 82 under the control of a starting box 83. The sumps 76 and 77 of the cooling towers are connected by pipes 84 and 85 to the cooling water inlet of the condenser-receiver 68 for thereby delivering cooled water to this condenser-receiver.

The cooling water outlet of the condenser-receiver is connected by pipes 86 and 87 to cooling tower pumps 88 and 89, respectively. The pump 88 may be driven by means of an electric motor 90 controlled by a starting box or relay 91. This starting box is indicated as comprising a starter coil 92 which actuates through a suitable armature, the switch arms 93 which are interposed in the three-phase power supply line for the motor 90. When the coil 92 is energized, the switch arms 93 will be brought into engagement with their respective contacts for completing the power circuit to the motor 90 for placing the pump 88 into operation. When the coil 92 is deenergized however, the switch arms 93 will disengage their contacts for interrupting the power circuit to the motor 90. The pump 89 may be driven by an electric motor 94 which is controlled by a starting box 95 which may be similar to the starting box 91 for motor 90.

The discharge of the pump 88 may be connected by a pipe 96 and check valve 96a to a header 97, and the discharge of the pump 89 may be connected by pipe 98 and check valve 99 to this header. The header 97 in turn is connected by a pipe 100 which leads upwardly through the building to the cooling towers 72 and 73 which may be located on the roof of the building. The pipe 100 is shown as being connected by pipe 101 to the spray pipe 74 of the cooling tower 72. This pipe 100 is also connected through a valve 102 and the pipe 102a to the spray pipe 75 of the cooling tower 73. The valve 102 is actuated by means of a two-position type of valve motor 103. This valve motor may be similar to the valve motor 35 and may be controlled by means of a relay 104. This relay may consist of a relay coil

105 which actuates through a suitable armature, a switch arm 106 cooperating with contacts 107 and 108. When the relay coil 105 is deenergized, the switch arm 106 will engage the contact 108 as shown and this will cause the valve motor 103 to close the valve 102. When the relay coil 105 is energized, the switch arm 106 will engage contact 107 which will cause the valve motor 103 to open the valve 102. The valve motor also actuates an auxiliary switch 109 shown as consisting of a mercury switch 110, this switch is arranged to be open whenever the valve 102 is closed, while being closed whenever the valve 102 is open. The purpose of auxiliary switch 109 will become apparent as this description proceeds.

Reference character 115 indicates a pressure responsive device which is responsive to the pressure in pipe 96. This control may be similar to the pressure controller 17 and includes a bellows 116 connected by pipe 117 to the pipe 96. This bellows actuates a mercury switch 118. This instrument may be so designed and adjusted that the bellows 116 collapses sufficiently to tilt switch 118 to open position when the pressure in pipe 96 is so low as to indicate that pump 88 is not in operation. When the pump 88 is in operation, the resulting increase in pressure in pipe 96 will cause the bellows 116 to expand for tilting the mercury switch 118 to closed position.

Reference character 120 indicates a pressure responsive device for checking the operation of the pump 89 and may be exactly the same as the controller 115. This controller is shown as comprising a bellows 121 connected by a tube 122 to the discharge pipe 98 of pump 89. When the pump 89 is not in operation the mercury switch 123 of the controller 120 will be opened, while when the pump 89 is in operation, this mercury switch will be tilted to closed position.

Reference character 125 indicates a sail switch which responds to the action of the cooling tower fan 81. This sail switch may be of any desired type and is diagrammatically illustrated as comprising a pivoted vane 126 is located in the discharge of the fan 81. This vane actuates a mercury switch 127. When the fan 81 is not in operation the vane 126 will assume the position shown in which the mercury switch 127 is tilted to open position. However, when the fan 81 is in operation, the vane 126 will swing in a clockwise direction due to the impact of the moving air, this tilting the mercury switch 127 to closed position. The cooling tower fan 78 is provided with a similar sail switch including a mercury switch 128 which opens when the fan 78 is not in operation but which closes when this fan is placed into operation.

Reference character 130 indicates a potentiometer type of thermostat. This thermostat is shown as comprising a bellows 131 which is connected by a capillary tube 132 to a control bulb 133 which is located upon the pipe 10 leading from the water cooler. The bulb 133, tube 132, and bellows 131 are charged with a suitable volatile fill for causing the pressure within bellows 131 to vary with changes in temperature of the water passing through pipe 10. The bellows 131 may actuate a bell crank lever having an actuating arm 135 and a control arm or slider 135 which cooperates with a control resistance 136 to form a potentiometer controller. As the temperature of the cold water passing to the cooling coils 6 or 28 decreases, the pressure within bellows 131 will decrease, this causing the control arm or slider 135 to travel to the right across control resistance

136 under the action of a spring 137. As the water temperature increases, however, the bellows 131 will expand for causing movement of the slider 135 in the opposite direction.

The thermostat 130 controls a step controller generally indicated as 138. This step controller includes a proportioning motor 139 which may be of the type shown and described in Patent 2,028,110 issued to Daniel G. Taylor on January 14, 1936. This type of motor is provided with an operating shaft 140 and is adapted to position this operating shaft under the control of a potentiometer type of controller, and provides a definite angular position of its operating shaft for each position of the slider 135 on the control resistance 136. The operating shaft 140 may actuate a series of cams 141, 142, 143, and 144 which in turn actuate a series of mercury switches 145, 146, 147, and 148. It will be noted that the cams are mounted upon the shaft 140 in a manner to provide for sequential actuation of the mercury switches 145, 146, 147 and 148 in the order named. When the temperature of the cooling water is relatively low, the slider 135 will engage the extreme right-hand end of resistance 136, this causing the motor to assume its extreme counterclockwise limit of rotation wherein the mercury switches 145, 146, 147, and 148 are opened. As the temperature of the cooled water increases, the slider 135 will move to the left on resistance 136, this causing the proportioning motor 139 to rotate its shaft in a clockwise direction. At first the mercury switch 145 will be closed. Upon further increase in temperature, the mercury switch 146 will be closed, and upon still further temperature increase the switches 147 and 148 will be sequentially closed.

Operation

With the parts in the positions shown, the pump motor 12 for the cold water circulating pump 8 is out of operation as indicated by the switch 13 being open. Also the cold water temperature is relatively low as indicated by the slider 135 being positioned upon resistance 136 at a point near its right-hand end. For this position of the slider, the step controller motor 139 has positioned its operating shaft 140 so as to close the mercury switch 145, while allowing the mercury switches 146, 147, and 148 to remain open. At this time, all of the compressors, the various pumps, and the cooling tower fans are out of operation. Now if the switch 13 is closed for placing the pump motor 12 of the cold water circulating pump into operation, the mercury switch 21 of the pressure responsive device 17 will be tilted to closed position due to the resulting increase in pressure at the pump discharge. Closure of the mercury switch 21 will complete a circuit for energizing the relay coil 92 of the starting box 91 for the cooling tower pump 88. This circuit is as follows: line wire 150, wire 151, mercury switch 21, wire 152, wire 153, wire 154, mercury switch 145, wire 155, and coil 92 to ground. It will be noted that the other line wire 156 is grounded. The resulting energization of the coil 92 will cause the switch arms 93 to engage their respective contacts for completing the power circuit to the pump motor 90 thus placing the pump 88 into operation. When the pump 88 is placed into operation, the mercury switch 118 of the pressure responsive device 115 will close, thereby completing a circuit to the starting box 80 of the cooling tower fan 78 as follows: line wire 150, wire 151, mercury switch 21, wire 75

152, wire 153, wire 157, wire 158, mercury switch 118, wire 159, and starting box 80 to ground. This will place the cooling tower fan 78 into operation and this action will cause closing of the sail switch 128 will complete a circuit to the starting box 63 of the compressor 54 as follows: line wire 150, wire 151, mercury switch 21, wire 152, wire 160, sail switch 128, wire 161, and starting box 63 to ground. This will place the compressor 55 in operation thereby causing chilling of the water passing through the water cooler 11.

From the foregoing it will be seen that before the compressor 55 is placed into operation, the cold water pump 8 must be running, the cooling tower pump 88 for the condenser must be running, and in addition the cooling tower fan 78 must be in operation. The control system described thus far therefore acts to prevent operation of the compressor unless the remainder of the system is operating satisfactorily, thereby avoiding any danger of damage to the system due to failure of proper condensing within the condenser-receiver and also preventing any danger of freezing the water in the water cooler. Also, it should be noted that due to the sequential control arrangement wherein the cooling tower pump is not started until after the cold water pump 8 is in operation, and in which the cooling tower fan is not started until the pump 88 operates, and in which the compressor 55 is not started until after the cooling tower fan is started, any chance of overloading the power lines to the system due to simultaneous starting of the motors is avoided. The control system thus far described therefore has the function of preventing the compressor 55 from operating unless the remainder of the system is operating properly, and has the further function of starting the various motors in sequence for preventing any possibility of overloading the power lines.

If the cooling load upon the system increases due for instance to hotter air being passed over cooling coils 6 and 28, the temperature of the water leaving the water cooler will gradually increase. This action will cause the slider 136 of the thermostat 130 to shift to the left across resistance 136 thus causing further counter-clockwise rotation of the shaft 140, this causing the cam 142 to tilt mercury switch 146 to closed position. Closure of mercury switch 146 will complete an energizing circuit to the starting box 64 of the compressor 56 as follows: wire 161, wire 162, mercury switch 146, wire 163 and starting box 64 to ground. This will place the compressor 56 into operation for increasing the amount of cooling performed upon the water within the water cooler 11.

Upon still further increase in load upon the system the temperature of the cold water leaving the water cooler 11 will increase, which will cause additional rotation of the shaft 140 in a clockwise direction thus tilting the mercury switch 147 to closed position. Closure of the mercury switch 147 will establish an energizing circuit for the relay 104 which controls the valve 102 at the inlet of the cooling tower 73. This circuit is as follows: from line wire 150, wire 151, mercury switch 21, wire 152, wire 153, wire 164, mercury switch 147, wire 165 and relay coil 105 to ground. This will cause the switch arm 106 of relay 104 to engage the contact 107 for causing the valve motor 103 to open valve 102 and to close the mercury switch 110 of auxiliary switch 109. The closure of the mercury switch 110 will complete a circuit to the starting box 95 for the

pump motor 94 as follows: Line wire 150, wire 151, mercury switch 21, wire 152, wire 153, wire 157, wire 166, wire 167, wire 168, mercury switch 110, wire 169 and starting box 95 to ground. This will place cooling tower pump 89 into operation. It should be noted at this time that the first action resulting from closing of the mercury switch 147 is the opening of valve 102 for permitting cooling water to flow to the spray pipe 75 of the cooling tower 73. When this valve is opened the pump 89 is placed into operation for pumping water from the condenser receiver to the spray pipe 75. Thus it should be noted that when only the cooling tower pump 88 is in operation, the valve 102 is closed thus causing all of the water delivered by pump 88 to be discharged to the cooling tower 72. When the mercury switch 147 closes, however, the valve 102 is opened and the pump 89 is placed into operation for delivering water to the spray pipe 75 of cooling tower 73. By this arrangement the pressure at the spray pipe 74 is not affected when the spray pipe 75 is placed into operation, as the pump 89 will supply an additional quantity of water thereby providing an adequate supply of water for both spray pipes.

When the pump 89 is placed into operation the pressure responsive device 120 will close its mercury switch 123 which will complete an energizing circuit for the starting box 83 of the cooling tower fan motor 82 as follows: from wire 166, wire 170, mercury switch 123, wire 171 and starting box 83 to ground. This will place the cooling tower fan 81 into operation and in response to this action the mercury switch 127 of the sail switch 125 will close. Closure of the mercury switch 125 will establish an energizing circuit for the starting box 65 for compressor motor 61 as follows: wire 167, wire 172, mercury switch 125, wire 173, wire 174 and starting box 65 to ground. This will place the compressor 57 into operation for increasing the amount of refrigeration performed by the system. It should be noted that before the compressor 57 is placed into operation the valve 102 must be open, the pump 89 must be in operation, and the cooling tower fan 81 must be in operation. The additional load imposed upon the condenser-receiver by operation of the compressor 57 therefore cannot be placed upon this condenser-receiver unless the cooling tower 73 is operating properly. Also due to the sequential control arrangement by which operation of one device is dependent upon operation of another, the pump motor 94, the fan motor 82, and the compressor motor 61 will be started in sequence thereby avoiding excessive loading of the power lines as would occur if these motors were started simultaneously. It should also be noted that the energizing circuit for the starting boxes 95, 83, and 65, is through the mercury switch 21 of the controller 17. Consequently when the pump 8 is out of operation neither the pump 89, the fan 81, nor the compressor 57 will operate. This prevents any possibility of freezing the water in the water cooler 11.

If the load upon the system increases still further the slider 135 of the thermostat 130 will cause further clockwise rotation of the shaft 140 for closing the mercury switch 148. This will establish an energizing circuit for the starting box 66 of compressor motor 62 as follows: wire 173, wire 175, mercury switch 148, wire 176, and starting box 66 to ground. This will place the compressor 58 into operation for further increasing the amount of refrigeration performed. Upon

diminishing of the cooling load upon the system it will be apparent that the various compressors, pumps, and fans will be placed out of operation in inverse order.

From the foregoing it should be apparent that I have provided a flexible control system for controlling the various compressors, pumps, and fans of a large refrigeration system and provide for varying the number of compressors in operation in accordance with the load upon the system. It should also be noted that my improved control system automatically uses but one cooling tower when only a part of the compressors are in operation and automatically places the second cooling tower into operation when a predetermined number of compressors are required to be placed in operation. It should be further noted that my improved control system provides for automatically checking the operation of the cold water pump, the cooling tower pump, and the cooling tower fan and prevents operation of a compressor in the event that one of these devices is not operating properly. It should additionally be noted that my control system provides for not only checking the operation of these devices but sequentially places the various motors into operation for preventing large surges in current due to simultaneous starting of a plurality of motors of large size.

Also from the foregoing description it should be apparent that my invention provides for the utilization of a plurality of cooling towers and for varying the number of cooling towers in operation in accordance with the load on the system, while at the same time utilizing but a single pipe leading from the condenser to the cooling towers. My invention therefore avoids the necessity of running separate pipes from the condenser to each cooling tower and thus provides for materially reducing the cost of a large installation.

While I have shown and described a preferred embodiment of my invention, it will be apparent that many modifications of the various instrumentalities which are within the scope of my invention will occur to those skilled in the art. I therefore desire to be limited only by the scope of the appended claims.

I claim as my invention:

1. In a system of the class described, in combination, heat exchange means, a first heat exchanger, a second heat exchanger, means including common conduit means for conveying heat exchange medium between each of said heat exchangers and said heat exchange means, pumping means for causing said heat exchange medium to flow through said conduit means, a controller for varying the operation of said pumping means, valve means for interrupting the flow of heat exchange medium between one only of said heat exchangers and said heat exchange means, motor means for opening and closing said valve means, and switching means actuated directly by said motor means for actuating said controller in a manner to increase the operation of said pumping means when the valve is opened and to decrease the operation of said pumping means when the valve is closed.

2. In a system for supplying cooling medium for a refrigeration system having heat exchange means requiring cooling medium, in combination, a first cooling device for cooling the cooling medium, a second cooling device for cooling the cooling medium, means including common conduit means for conveying cooling medium be-

tween said cooling devices and said heat exchange means, pumping means for causing said cooling medium to flow through said conduit means, control means for varying the output of said pumping means, valve means for interrupting the flow of cooling medium between one only of said cooling devices and said heat exchange device, motor means for opening and closing said valve means, and means for controlling said controller and said valve motor means in a manner to open said valve means and to increase the operation of said pumping means, or to close said valve means and decrease the operation of said pumping means.

3. In a system for supplying cooling medium for a refrigeration system having heat exchange means requiring cooling medium, in combination, cooling tower means including a first spray device and a second spray device, means for conveying cooled cooling medium from said cooling tower means to said heat exchange means, means including a common conduit for conveying heated cooling medium from said heat exchange means to the spray devices, pumping means for forcing said cooling medium through said common conduit to said spray devices, control means for varying the output of said pumping means, valve means for interrupting the flow to one only of said spray devices, motor means for opening and closing said valve means, and remote control means for controlling said valve motor means.

4. In a system for supplying cooling medium for a refrigeration system having heat exchange means requiring cooling medium, in combination, cooling tower means including a first spray device and a second spray device, means for conveying cooled cooling medium from said cooling tower means to said heat exchange means, means including a common conduit for conveying heated cooling medium from said heat exchange means to the spray devices, pumping means for forcing said cooling medium through said common conduit to said spray devices, a controller for varying the output of said pumping means, valve means for interrupting the flow to one only of said spray devices, motor means for opening and closing said valve means, and means for actuating said controller and said valve motor means for thereby placing one of said spray devices into or out of operation without varying the pressure of the medium supplied to the other spray device.

5. In a system for supplying cooling medium for a refrigeration system having heat exchange means requiring cooling medium, in combination, cooling tower means including a first spray device and a second spray device, means for conveying cooled cooling medium from said cooling tower means to said heat exchange means, means including a common conduit for conveying heated cooling medium from said heat exchange means to the spray devices, pumping means for forcing said cooling medium through said common conduit to said spray devices, a controller for varying the output of said pumping means, valve means for interrupting the flow to one only of said spray devices, motor means for opening and closing said valve means, and means actuated by said motor means for actuating said controller in a manner to increase the operation of said pumping means when the valve is opened, and to decrease the operation of said pumping means when the valve is closed.

6. In a system for supplying cooling medium for a refrigeration system having heat exchange

means requiring cooling medium, in combination, cooling tower means including a first spray device and a second spray device, means for conveying cooled cooling medium from said cooling tower means to said heat exchange means, means including a common conduit for conveying heated cooling medium from said heat exchange means to the spray devices, pumping means for forcing said cooling medium through said common conduit to said spray devices, a controller for varying the output of said pumping means, valve means for interrupting the flow to one only of said spray devices, valve motor means for opening and closing said valve means, fan means for said cooling tower means, a fan controller for varying the operation of said fan means, a controller for said valve motor means, means actuated by said valve motor means for actuating said pumping means controller, and means actuated by the pressure produced by said pumping means for controlling said fan means.

7. In a system for supplying cooling medium for a refrigeration system having heat exchange means requiring cooling medium, in combination, cooling tower means including a first spray device and a second spray device, means for conveying cooled cooling medium from said cooling tower means to said heat exchange means, means including a common conduit for conveying heated cooling medium from said heat exchange means to the spray devices, pumping means for forcing said cooling medium through said common conduit to said spray devices, a controller for varying the output of said pumping means, valve means for interrupting the flow to one only of said spray devices, valve motor means for opening and closing said valve means, fan means for said cooling tower means, a fan controller for varying the operation of said fan means, a controller for said valve motor means, means actuated by said valve motor means for actuating said pumping means controller, means actuated by the pressure produced by said pumping means for controlling said fan means, and means actuated by operation of said fan means for controlling the operation of said refrigeration system.

8. In a refrigeration system, in combination, a compressor, a condenser, a cooling tower for supplying cooling water for said condenser, a fan for said cooling tower, a conduit for conveying water from said condenser to said cooling tower, pumping means, valve means for controlling the flow of water between said condenser and cooling tower, motor means for actuating said valve means, control means responsive to the position of said valve means, control means responsive to operation of said fan means, control means responsive to operation of said pumping means, and means controlled by each of said control means for preventing operation of said compressor unless said valve is open, the pumping means is in operation, and the fan is in operation.

9. In a refrigeration system, in combination, a compressor, a condenser, a cooling tower for supplying cooling water for said condenser, a fan for said cooling tower, conduit means for conveying water between said cooling tower and condenser, pumping means for causing cooling water to flow through said conduit means, a controller for said fan means, said pumping means, and said compressor, control means responsive to operation of said fan means, control means responsive to operation of said pumping means, and means controlled by said control means for preventing operation of said compressor unless

both the fan means and pumping means are in operation.

10. In a refrigeration system, in combination, a compressor, a condenser, a cooling tower for supplying cooling water for said condenser, a fan for said cooling tower, conduit means for conveying water between said cooling tower and condenser, pumping means for causing cooling water to flow through said conduit means, a controller for said fan means and compressor, control means responsive to operation of said fan means, and means controlled by said control means for preventing operation of said compressor unless the fan means is in operation.

11. In a refrigeration system, in combination, a pair of compressors, condensing means, means for supplying cooling medium to said condensing means including a first pump and a second pump, a condition responsive means responsive to a condition which is a measure of the load on the system for sequentially placing said compressors and pumps in operation as the load upon the system increases, control means responsive to operation of one of said pumps, means controlled by said control means for preventing operation of one of said compressors when said one pump is not in operation, control means responsive to operation of said other pump, and means controlled by said last mentioned control means for preventing operation of said other compressor when said other pump is not in operation.

12. In a refrigeration system, in combination, a pair of compressors, condensing means, means for supplying cooling medium to said condensing means including cooling tower means having a first spray device and a second spray device, a first fan means for said first spray device, a second fan means for said second spray device, first and second pumping means for forcing cooling medium to said spray devices, control means including a condition responsive device responsive to a condition which is a measure of the load on the system for sequentially controlling said compressors, fan means, and pumping means, said control means being arranged for first placing one of said compressors, said first fan means and said first pumping means into operation and then placing said other compressor, said second fan means, and said second pumping means into operation as the load upon the system increases.

13. In a refrigerating system, in combination, a pair of compressors, condensing means, means for supplying cooling medium to said condensing means including cooling tower means having a first spray device and a second spray device, a first fan means for said first spray device, a second fan means for said second spray device, first and second pumping means for forcing cooling medium to said spray devices, means including a condition responsive device responsive to a condition which is a measure of the load on the system for sequentially controlling said compressors, fan means, and pumping means, control means responsive to operation of said first fan means and said first pumping means, means controlled by said control means for preventing operation of one of said compressors when either said first fan means or said first pumping means is not in operation, control means responsive to operation of said second fan means and said second pumping means, and means controlled by said last mentioned control means for preventing operation of said other compressor when either said second fan means or said second pumping means is not in operation.

14. In a refrigeration system, in combination, a pair of compressors, condensing means, means for supplying cooling medium to said condensing means including cooling tower means having a first spray device and a second spray device, common conduit means for conveying cooling medium from said condensing means to said spray devices, pumping means for causing said cooling medium to flow through said conduit means, a controller for varying the operation of said pumping means, valve means for interrupting the flow of cooling medium to one only of said spray devices, control means including a condition responsive device for sequentially controlling said compressors, said valve means and said pumping means, in a manner to place one of said compressors in operation, and then to place said other compressor into operation while opening said valve means and increasing the operation of said pumping means as the load upon the system increases.

15. In a refrigeration system, in combination, a pair of compressors, condensing means, means for supplying cooling medium to said condensing means including cooling tower means having a first spray device and a second spray device, common conduit means for conveying cooling medium from said condensing means to said spray devices, pumping means for causing said cooling medium to flow through said conduit means, a controller for varying the operation of said pumping means, valve means for interrupting the flow of cooling medium to one only of said spray devices, means for controlling said compressors, control means responsive to the position of said valve means, control means responsive to increase in operation of said pumping means, and means controlled by both of said control means for preventing operation of one of said compressors when either the valve is not in open position or the operation of said pumping means is not increased.

16. In a refrigeration system, in combination, a

first compressor, a second compressor, evaporator means, condensing means, power actuated means for causing heat exchange medium to flow into heat exchange relationship with said evaporator means, pumping means for supplying cooling medium to said condensing means, means including a condition responsive device responsive to a condition which is a measure of the load on the system for sequentially controlling said compressors and varying the operation of said pumping means in a manner to place one of said compressors into operation and then to place the other compressor into operation and increase the operation of said pumping means as the load on the system increases, control means responsive to increase in operation of said pumping means, means controlled by said control means for preventing operation of said other compressor when the operation of said pumping means is not increased, control means responsive to operation of said power actuated means, and means controlled by said last mentioned control means for preventing operation of both of said compressors when said power actuated means is not in operation.

17. In a refrigeration system, in combination, compressing means, evaporator means, condensing means, pumping means for causing heat exchange medium to flow into heat exchange relationship with said refrigeration system, means including a condition responsive device responsive to a condition which is a measure of the load on the system for controlling the compressing means and the pumping means in a manner to increase the operation of said compressing means and said pumping means as the load upon the system increases, control means responsive to increase in operation of said pumping means, and means controlled by said control means for preventing increase in operation of said compressing means when the operation of said pumping means is not increased.

JOSEPH E. ROBB.