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W. F. BORGERD

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CONTROL FOR HEAT PUMP AND WATER HEATER

Filed Oct. 15, 1951

2 Sheets-Sheet 1

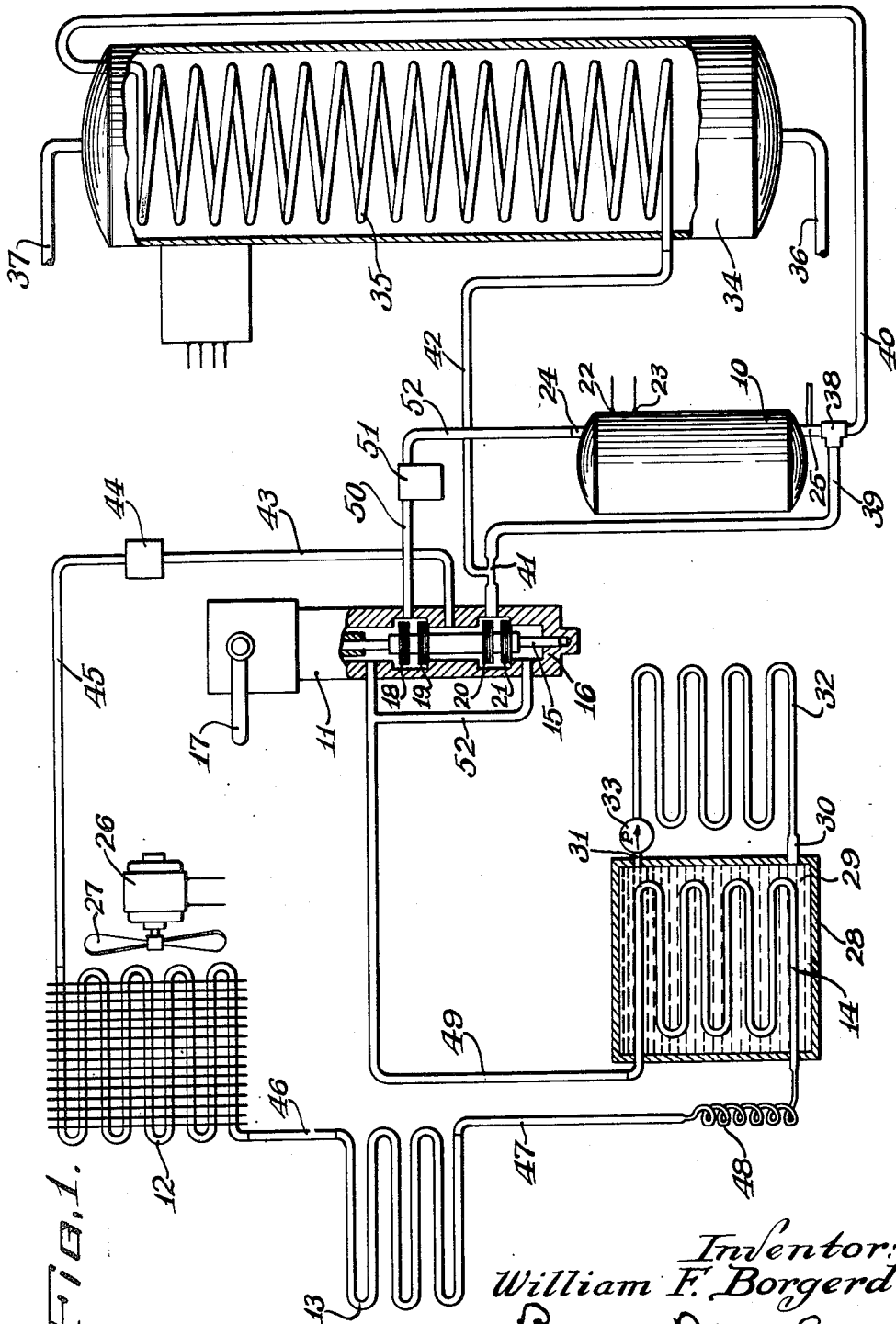


FIG. 1.

Inventor:
William F. Borgerd
Paul O. Rippert
Atty.

Oct. 5, 1954

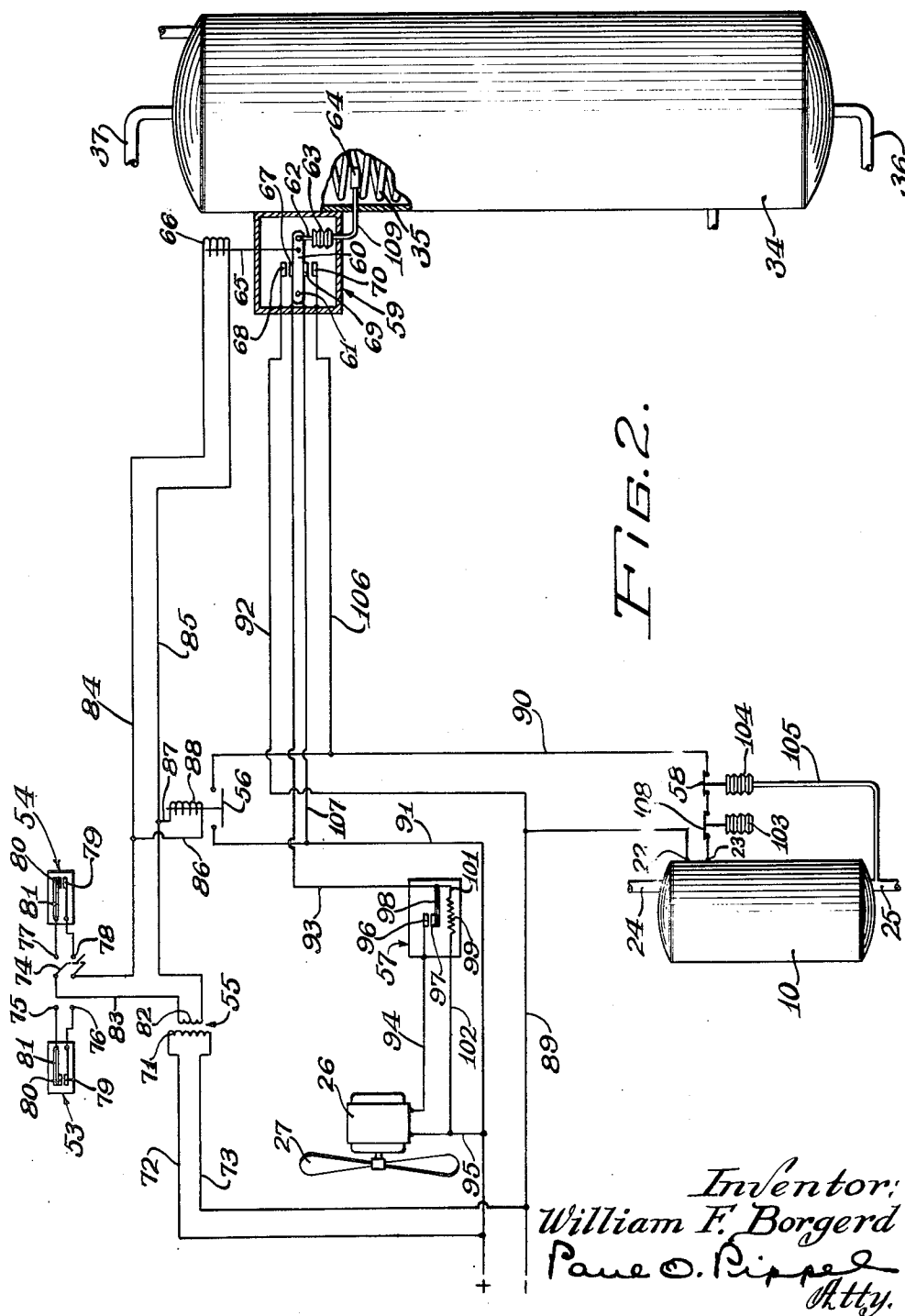
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,690,649

CONTROL FOR HEAT PUMP AND WATER HEATER

William F. Borgerd, Evansville, Ind., assignor to
International Harvester Company, a corpora-
tion of New Jersey

Application October 15, 1951, Serial No. 251,381

19 Claims. (Cl. 62—4)

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This invention relates generally to a control for a refrigeration system and more particularly to an automatic control system for a combination heat pump and water heater.

In my copending application titled "Combina-
tion Heat Pump and Water Heater," filed October
15, 1951, Serial No. 251,380, there is described and
claimed a combination heat pump and water
heater. The combination disclosed therein com-
prises two heat exchange units connected in series
to a motor-compressor assembly with means for
reversing the flow of refrigerant through the
units, and a water tank having a refrigerant coil
which is connected to the compressor's outlet and
positioned in heat exchange relation with the
water in the tank. The water will be quickly
heated by the hot refrigerant gases during opera-
tion of the compressor, and by providing fan
means for passing air from the enclosure into
contact with one of the heat exchange units,
the enclosure will be conditioned to a proper
temperature range. The general purpose of the
present invention is to provide automatic means
for controlling the operation of the motor-com-
pressor assembly and fan means.

Another object of the present invention is to
provide automatic means for controlling the op-
eration of the fan means and motor-compressor
assembly in response to the temperature of the
air within the enclosure.

Another object of the invention is to provide
means for controlling operation of the motor-
compressor assembly in response to the tempera-
ture of the water within the water tank.

Another object of the invention is to provide
an electric circuit for the motor-compressor unit
and fan means having means for breaking the circuit
when overload conditions are encountered in
order to prevent damage to the motor-compressor
assembly.

Another object of the invention is to provide
means for delaying the energization of the fan
means for a predetermined period of time after
the motor-compressor has been initially ener-
gized.

Another object of the invention is to provide
the circuit with thermostatic means for automati-
cally controlling the operation of the heat pump
in response to the temperature of the air within
the room during both the heating and cooling
cycle.

Another object of the invention is to provide
a thermal overload protector which will open the
circuit when the temperature of the motor-com-
pressor unit exceeds a safe maximum value.

Another object of the invention is to provide
means for operating the motor-compressor unit
while the fan means is inoperative in order that
the high side temperature and pressure will be
raised above normal values whereby the water

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within said water tank will be heated to a higher
temperature.

Another object is to provide the circuit with
a high pressure cutout which automatically opens
the circuit when the high side pressure of the
refrigeration system exceeds a predetermined
maximum value.

Further objects and advantages of the present
invention will be apparent from the following
description, reference being had to the accom-
panying drawings wherein a preferred form of
the present invention is clearly shown.

In the drawings:

Fig. 1 is a diagrammatic view of the refrigera-
tion system.

Fig. 2 is a simplified diagram of the control
system for the refrigeration system.

Referring to Fig. 1 of the drawings, a com-
bination heat pump and water heater system is
diagrammatically represented. For a detailed
description of this system reference may be had
to the above mentioned copending application.
The system comprises generally a motor-com-
pressor unit 10, a reversing valve 11, a room heat
exchange unit 12, a basement heat exchange unit
13, and a submerged coil 14. The reversing valve
11 is provided with a valve stem 15 which is
slidably secured within the valve casing 16. The
upper end of the valve stem 15 is connected to
a lever 17 which may be rotated to impart longi-
tudinal movement to the valve stem. Four valve
heads 18, 19, 20 and 21 are secured to valve stem
15 in spaced relationship so that the valve heads
19 and 21 will seat when the valve stem is moved
in one direction, and valve heads 18 and 20 will
seat when the valve stem is moved in the opposite
direction.

The motor-compressor unit 10 comprises an
electric motor and a compressor hermetically
sealed within an outer casing. Electrical ter-
minals 22 and 23 are provided for the electric
motor and a refrigerant inlet 24 and outlet 25
are provided for the compressor.

It is contemplated that the finned tube room
coil 12 either be located in an enclosure or room
which is to be conditioned, or be connected to
the rooms of a building by suitable ducts. An
electric motor 26 is provided with a fan 27 which
will circulate room air into heat exchange rela-
tion with the surface of the coil 12. The base-
ment coil 13 can be positioned within the base-
ment of the building or be connected thereto by
ducts with fan means (not shown) for circulat-
ing the air from the basement into contact with
the coil. The submerged coil 14 is enclosed by
a casing 28 and is surrounded by a heat ex-
change liquid 29. The casing is provided with
an inlet 30 and outlet 31 to which a coil 32 is
connected with a pump 33 for circulating the
liquid 29 therethrough. It is contemplated that

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coil 32 be buried in the ground so that the temperature of the earth surrounding the ground coil will remain constant throughout the year.

Reference numeral 34 designates a water tank in which a refrigerant coil 35 is disposed. The lower portion of the tank 34 is provided with a water inlet 36 which may be connected to a suitable water supply (not shown). A water outlet 37 is connected into the upper portion of the tank 34 and it is contemplated that the water outlet be connected to the hot water faucets of the building in the usual manner whereby hot water from the tank can be supplied to various parts of the building.

Motor-compressor outlet 25 is connected to coupling 38 which has one leg joined to conduit 39 and the other leg joined to conduit 40. The inlet of tank coil 35 is joined to one end of conduit 40 and the outlet is connected to a reduced portion 41 of conduit 39 by conduit 42.

With lever 17 in the horizontal position as shown in Fig. 1, valve heads 19 and 21 are in seated position and the heat pump will be operating to heat the building. Part of the compressed refrigerant gases from the motor-compressor assembly 10 flows through conduit 39 and part flows through conduit 40 into coil 35 whereby the water within the tank 34 is heated. From the coil 35 the gases are returned to conduit 39 by conduit 42. The refrigerant gases then pass through valve 11, conduit 43, receiver 44 and conduit 45 into room coil 12 where they will be condensed by the room air being circulated into contact with the coil by fan 27. The condensed refrigerant then flows through conduit 46 into basement coil 13, where it will be further cooled by the basement air circulating thereover, then through conduit 47 and capillary restrictor tube 48. As the refrigerant passes through the restrictor tube 48, it changes from a high pressure to a low pressure and then flows through submerged coil 14 where it is vaporized by absorbing heat from the heat exchange liquid 29. These vapors then pass through conduit 49, valve 11, and conduit 50 into the combination accumulator, strainer and drier 51 from which they are pulled into the motor-compressor unit 10 through conduit 52 to be recompressed and recirculated through the system. During the heating cycle, room coil 12 will be functioning as a condenser and basement coil 13 will be sub-cooling the liquid refrigerant so that the air being passed thereover will be heated to a desired temperature.

To change the system of the cooling cycle, lever 17 is rotated so that valve stem 15 is moved upwardly to a position where valve heads 19 and 21 are unseated and valve heads 18 and 20 are seated. The compressed refrigerant vapors flow through coupling 38 and divide, part passing through conduit 39 and part passing through conduit 40 into tank coil 35. The water within the tank 34 is heated by coil 35 and the partially cooled refrigerant from the coil flows through conduit 42 into conduit 41. The refrigerant vapors then pass through valve 11 and conduits 52 and 49 to the submerged coil 14 where the heat exchange liquid 29 cools and condenses the refrigerant within the coil. The liquefied refrigerant is forced through the capillary tube 48 into conduit 47 and through basement coil 13 and room coil 12 where it is vaporized by the heat absorbed by the air being circulated over the coils. The refrigerant vapors are returned to the motor-compressor unit 10 through conduit 45,

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receiver 44, conduit 43, valve 11, conduit 50, accumulator 51, and conduit 52. Basement coil 13 will cool and dehumidify the air within the basement and room coil 12 will maintain the room air within a predetermined temperature range.

Fig. 2 of the drawing shows an electric circuit and controls for the fan motor 26 and motor-compressor assembly 10. It comprises generally a cooling thermostatic switch 53, a heating thermostatic switch 54, a transformer 55, a solenoid switch 56, a time delay switch 57, a thermostatic switch 108, a pressure responsive switch 58, and a control box 59. The control box comprises a non-conducting lever 60 having one end thereof pivotally connected at 61. The opposite end of the lever is connected by link 62 to a bellows 63 which is operated by a bulb 64 located in heat exchange relation with the water within tank 34. An intermediate portion of lever 60 is connected to an armature 65 of solenoid 66 which will pull the lever 60 upwardly when energized. Contact 67 is secured to lever 60 and is adapted to engage contact 68 when lever 60 is pulled upwardly by solenoid 66. Contact 69 is secured to lever 60 and is arranged to engage fixed contact 70 when the lever 60 is pulled downwardly by bellows 63.

The primary coil 71 of the transformer 55 is connected by lines 72 and 73 to a suitable power source. To operate the heat pump, switch 74 is manually set to engage contacts 75 and 76 when cooling is required or contacts 77 and 78 when heating is required. Each of the thermostatic switches 53 and 54 comprises a fixed contact 79 and a movable contact 80 which is secured to the movable end of a bi-metallic strip 81. By way of example, when switch 74 is moved into engagement with contacts 75 and 76, bi-metallic strip 81 will move contact 80 into engagement with contact 79 when the room air requires cooling. It is contemplated that thermostats 53 and 54 be positioned within a room with switch 74 located in such a position that it can be easily reached by an operator. With contacts 79 and 80 in engagement, the circuit through secondary coil 82, line 83, thermostat 53, line 84, solenoid 66 and line 85 will be completed. Solenoid 66 will also be energized through lines 86 and 87 which are connected to lines 84 and 85 respectively so that switch 56 is closed. Upon energization of solenoid 66, lever 60 will be pulled upwardly and contacts 67 and 68 will be brought into engagement.

Switch 56 will be closed simultaneously with the engagement of contacts 67 and 68 whereupon the circuit to the motor-compressor unit 10 will be completed. This circuit comprises line 89, motor-compressor 10, switch 108, switch 58, line 90, switch 56, and line 91. Fan motor 26 is connected in parallel with the motor-compressor unit 10 by line 92, contacts 67 and 68, line 93, time delay switch 57, line 94, and line 95. As seen in Fig. 2, time delay switch 57 comprises a fixed contact 96 and a movable contact 97 which is fastened to bi-metallic strip 98. A resistor 99 is connected in parallel with contacts 96 and 97 by lines 101 and 102 so that current will flow therethrough. The bi-metallic strip 98 is calibrated so that after current has flowed through resistor 99 for approximately thirty seconds, the strip will be bent by the heat from the resistor and contact 97 will engage contact 96 whereby fan motor 26 is energized. By this arrangement the current surge from the fan motor 26 follows

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the heavy current surge from the motor-compressor 10, and the temperature of coil 12 has been adjusted to normal before room air is blown thereover. Switch 108 is operated by a bellows 103 which is filled with a volatile fluid and positioned in close proximity to the motor-compressor unit 10. The bellows 103 opens the switch 108 when the temperature of the unit exceeds a safe value. Switch 58 is operated by bellows 104 which is connected to the compressor outlet 25 by tube 105. The bellows 104 automatically moves switch 58 to break the circuits to motor-compressor assembly 10 when the high side pressure of the system raises beyond a predetermined maximum value.

After the room air has been cooled to a proper temperature, bi-metallic strip 81 will bend and move contact 80 away from contact 79 whereby the circuit to solenoid 83 and 66 will be broken. This causes switch 56 to be opened and contact 67 to be moved away from contact 68 whereby the circuit to motor-compressor assembly 10 and fan motor 26 is opened. When cooling is again needed, the circuits will be automatically closed by cooling thermostat 53. When the heat pump is to be operated to heat the building, lever 17 of reversing valve 11 is rotated to heating position and switch 74 is moved into engagement with contacts 77 and 78. Heating thermostat 54 will now automatically regulate the operation of motor-compressor assembly 10 and fan motor 26 in response to room temperature.

In a heat pump system of the character illustrated, the high side temperature will probably range from 100 to 125 degrees Fahrenheit. For satisfactory home use, the water withdrawn from water tank 34 should be around 145 degrees Fahrenheit. Since the water will only be heated to approximately 120 degrees by the refrigerant coil during the regular cycling periods of the refrigeration system, it is contemplated that the motor-compressor 10 be operated for a few minutes at the end of each running cycle. The operation of the motor-compressor is automatically controlled by bellows 63 of control box 59. This bellows is connected by tube 109 to the feeler bulb 64 which is filled with a volatile fluid and placed in heat exchange relation with the water within tank 34. The bellows 63 is set to pull lever 60 downwardly as long as the water temperature is below a predetermined value. The pull of solenoid 56 may be adjusted so that it will overcome the pull of bellows 63 whenever the circuit to the solenoid is closed. At the end of the running cycle, solenoid 66 will be deenergized and lever 60 will be pulled downwardly by bellows 63 to bring contacts 69 and 70 into engagement. This energizes the motor-compressor assembly 10 through line 89, switch 108, switch 58, line 93, line 105, contacts 70 and 69, line 107, and line 91. The circuit to fan motor 26 remains open and no air will be circulated over room coil 12. The refrigerant will circulate through the system, but since fan 27 is not operating, only about one-third to one-half of the full capacity of the compressor will be used because of the limited size of the tank coil 35. This will cause the high side pressure and temperature to rise rapidly, and since a mixture of liquid and gas will be delivered to the capillary tube 48, this high pressure and temperature will be maintained. The increased temperature of the refrigerant flowing through tank coil 35 will heat the water to a corresponding higher temperature, and when the bulb 64 has been subjected

to a predetermined temperature, bellows 63 will force lever 60 upwardly whereby contact 69 will be moved away from contact 70 and the circuit to the motor-compressor 10 will be broken. In this way the water within tank 34 will be heated to approximately 145 degrees Fahrenheit.

During a few months out of the year, generally in the spring and fall, there are days when neither heating nor cooling of the room air is required. Since hot water is still required during such periods, it is contemplated that bellows 63 be used to control operation of the motor-compressor assembly 10. By this arrangement the heat pump will operate to heat the water within tank 34, and since fan 27 is not operating, the air within the rooms of the building will not be affected.

As is apparent from the foregoing description, I have provided an effective control system for a combination heat pump and water heater. The operation of the refrigeration system is controlled by thermostatic means which are responsive to room air temperature. The energizing of the fan motor is delayed until after the motor-compressor assembly has started in order to reduce the total starting current and to allow the temperature of the room coil to be adjusted to a normal operating temperature before room air is circulated thereover. The control system provides means for running the motor-compressor assembly a short time after each cycling period in order that the water within the water tank will be heated to a high temperature by the increased high side temperature.

The invention is not to be understood as being limited to the details described, since there may be modifications within the scope of the appended claims without departing from the spirit or scope of the invention.

Having thus described the invention, what I claim as new and desire to secure by Letters Patent is:

1. In a refrigeration system having a motor-compressor and a heat exchange unit, electric means for circulating air to be conditioned over said heat exchange unit, a coil positioned in heat exchange relation with a liquid, said coil being connected to said motor-compressor so that a portion of the compressed refrigerant flows there-through, first means for operating said motor-compressor and said electric means in response to the temperature of said air, and second means for operating said motor-compressor independent of said electrical means in response to the temperature of the liquid.

2. In a refrigeration system having a motor-compressor and a heat exchange unit, electric means for circulating air to be conditioned over said heat exchange unit, a coil positioned in heat exchange relation with a liquid, said coil being connected to said motor-compressor so that a portion of the compressed refrigerant flows there-through, a first circuit connecting said motor-compressor to a power supply, a second circuit connecting said electric means to said power supply, means for opening and closing said circuits in response to the temperature of said air, and means for opening and closing said first circuit independent of said second circuit in response to the temperature of said liquid.

3. In a refrigeration system having a motor-compressor and a heat exchange unit, electric means for circulating air to be conditioned over said heat exchange unit, a coil positioned in heat exchange relation with a liquid, said coil being connected to said motor-compressor so

8. In a refrigeration system having a motor-

12. In a refrigeration system having a motor-compressor and a heat exchange unit, electric means for circulating air to be conditioned over said heat exchange unit, a circuit connecting said motor-compressor and said electric means to a power supply, thermostatic means for opening and closing said circuit, a switch for delaying en-

energization of said electric means a predetermined time after said motor-compressor is energized, a thermostatic switch for breaking the circuit when the temperature of said motor-compressor reaches a predetermined value, and a pressure operated switch for breaking the circuit when the high side pressure reaches a predetermined value.

13. In a refrigeration system having a motor-compressor and a heat exchange unit, a coil positioned in heat exchange relation with a liquid, said coil being connected to said motor-compressor so that a portion of the compressed refrigerant flows therethrough, a circuit connecting said motor-compressor to a power supply, thermostatic means for opening and closing said circuit in response to the temperature of said air, a thermostatic switch for opening and closing said circuit in response to the temperature of said liquid, and means for maintaining said thermostatic switch in open position when said thermostatic means is in closed position.

14. In a refrigeration system having a motor-compressor and a heat exchange unit, a coil positioned in heat exchange relation with a liquid, said coil being connected to said motor-compressor so that a portion of the compressed refrigerant flows therethrough, a circuit connecting said motor-compressor to a power supply, thermostatic means for opening and closing said circuit in response to the temperature of said air, a thermostatic switch for opening and closing said circuit in response to the temperature of said liquid, and a solenoid which is energized when said circuit is closed, said solenoid acting to hold said thermostatic switch in open position when energized.

15. In a refrigeration system having a motor-compressor and a heat exchange unit, electric means for circulating air to be conditioned over said heat exchange unit, a coil positioned in heat exchange relation with a liquid, said coil being connected to said motor-compressor so that a portion of the compressed refrigerant flows therethrough, a first circuit connecting said motor-compressor to a power supply, a second circuit connecting said electric means to said power supply, thermostatic means for opening and closing said circuits in response to the temperature of said air, a thermostatic switch for opening and closing said first circuit in response to the temperature of said liquid, electromagnetic means for holding said thermostatic switch in open position when said thermostatic means has closed said circuits.

16. In a refrigeration system having a motor-compressor and a heat exchange unit, electric means for circulating air to be conditioned over said heat exchange unit, a coil positioned in heat exchange relation with a liquid, said coil being connected to said motor-compressor so that a portion of the compressed refrigerant flows therethrough, a first circuit connecting said motor-compressor to a power supply, a second circuit connecting said electric means to said power supply, thermostatic means for opening and closing said circuits in response to the temperature of said air, a time delay switch for delaying energization of said electric means a predetermined period of time after the motor-compressor is energized, and a thermostatic switch for opening and closing said first circuit in response to the temperature of said liquid.

17. In a refrigeration system having a motor-compressor and a heat exchange unit, electric means for circulating air to be conditioned over

said heat exchange unit, a coil positioned in heat exchange relation with a liquid, said coil being connected to said motor-compressor so that a portion of the compressed refrigerant flows therethrough, a first circuit connecting said motor-compressor to a power supply, a second circuit connecting said electric means to said power supply, thermostatic means for opening and closing said circuits in response to the temperature of said air, a time delay switch for delaying energization of said electric means a predetermined period of time after the motor-compressor is energized, a thermostatic switch for opening and closing said first circuit in response to the temperature of said liquid, and electro-magnetic means for holding said thermostatic switch in open position when said thermostatic means has closed said circuits.

18. In a refrigeration system, a motor-compressor unit, a heat exchange unit mounted to cooperate with air to be conditioned and connected to said motor-compressor unit, electric means operable to circulate said air over said heat exchange unit, a liquid, a coil mounted in a heat exchange relationship with said liquid, a refrigerant charging said system, said coil being connected to the outlet and inlet of said motor-compressor unit so that a portion of said refrigerant flowing from the outlet of said motor-compressor unit and into the inlet of said motor-compressor unit passes through said coil when said motor-compressor unit is operating, first means operating responsive to the temperature of said air for simultaneously operating said motor-compressor unit and said electric means, and second means operating responsive to the temperature of said liquid for operating said motor-compressor unit independent of said electric means.

19. In a refrigeration system, a motor-compressor unit, a heat exchange unit mounted to cooperate with air to be conditioned and connected to said motor-compressor unit, electric means operable to circulate said air over said heat exchange unit, a liquid, a coil mounted in a heat exchange relationship with said liquid, a refrigerant charging said system, said coil being connected to the outlet and inlet of said motor-compressor unit so that a portion of said refrigerant flowing from the outlet of said motor-compressor unit and into the inlet of said motor-compressor unit passes through said coil when said motor-compressor unit is operating, a thermostat operating responsive to the temperature of said air, a first circuit including said first thermostat, said motor-compressor unit and said electric means, for simultaneously operating said motor-compressor unit and said electric means responsive to the operation of said first thermostat, a second thermostat operating responsive to the temperature of said liquid, and a second circuit including said motor-compressor unit and said second thermostat for operating said motor-compressor unit independent of said electric means responsive to the operation of said second thermostat.

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