

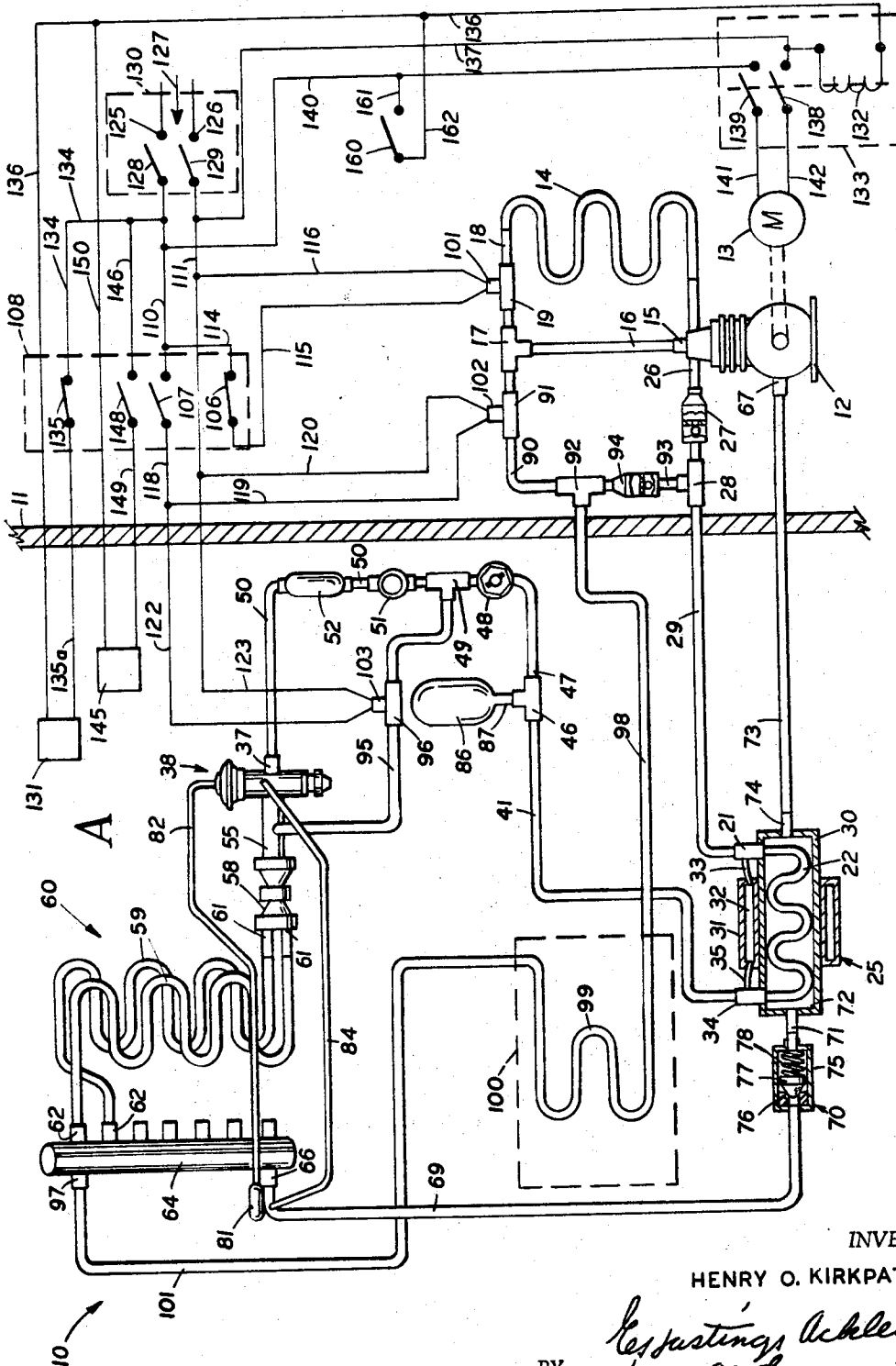
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AIR CONDITIONING APPARATUS WITH HOT GAS HEATING MEANS

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1

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AIR CONDITIONING APPARATUS WITH HOT GAS HEATING MEANS

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This invention relates to air conditioning apparatus and more particularly to an apparatus for selectively heating or cooling a conditioned chamber or space.

An object of this invention is to provide a new and improved air conditioning apparatus having a compressor for compressing refrigerant fluid, a condenser for cooling and liquifying the compressed refrigerant fluid, and an evaporator in which the liquified refrigerant gas is allowed to evaporate and expand during the cooling cycle of operation of the apparatus to cool the conditioned space and through which the hot compressed gas from the compressor, without flowing through the condenser, is caused to flow during the heating and defrost cycles of operation of the apparatus.

Another object is to provide an air conditioning apparatus wherein an optimum amount of the energy imparted to the refrigerant fluid by the compressor is utilized to heat the conditioned space during the heating cycle of operation of the apparatus or melt ice and frost off the evaporator during the defrost cycle of operation.

Still another object is to provide an air conditioning apparatus wherein during the heating and defrosting cycles of operation of the apparatus, the refrigerant fluid which is cooled during flow through the evaporator coils is reheated so that the refrigerant fluid reaching the inlet of the compressor is not in liquid state.

A further object is to provide an air-conditioning apparatus wherein all operative portions of the refrigerant fluid circulating apparatus except the compressor and the condenser are disposed within the conditioned chamber or space to minimize loss of heat to the atmosphere during the heating cycle of operation and increase the speed of the defrosting during the defrost cycle.

A still further object is to provide an air-conditioning apparatus for controlling the temperature in a chamber wherein the compressor and the condenser are disposed exteriorly of the chamber and an evaporator and a heat exchanger are disposed in the conditioned chamber, the apparatus being provided with means for selectively causing the hot compressed fluid from the compressor during the cooling cycle of operation of the apparatus to flow successively through the condenser to be cooled and liquified therein, through the evaporator wherein the refrigerant fluid evaporates and expands and back to the compressor through a heat exchanger, the fluid flowing to the compressor through one passage of the heat exchanger absorbing heat from the refrigerant fluid flowing from the condenser to the evaporator, and, during the heating cycle of operation, for causing a portion of the hot refrigerant fluid from the compressor to flow through the one passage of the heat exchanger to the downstream ends of the coils of the evaporator and another portion to flow to the upstream ends of the coils of the evaporator and then back through the other passage of the heat exchanger to the inlet of the compressor.

A still further object is to provide an apparatus wherein a portion of the hot refrigerant fluid from the compressor flows through one passage of the heat exchanger to the suction header of the evaporator and another portion directly to the inlets of the evaporator coils whereby the portion flowing to the suction header vaporizes or disperses into droplets any of the refrigerant fluid which may have been liquified in flowing through the coils of the evaporator

2

and wherein the heat absorbed from the refrigerant fluid flowing through the passage of the heat exchanger to the suction header from the refrigerant fluid flowing through another passage of the heat exchanger to the inlet ends of the evaporator coils further insures that refrigerant fluid in liquid state does not reach the inlet of the compressor.

Still another object is to provide an air-conditioning system having means for preventing flow of the refrigerant into the condenser during the heating and defrost cycles of operation.

Additional objects and advantages of the invention will be readily apparent from the reading of the following description of a device constructed in accordance with the invention, and reference to the accompanying drawing thereof, wherein:

The single figure is a diagrammatic illustration of the apparatus embodying the invention and its electrical control circuit.

Referring now to the drawings, the heating and refrigeration apparatus 10 embodying the invention is employed to maintain the temperature in a chamber A above a predetermined value if the temperature exteriorly of the chamber is below such predetermined value and to maintain the temperature in the chamber below a predetermined value if the temperature exteriorly of the chamber is above such predetermined value. For example, the chamber A may be the cargo chamber of a vehicle, such as a truck or trailer which is used to transport such perishable cargo as food, beverages and the like which, if the temperature within the chamber rises above a predetermined value, for example 40 degrees Fahrenheit, will deteriorate or spoil and if the temperature falls below 32 degrees will freeze and therefore will also spoil or deteriorate. It will be apparent that if the atmospheric temperature is below freezing, the chamber must be heated to prevent the cargo from freezing and that if the atmospheric temperature is above 40 degrees in the instant case, the chamber must be cooled. The bulk head or wall 11 of such vehicle is shown to indicate that certain components of the apparatus are located in the chamber and that other components thereof are located exteriorly of the chamber.

The apparatus includes a compressor 12 which may be driven by an electric motor 13 and a condenser 14. The compressor and motor are located exteriorly of the chamber A. Suitable means such as a blower, not shown, may be employed to move atmospheric air over the condenser to cool hot compressed refrigerant fluid in gaseous state delivered thereto from the compressor when the apparatus is in the refrigeration or cooling cycle of its operation.

The refrigerant fluid is transmitted from the high pressure outlet 15 of the compressor to the top inlet end of the condenser through a conduit 16, a T-coupling 17 and a conduit 18 having a solenoid valve 19 connected therein which controls fluid flow therethrough. The lower outlet end of the condenser is connected to the inlet 21 of an internal coil 22 of a heat exchanger 25 by a conduit 26 having a check valve 27 connected therein which permits flow from the condenser outlet to the inlet 21 and prevents flow in the opposite direction through the conduit 26 to the outlet end of the condenser, a T-coupling 28 and a conduit 29.

The heat exchanger 25 includes an inner tubular shell 30, in which the coil 22 is disposed, and an outer shell 31 disposed about the inner shell, the two shells providing an outer passage 32 therebetween. The inlet 21 is connected to one end of the outer passage by a branch duct 33 and the outlet 34 of the coil is connected to the passage at its other end by a branch duct 35. As a result, a portion of the refrigerant fluid flowing from the conduit 28 to the heat exchanger flows through its coil 22

and another portion thereof flows through its outer passage 32.

The outlet 34 of the heat exchanger is connected to the inlet 37 of an expansion valve 38 by a conduit 41, a T-coupling 46, a conduit 47, having a manually operable shut off valve 48 connected therein, a T-coupling 49 and a conduit 50 in which are connected a sight glass 51 and a dryer 52.

The outlet 55 of the expansion valve is connected to a distributor 58 and the lower inlet ends of the coils 59 of the evaporator 60, only two of which are shown, are connected to the outlets 61 of the distributor. It will be apparent of course that the distributor has as many outlets 61 as the evaporator has coils. The upper outlet ends of the evaporator coils are connected to the inlets 62 of the suction header 64 of the evaporator, it also being apparent that the suction header has as many inlets 62 as the evaporator has coils. The outlet 66 of the header is connected to the suction inlet 67 of the compressor through a conduit 69 which has a back pressure of hold-back valve 70 connected therein and is connected to the inlet 71 of the shell 30, the interior or passage 72 of the shell, and a conduit 73 which is connected at one end to the outlet 74 of the shell and at its other end to the compressor inlet.

The hold-back valve 70 may be of any suitable type and is shown schematically as having a housing 75, a seat ring 76 and a valve member 77 biased toward seating engagement with the seat ring to close the valve by a spring 78. It will be apparent that a predetermined pressure differential must exist across the valve member before it is moved toward its open position to permit flow from the conduit 69 to the passage 72 of the shell 30.

The expansion valve 38 may be of any suitable well known type which controls the rate of refrigerant fluid flow therethrough in accordance with the temperature of the refrigerant fluid flowing from the suction header 64, which is sensed by a temperature bulb 81 filled with a suitable liquid and connected to the expansion valve by a conduit 82, and with the pressure of the refrigerant fluid at the suction header outlet which is communicated to the expansion valve by a conduit 84. The pressure of the liquid in the temperature bulb, which varies directly in accordance with the temperature of the refrigerant fluid flowing from the evaporator, is transmitted to one side of a diaphragm of the expansion valve and tends to open the valve while the pressure of the refrigerant fluid transmitted to the opposite side of the diaphragm tends to close the valve.

A receiver 86 which may be in a form of a closed container or tank has its downwardly opening neck or pipe 87 is connected to the upwardly extending leg of the T-connector 46. The level of the liquid refrigerant fluid in the receiver 86 will of course vary with the pressure in the conduits 41 and 47, such pressure dropping as the efficient operation of the apparatus require more refrigerant fluid in circulation through the apparatus and thus causing more refrigerant fluid to flow from the receiver for circulation through the apparatus. The receiver may be omitted if desired.

During the normal refrigeration or cooling cycle of operation of the apparatus, the hot compressed refrigerant in gaseous state flows from the high pressure outlet 15 of the compressor to the inlet of the condenser 14 through the open solenoid valve 19 in the conduit 18 and then in flowing through the condenser is cooled and liquified. The cooled and liquified refrigerant fluid from the condenser flows through the inner coil 29 and the outer passage 32 of the heat exchanger where it is further cooled by the absorption of heat therefrom by the refrigerant fluid flowing from the evaporator to the inlet of the compressor through the inner passage 72 or chamber of the heat exchanger. The refrigerant fluid then flows to the inlet 37 of the expansion valve through the conduit 41, the T-coupling 46, the conduit 47, the coupling 49 and

the conduit 50. The liquid refrigerant fluid in flowing through the expansion valve evaporates and expands and in flowing through the coils 58 of the evaporator to the suction header 64 further expands and absorbs heat from the chamber A. A suitable blower, not shown, circulates the air in the chamber through the evaporator coils. The warmed refrigerant fluid then flows from the suction header of the evaporator through the conduit 69 and its back pressure valve 70 to the chamber 72 of the heat exchanger where it absorbs heat from the refrigerant fluid flowing through the coil 22 and the outer passage 32 of the heat exchanger and then flows back to the inlet 67 of the compressor through the conduit 73.

During the heating cycle of operation of the apparatus, the high pressure outlet 15 of the compressor is connected to the inlet 21 of the heat exchanger 25 through the conduit 16, the T-coupling 17, a conduit 90 in which is connected a solenoid valve 91 which controls fluid flow there-through, a T-coupling 92, a conduit 93 in which a check valve 94 is connected, the T-coupling 28 and the conduit 29. The outlet 34 of the heat exchanger is connected to the outlet 55 of the expansion valve through the conduit 41, the T-coupling 46, the conductor 47, the T-coupling 49, and the expansion valve by-pass conduit 95, which has a solenoid valve 96 connected therein.

The high pressure outlet of the compressor during the heating cycle of operation of the apparatus is connected to the inlet 97 of the suction header through the conduit 90, the T-coupling 92, a conduit 98, a defrost coil 99 disposed in the usual drip pan 100 located below the evaporator 60, and the conduit 101.

The refrigerant fluid flows from the suction header to the inlet of the compressor through the conduit 69, the heat exchanger passage 72 and the conduit 73.

The solenoid valves 19, 91, and 96 are open when their solenoids 101, 102 and 103, respectively, are energized and are closed when their solenoids are de-energized.

The energization of the solenoids and of the motor may be controlled by any suitable control circuit, the circuit illustrated in the drawing being merely exemplary of such a control circuit. As shown in the drawing, the energization of the solenoid 101 is controlled by the contact 106 and of the solenoids 102 and 103 by the contact 107 of a switch 108. When the contact 106 is in the closed position illustrated in the drawing, the solenoid 101 of the valve 19 is connected across the main conductors 110 and 111 by means of the conductor 114, the contact 106, and the conductors 115 and 116. When the contact 107 is in its closed position, the solenoid 102 of the valve 91 is connected across the main conductors 110 and 111 by the conductors 118, 119 and 120 and the solenoid 103 of the valve 96 is connected across the main conductors 110 and 111 by the conductors 118, 122 and 123. The main conductors 110 and 111 are connectable to the terminals 125 and 126 of an input circuit 127 by the contacts 128 and 129 of a main switch 130.

The operation of the electric motor 13 and therefore of the compressor 12, when the apparatus is in use to cool the chamber A and maintain it below a predetermined value, may be controlled by a thermostat 131 positioned in a suitable location in the chamber which closes whenever the temperature in the chamber rises above a predetermined value to connect the winding 132 of a relay 133 across the main conductors through the conductor 134, the contact 135 of the switch 108 and the conductors 135a, 136 and 137. The relay winding 132 when energized moves its contacts 138 and 139 to their closed positions which then connect the motor 13 across the main conductors 110 and 111 through the conductors 140, 141, 142 and 137.

When the apparatus is in use to maintain the temperature in the chamber A above a predetermined value, the operation of the motor 13 is controlled by a second thermostat 145 which closes whenever the temperature in the chamber drops below a predetermined value to

5

connect the relay winding 132 across the main conductors through the conductors 134 and 146, the contact 148 of the switch 108 which is now in its closed position, and the conductors 149, 150, 136 and 137.

It will be apparent that the contacts of the switch 108 may be mechanically interconnected so that in the position of the switch 108 placing the apparatus in its cooling cycle of operation, the contacts 106 and 135 are in their closed positions and its contacts 107 and 148 are in their open positions, and in the position of the switch placing the apparatus in its heating cycle of operation, its contacts 106 and 135 are in their open positions and their contacts 107 and 148 are in their closed positions. It will also be apparent that protective devices for the motor and compressor such as switches responsive to refrigerant fluid pressure at the outlet and inlet of the compressor may be provided which will disconnect the motor from the main conductors when abnormal pressure conditions occur in the apparatus. Such protective devices and associated circuitry have not been illustrated and described since they do not constitute any portion of the present invention.

A manually operable defrost switch 160 may be provided which when closed connects the relay winding 132 across the main conductors 110 and 111 through the conductors 140, 161, 162, 136 and 137.

In use, during the refrigeration or cooling cycle of operation of the apparatus the contacts 128 and 129 of the main switch 130 are in their closed positions, the contacts of the switch 108 are in the positions illustrated in the drawing with the contacts 106 and 135 being in their closed positions and the contacts 107 and 145 being in their open positions, the solenoid valves 91 and 96 are closed, and the solenoid valve 19 is open. If the temperature within the chamber A now rises above a predetermined value, for example above 36 degrees, the thermostat 131 will close and connect the winding 132 of the relay 133 across the main conductors 110 and 111, the relay contacts 138 and 139 are moved to their closed position and the motor 13 which drives the compressor 12 is connected across the main conductors. Energization of the motor causes the compressor to draw in refrigerant fluid through its inlet 67, compress the refrigerant fluid thus imparting energy thereto and also raising its temperature and expel the hot compressed refrigerant fluid through its outlet 15 to flow to the upper end of the condenser 14. The refrigerant fluid cannot now flow through the condenser by-pass conduit 90 because the valve 91 is closed. In flowing downwardly through the condenser, the refrigerant fluid is cooled and liquified and then flows through the conduit 26, the check valve 27 and the conduit 29 to the heat exchanger. The refrigerant fluid in flowing through the coil 22 and the outer passage 32 thereof is further cooled due to the absorption of heat from the refrigerant gas which is flowing through the chamber 72 of the heat exchanger to the inlet 67 of the compressor. The liquid refrigerant fluid then flows to the inlet 37 of the expansion valve and through the expansion valve to the evaporator coils 59. The refrigerant fluid cannot now flow through the expansion valve by-pass conduit 95 to the outlet 55 of the expansion valve because the valve 96 is closed. The check valve 94 now prevents flow from the T-coupling 28 through the conduit 93 to the T-coupling 92. The refrigerant fluid in evaporating and expanding during its flow through the expansion valve and the evaporator coils absorbs heat from the air within the chamber A. It will be apparent, of course, that a suitable blower is employed to move the air within the chamber A over the coils of the evaporator. The refrigerant fluid then flows from the suction header 64 through the conduit 69, the back pressure valve, and the chamber 72 of the heat exchanger to the inlet 67 of the compressor. The refrigerant fluid flowing through the passage 72 is in gaseous state and at a lower temperature than the liquid refrigerant

6

fluid flowing through the heat exchanger coil 22 and the passage 32 so that it absorbs heat from the refrigerant fluid flowing toward the expansion valve through the coil 22 and the outer passage 32 of the heat exchanger. The back pressure valve 70 maintains a certain predetermined back pressure in the conduit 69 and therefore in the evaporator coil. When the temperature in the chamber drops below the predetermined value the thermostat 131 opens and the motor is de-energized thus stopping operation of the apparatus.

During the cooling cycle of operation of the apparatus, condensate may collect on the evaporator coils and the drip pan 100, and may also drip off the coils into the drip pan since the drip pan is immediately below the coils 59. When the temperature at the evaporator drops below freezing temperature, such condensate in the drip pan and on the evaporator coils freezes or such condensate may deposit on the coils and the drip pan in the form of frost. If it is desired to defrost the evaporator by melting off such frost or ice, the switch 108 is moved to position wherein the switches 106 and 135 are open and the switches 107 and 148 are closed. The solenoid 101 is thus de-energized and the valve 19 closes, and the solenoids 102 and 103 are energized and the valves 91 and 96 are opened. The defrost switch is then closed to insure that the motor 13 is energized in the event that the temperature in the chamber A during cooling operations is at a temperature higher than the temperature below which the thermostat 145 closes. Closing of the defrost switch causes the relay winding 132 to be energized and the operation of the motor now causes the compressor to operate and hot compressed refrigerant fluid from the outlet 15 of the compressor to flow through the conduits 16 and 90, the valve 91, the T-coupling 92, the check valve 94, the conduit 93, the T-coupling 28 and the conduit 29 to the inlet 21 of the heat exchanger. The closed valve 19 now prevents flow of refrigerant fluid from the compressor outlet to the condenser. The check valve 27 prevents flow of refrigerant fluid to the lower end of the condenser. The hot refrigerant gas in flowing through the inner coil 22 and the outer passage 32 of the heat exchanger absorbs heat from the refrigerant fluid flowing through the passage 72 of the shell 30 to the inlet of the compressor to insure that any refrigerant fluid which may be in liquid state when it reaches the heat exchanger is evaporated before it moves to the inlet of the compressor. The hot refrigerant fluid flows through from the heat exchanger outlet to the outlet 55 of the expansion valve through the conduit 41, the T-coupling 46, the conduit 48, the coupling 49 and the expansion valve by-pass conduit 95. A portion of the hot compressed refrigerant fluid from the outlet of the compressor now flows to the suction header to evaporate or disperse into droplets any liquid refrigerant which may be flowing from the evaporator coiled into the suction header from the T-coupling 92 through the conduit 98, the drip pan coil 99 and the conduit 101. If a portion of the hot gas were not transmitted directly to the suction header without passing through the heat exchanger and the evaporator coils, at the initiation of operation of the compressor the first portion of the refrigerant fluid in flowing through the heat exchanger and evaporator coils would tend to condense or liquify due to the rapid absorption of heat therefrom by the ice and frost present on the coils and a slug of the liquid refrigerant fluid would reach the inlet of the compressor which could result in malfunction of the compressor and also damage thereto. The introduction of a portion of the hot refrigerant fluid into the suction header causes the portion of the refrigerant fluid liquified in passing through the condenser coils to be re-evaporated or at least dispersed into droplets. The cooled refrigerant fluid flows from the outlet 66 of the suction header through the conduit 69 in its gaseous state, or as a mixture of droplets and gas, through the back-up valve and into the passage 72 of the heat exchanger where the heat

absorbed from the hot compressed refrigerant fluid flowing through the inner coil and the passage 32 thereof causes evaporation of any droplets of the refrigerant fluid. Little or no refrigerant fluid will flow through the expansion valve during this defrost operation of the apparatus since the pressures on both sides thereof will be substantially equal and the expansion valve will remain in its normally closed or substantially fully closed position. The melted condensate is drained from the pan through a suitable drain conduit, not shown. After ice and frost have been melted off the evaporator and drain pan, the defrost switch is opened and the switch 108 is moved back to its position illustrated in the drawing whereupon the thermostat 131 will again control operation of the apparatus to maintain the temperature of the chamber A below the predetermined value.

Defrosting of the evaporator and the drip pan is accomplished in a very short period of time before the temperature within the chamber A can rise to an undesired degree since substantially all of the energy imparted to the refrigerant fluid during its compression by the compressor 12 is utilized to melt the frost or ice from the drain pan and the evaporator since no portion of the hot compressed gas can flow to the condenser 14 which would dissipate some of the heat energy to atmosphere. To further minimize loss of heat energy by the refrigerant fluid during the defrost cycle of operation of the apparatus, the portions of the conduit means through which the refrigerant fluid is transmitted to and from the compressor located exteriorly of the chamber are preferably encased or covered by a heat insulating substance. For example, the conduit 16, the T-coupling 17, the conduit 90 and its valve 91, the T-coupling 92, the conduit 93 and its check valve 94, the coupling 28, and the portions of the conduits 29 and 73 located externally of the chamber are preferably insulated.

When the ambient temperature exteriorly of the chamber A is lower than the predetermined temperature at which the chamber must be maintained, so that the apparatus 10 must be employed to heat the chamber A, the switch 108 is moved to the position wherein its contacts 106 and 135 are open, the valve 19 closed and the thermostat 131 is ineffective to control energization of the relay winding 132; and its contacts 107 and 148 are closed, the valves 91 and 93 are open, and the thermostat 145 is effective to control energization of the relay winding 132. When the temperature in chamber A falls below the predetermined value, for example 36 degrees, the thermostat switch 145 will close and will cause connection of the relay winding 132 across the main conductors and the closure of its contacts 141 and 142 will energize the motor 13. The hot compressed gas from the outlet 15 of the compressor will now flow to the evaporator in the same manner as described above in connection with the defrost cycle and in moving through the drip pan coil 92 and the evaporator coils 59 will absorb heat from the air within the chamber A and thus raise its temperature. The thermostat 145 of course opens whenever the temperature rises above the predetermined temperature.

It will be noted that very little of the heat energy imparted to the refrigerant fluid due to the operation of the compressor can be lost to the atmosphere since the heat exchanger, the evaporator, and the receiver are all located within the chamber A and since the conduit means of the systems located exteriorly of the wall 11 through which the refrigerant fluid is being circulated during the heating cycle of operation of the apparatus are insulated. No portion of the fluid being circulated by the compressor can migrate to the condenser 14 since the check valve 27 prevents flow of the refrigerant fluid to the lower end of the condenser and the closed valve 19 prevents its flow to its upper end. Since the condenser 14 is at a low temperature, if the check valve 27 were not provided the refrigerant fluid would tend to migrate to the condenser and cool and change to its liquid state and, as a result, the

apparatus would not function efficiently to heat the chamber since sufficient refrigerant fluid would not be in circulation through the evaporator and the heat exchanger.

Due to the provision of by-pass means which causes a portion of the compressed gas to bypass the evaporator coils 59 and flow directly to the suction manifold 64, should any portion of the refrigerant fluid in flowing through the evaporator coils tend to liquify due to the absorption of heat therefrom by the air in the chamber, the hot refrigerated fluid flowing directly into the suction header will tend to evaporate any such liquid fluid flowing into the header from the evaporator coils or disperse such liquid fluid into droplets. The heat exchanger further ensures that the refrigerant fluid flowing to the inlet of the compressor is in its gaseous state so that the compressor will function properly and will not be subjected to overloads due to liquid refrigerant fluid reaching its inlet.

The effective orifices of the conduits providing for flow of the hot compressed refrigerant fluid simultaneously to the inlet ends of the evaporator coils and to the suction header inlet 97 have been found not to be critical and the apparatus to function properly if the orifices are approximately equal.

It will be appreciated that, if desired, by use of suitable controls well known in the art, the defrosting of the evaporator may be made automatic and responsive to a predetermined accumulation of ice in the drain pan or on the evaporator coils.

It will now be apparent that the energy imparted to the refrigerant fluid by the compressor may be utilized to heat the drain pan coil and the evaporator coils and thus defrost the evaporator and the drain pan, or, if the ambient temperature is lower than the predetermined temperature which must be maintained in the conditioned chamber, the energy imparted to the refrigerant fluid by the compressor may be used to heat the conditioned chamber.

It will now be seen that a new and improved air-conditioning apparatus for controlling the temperature in a chamber has been illustrated and described which has a compressor 12 and a condenser 14 disposed exteriorly of the conditioned chamber; an evaporator 44 which includes an expansion valve 38, a distributor 58, a plurality of coils 59 and a suction header 64 disposed in the chamber; a first conduit means, such as the conduit 16, the T-coupling 17 and the conduit 18, for conducting refrigerant fluid from the outlet of the compressor to the condenser; a second conduit means, such as the conduit 26, the coupling 28, the conduit 29, the inner coil 22 of the heat exchanger 25 and its outer passage 32, the conduit 41, the T-coupling 46, the conduit 47, the coupling 49 and the conduit 50, for conducting refrigerant fluid from the condenser to the inlet of the expansion valve; a first or condenser bypass means, which may include the T-coupling 17, the conduit 90, the coupling 92, the conduit 93 and the coupling 28 connected to the first and second conduit means for conducting fluid from the outlet of the compressor to the second conduit means without passing through the condenser; a second or expansion valve bypass means, such as the T-coupling 49 and the conduit 95 for conducting refrigerant fluid from the second conduit means to the outlet of the expansion valve and therefore to the upstream or inlet ends of the evaporator coils; a third bypass means, which may include the T-coupling 92, the conduit 98, the drip pan coil 99 and the conduit 101 connected between the first by-pass means and the inlet 97 of the suction header, and therefore, to the downstream or outlet ends of the evaporator coils for conducting hot compressed refrigerant fluid from the first by-pass means to the suction header, a third conduit means, which may include the conduit 69, the back pressure valve 70, the passage 72 of the shell 30 of the heat exchanger 25 and the conduit 73, for conducting refrigerant fluid from the suction header of the evaporator to the inlet of the com-

pressor; and valve means such as the valves 19, 91 and 96 connected in the first conduit means, the first by-pass means and the second by-pass means, respectively, for causing refrigerant fluid to flow from the outlet of the compressor through the condenser and the evaporator to the inlet of the compressor during the cooling cycle of operation and for causing refrigerant fluid to flow from the outlet of the compressor to the suction header and to the outlet of the expansion valve, and thus to opposite ends of the evaporator coils 59, and from the suction header through the third conduit means to the inlet of the compressor during the heating and defrost cycles of operation of the compressor.

It will further be seen that, if desired, a reservoir for the refrigerant fluid, such as the receiver 86, may be connected to the second conduit means, as by the T-coupling 46 downstream of the heat exchanger and upstream of the expansion valve 38, in which a reserve quantity of the refrigerant fluid may be stored so that a proper quantity of the refrigerant fluid is always available for circulation through the apparatus during the operation of the apparatus.

It will further be seen that a valve means, such as the check valve 27, is connected in the second conduit means for preventing migration or flow of fluid into the condenser during the heating cycle of operation of the apparatus and a valve means, such as the check valve 94, is provided in the first by-pass means to prevent flow of refrigerant gas to the suction header during the cooling cycle of operation of the apparatus.

It will further be apparent that the heat exchanger, and the receiver if it is used, as well as the evaporator are all disposed within the conditioned chamber A in order that the maximum quantity of the energy imparted to the refrigerant fluid by the compressor during the heating cycle of operation of the apparatus be available to heat the condition chamber A and not be dissipated to the atmosphere.

The foregoing description of the invention is explanatory only, and changes in the details of the construction illustrated may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. An air conditioning apparatus for controlling the temperature in a chamber including: a compressor having an inlet and an outlet; a condenser, said compressor and said condenser being disposed exteriorly of the chamber; an evaporator having coil means and an expansion valve for controlling flow of liquid refrigerant fluid to said coil means, said evaporator being disposed in the chamber; first conduit means for conducting refrigerant fluid from said outlet of said compressor to said condenser; second conduit means for conducting refrigerant fluid from said condenser to said expansion valve; first bypass means connected to said first and second conduit means for conducting fluid from said outlet of said compressor to said second conduit means without passing through said condenser; second bypass means connected to said second conduit means for conducting fluid from said second conduit means to the inlet end of said coil means without passing through said expansion valve; third bypass means for conducting fluid from said first bypass means to the outlet end of said coil means; third conduit means for conducting refrigerant fluid from said evaporator to said inlet of said compressor; and valve means operatively associated with said bypass means and said first conduit means for causing refrigerant fluid to flow from said outlet of said compressor through said condenser, said expansion valve, said evaporator and said third conduit means to said inlet of said compressor during the cooling cycle of operation of said apparatus and for causing refrigerant fluid to flow from said outlet of said compressor to opposite ends of said coil means and through said third conduit means to said

inlet of said compressor during the heating cycle of operation of said apparatus.

2. The air conditioning apparatus of claim 1, and a heat exchanger operatively associated with said second and third conduit means wherein refrigerant fluid flowing through said third conduit means to the inlet of the compressor absorbs heat from the refrigerant fluid flowing through said second conduit means, said third bypass means being connected to said first bypass means upstream of said heat exchanger whereby during the heating cycle of operation refrigerant fluid flows to the outlet end of said coil means without passing through said heat exchanger.

3. The air conditioning apparatus of claim 2, and first valve means in said second conduit means for preventing refrigerant fluid flow through said first conduit means to said condenser during the heating cycle of operation of the apparatus.

4. The air conditioning apparatus of claim 3, and second valve means operatively associated with said third bypass means for preventing refrigerant fluid flow through said third bypass means about said coil means during the cooling cycle of operation of the apparatus.

5. The air conditioning apparatus of claim 4, and a pressure regulating means connected in said third conduit means upstream of said heat exchanger.

6. The air conditioning apparatus of claim 5, and a receiver for refrigerant fluid connected to said second conduit means, said receiver being disposed in the chamber.

7. The air conditioning apparatus of claim 1, and first valve means in said second conduit means for preventing refrigerant fluid flow through said first conduit means to said condenser during the heating cycle of operation of the apparatus.

8. The air conditioning apparatus of claim 7, and second valve means operatively associated with said second bypass means for preventing refrigerant fluid flows through said second bypass means during the cooling cycle of operation of the apparatus.

9. The air conditioning apparatus of claim 8, and a pressure regulating means connected in said third conduit means upstream of said heat exchanger.

10. The air conditioning apparatus of claim 9, and a receiver for refrigerant fluid connected to said second conduit means between said heat exchanger and said second bypass means, said receiver being disposed in the chamber.

11. The air conditioning apparatus of claim 2, and a receiver for refrigerant fluid connected to said second conduit means, said receiver being disposed in the chamber.

12. An air conditioning apparatus for controlling the temperature in a chamber including: a compressor having an inlet and an outlet; a condenser, said compressor and said condenser being disposed exteriorly of the chamber; and evaporator comprising a plurality of tubular coils, an expansion valve, a distributor connected between the outlet of the expansion valve and the inlet ends of the coils, and a suction header, the outlet ends of the coils being connected to the suction header, said evaporator being disposed in the chamber; first conduit means for conducting refrigerant fluid from the outlet of said compressor to said condenser; second conduit means for conducting refrigerant fluid from said condenser to the inlet of said expansion valve; bypass means for conducting fluid from said outlet of said compressor to said second conduit means without passing through said condenser; bypass means for conducting fluid from said second conduit means to the inlet ends of the evaporator coils without passing through said expansion valve and for conducting fluid from said outlet of said compressor to said suction header; third conduit means for conducting refrigerant fluid from said suction header to said inlet of said compressor; and valve means operatively associated with said

11

bypass means and said first and second conduit means for causing refrigerant fluid to flow from said outlet of said compressor through said condenser, said expansion valve, said evaporator coils, said suction header and said third conduit means to said inlet of said compressor during the cooling cycle of operation of the apparatus and for causing refrigerant fluid to flow from said outlet of said compressor to said inlet ends of said evaporator coils and to said suction header, and from said suction header through said third conduit means to said inlet of said compressor during the heating cycle of operation of said compressor.

13. The air conditioning apparatus of claim 12, and a heat exchanger operatively associated with said second and third conduit means wherein refrigerant fluid flowing through said third conduit means to the inlet of the compressor absorbs heat from the refrigerant fluid flowing through said first conduit means, the second mentioned bypass means being connected to conduct fluid from said outlet of said compressor to said suction header without passing through said heat exchanger.

14. The air conditioning apparatus of claim 13, and valve means in said second conduit means for preventing

12

refrigerant fluid flow through said second conduit means to said condenser.

15. The air conditioning apparatus of claim 14, and second valve means operatively associated with the second mentioned bypass means for preventing refrigerant fluid flow through said second mentioned bypass means during the cooling cycle of operation of the apparatus.

16. The air conditioning apparatus of claim 15, and a pressure regulating means connected in said third conduit means upstream of said heat exchanger for maintaining a predetermined pressure in said third conduit means upstream of said heat exchanger.

17. The apparatus of claim 16, and a receiver for refrigerant fluid connected to said second conduit means, said receiver being disposed in the chamber.

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