

March 23, 1954

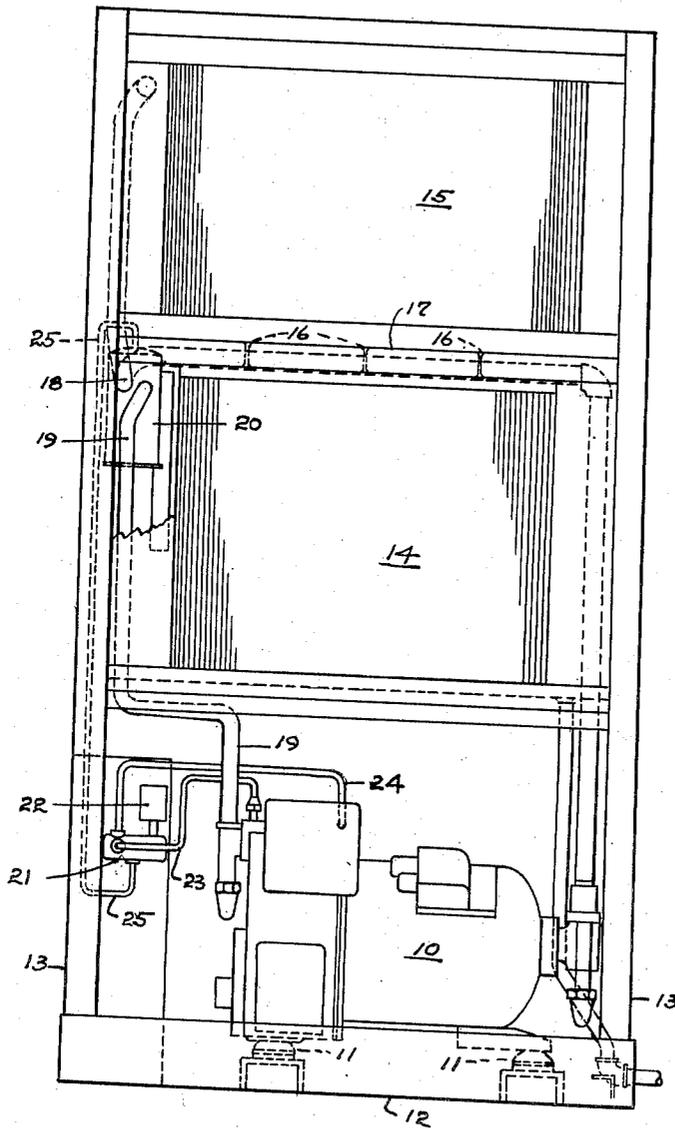
J. L. DITZLER ET AL  
AIR CONDITIONING APPARATUS

2,672,734

Filed Nov. 7, 1950

6 Sheets-Sheet 1

FIG. 1



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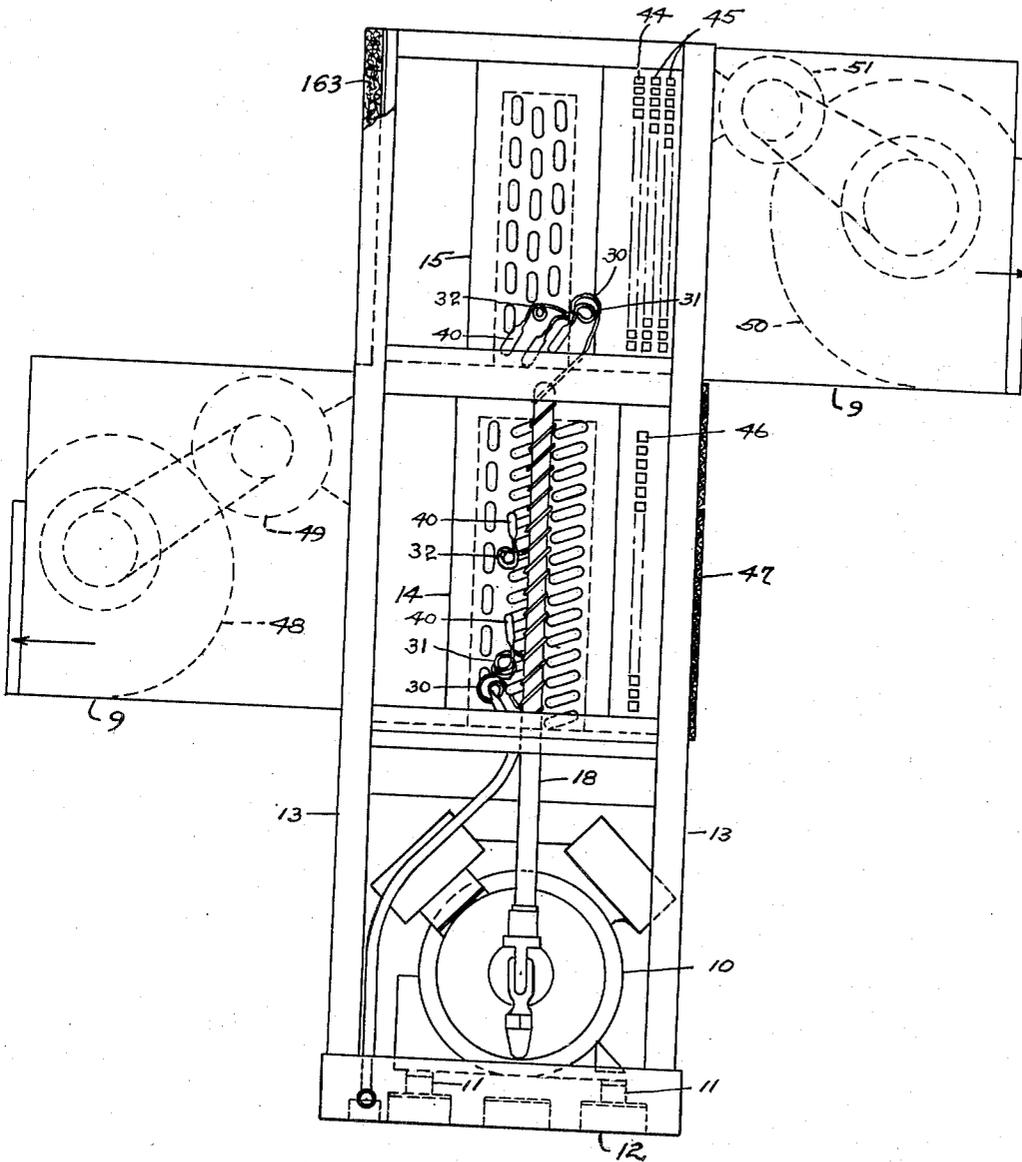
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FIG. 2



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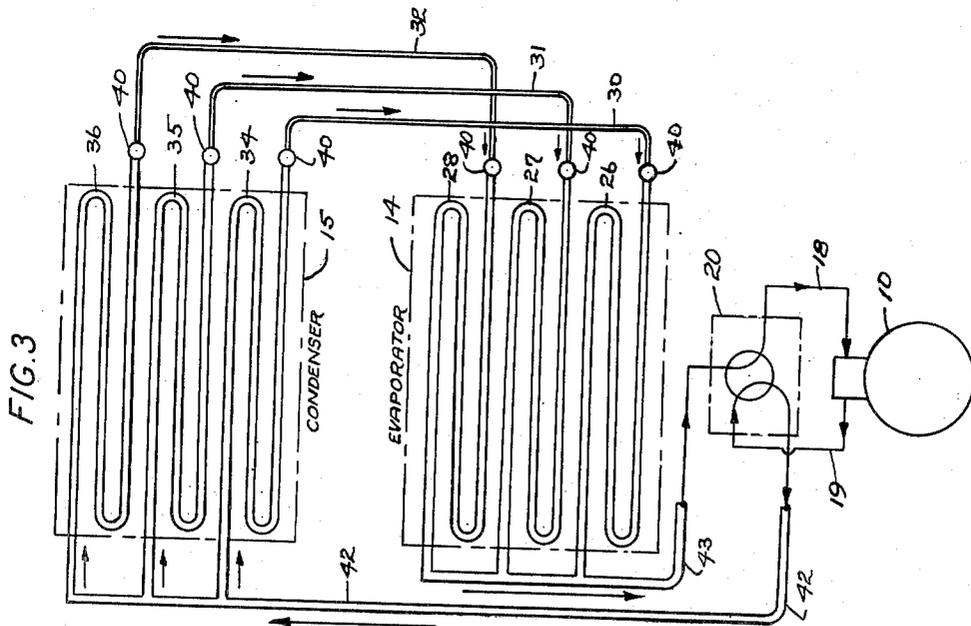
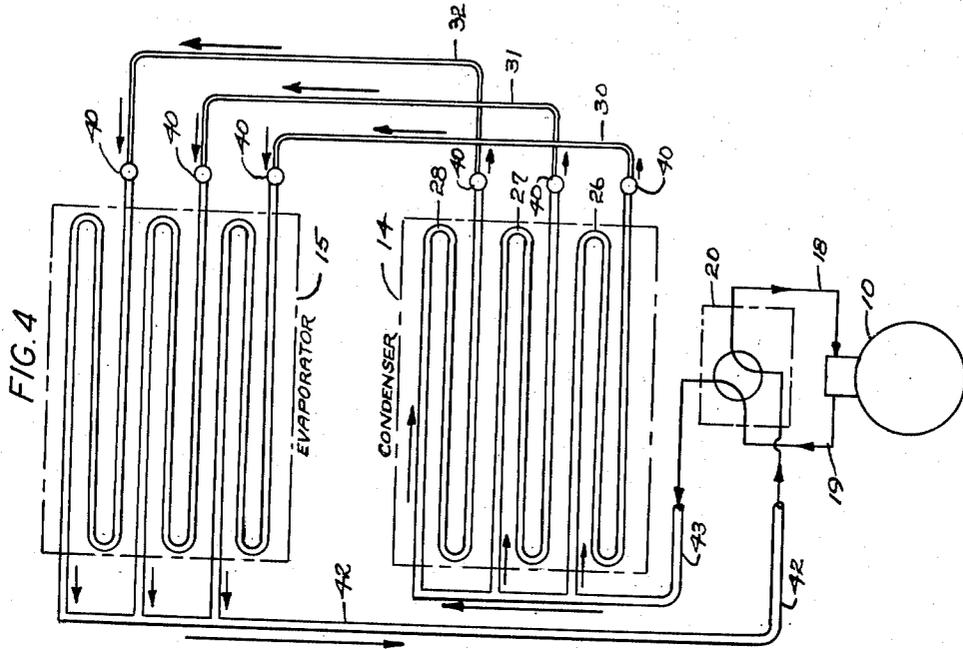
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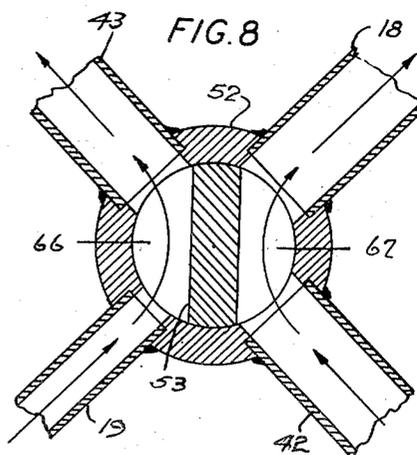
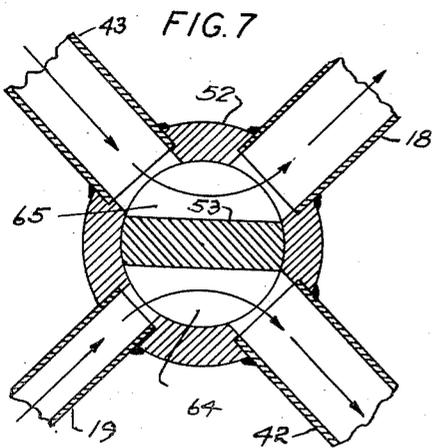
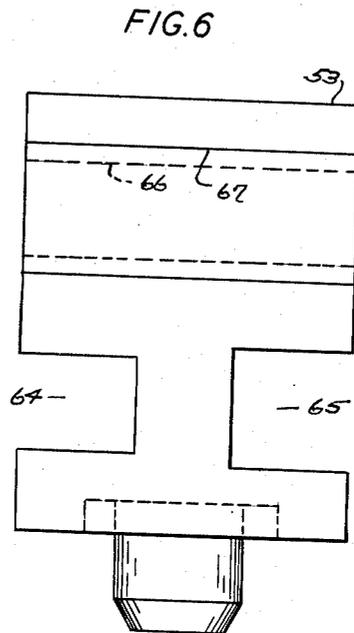
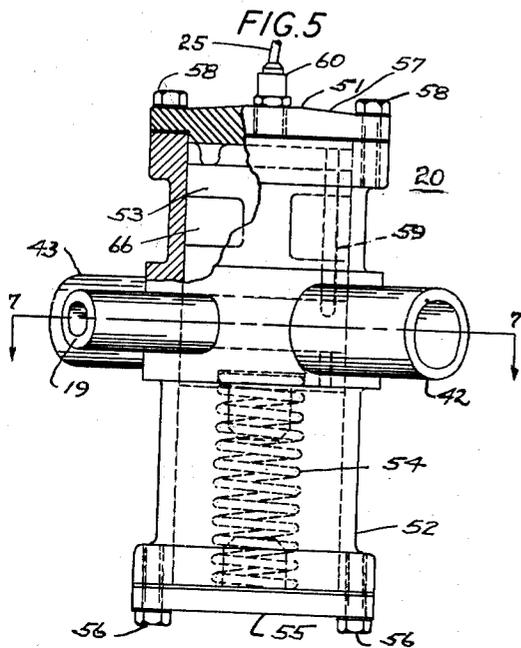
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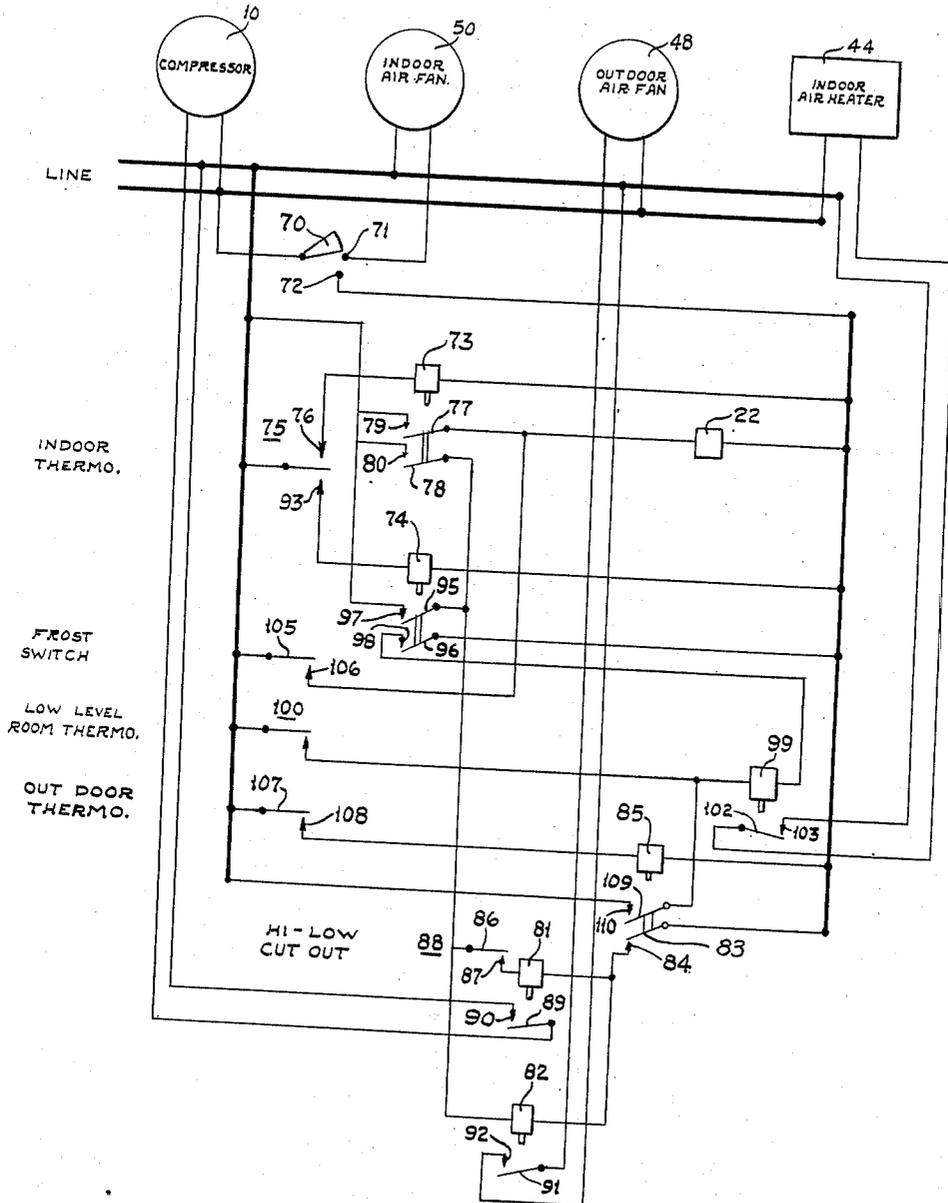
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6 Sheets-Sheet 5

FIG. 9



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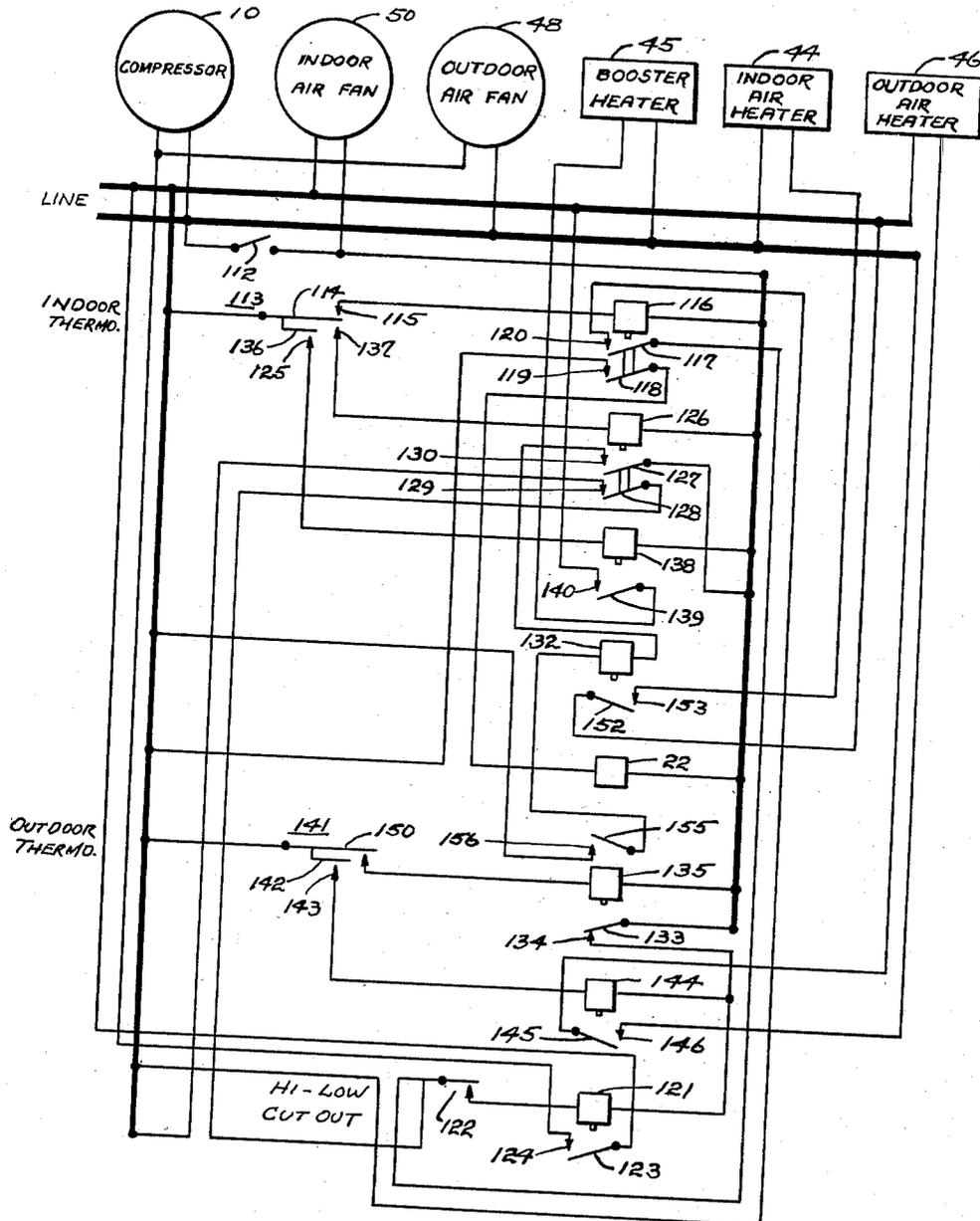
J. L. DITZLER ET AL  
AIR CONDITIONING APPARATUS

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6 Sheets-Sheet 6

FIG. 10



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# UNITED STATES PATENT OFFICE

2,672,734

## AIR CONDITIONING APPARATUS

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3 Claims. (Cl. 62-6)

1

This invention relates to refrigeration apparatus, and relates more particularly to heat pumps of the type used for air cooling in summer and for air heating in winter.

Prior heat pumps for cooling air in summer and for heating air in winter have been unduly complicated and costly, and have required elaborate controls for reversal of operation. This invention overcomes these disadvantages.

A feature of this invention is that the evaporator and condenser are arranged to have an equal number of refrigerant paths, expansion taking place in capillary tubes which are self draining and in which flow can take place in either direction in instantaneous balance when reversal is required. The capillary tubes may be wrapped around the suction pipe of the refrigerant compressor for superheating the gas therein and for subcooling the liquid in the capillary tubes.

Another feature of this invention is that the tubes used as evaporator tubes in summer are supported directly over the tubes used at that time as condenser tubes, and precipitate moisture condensed from the air thereon for providing evaporative cooling thereof.

Another feature of this invention is that separate fans are used with the evaporator and condenser tubes, one fan acting to move indoor air in the same direction in both the cooling and heating seasons, and the other fan being arranged to move outdoor air in the same direction in both the cooling and heating seasons, the fans being so supported that either can be arranged to move air in different directions, thereby enabling them to be connected to ducts extending in different directions.

Another feature of this invention is that simple, effective control systems may be used, which energize electric heaters for auxiliary indoor heat when needed, and which defrost or prevent the frosting of the evaporator tubes in the heating season.

Another feature of this invention is that the heat exchange tubes are centrally arranged in supporting racks with spaces on both sides thereof for the location of electric heaters and filters so that the air flow can be in either direction without affecting performance.

Another feature of this invention is that the refrigerant paths are so arranged that the air flow through the heat exchange tubes can be in either direction without affecting efficiency.

Another feature of this invention is that in case of failure of any component, the reversing

2

valve means used will operate in the heating cycle, preventing any possibility of the heat pump operating in the cooling cycle during the heating season.

5 An object of the invention is to simplify heat pumps used for heating air in winter and for cooling air in summer.

Another object of the invention is to simplify the controls of heat pumps used for heating air in winter and for cooling air in summer.

Another object of the invention is to improve the performance of heat pumps for heating air in winter and for cooling air in summer.

The invention will now be described with reference to the drawing, of which:

Fig. 1 is a side elevation of a heat pump embodying this invention;

Fig. 2 is an end elevation of the heat pump;

Fig. 3 is a simplified flow diagram illustrating the refrigerant circuit in the heating cycle;

Fig. 4 is a simplified flow diagram illustrating the refrigerant circuit in the cooling cycle;

Fig. 5 is an enlarged side elevation, partially in section, of the reversing valve means with its piston in the normal position for operation in the heating cycle;

Fig. 6 is an enlarged side elevation of the piston of the valve means;

Fig. 7 is a sectional view along the lines 7-7 of Fig. 5, with arrows illustrating the flow of the refrigerant in the heating cycle;

Fig. 8 is a view similar to Fig. 7 and illustrates the flow of the refrigerant in the cooling cycle, at which time the piston of Fig. 5 is depressed;

Fig. 9 is a diagrammatic view illustrating a control circuit which may be used, and

Fig. 10 is a diagrammatic view illustrating another control circuit which may be used.

The hermetically sealed, refrigerant compressor 10 is supported by the resilient supports 11 on the base channels 12 and between the vertical channels 13.

The finned heat exchanger 14 which acts as the condenser for the compressor in the cooling cycle, is supported from the channels 13 directly above the compressor, and the finned heat exchanger 15 which acts as the evaporator during the cooling cycle, is supported from the channels 13 directly above the heat exchanger 14. The slits 16 in the cross support 17 between the heat exchangers 14 and 15 permit moisture condensed from the air during the cooling cycle on the surface of the heat exchanger 15, to drain upon the heat exchanger 14 so as to aid in cooling it by evaporative cooling.

3

The suction and discharge pipes 18 and 19 respectively, of the compressor are connected to the reversing valve means 20 and through same to the heat exchangers 14 and 15. The control for the reversing valve means consists of the three-way valve 21 operated by the solenoid 22, and connected by the tube 23 to the discharge side of the compressor, by the tube 24 to the suction side of the compressor, and by the tube 25 to the space above the piston in the reversing valve 20.

The heat exchanger 14 comprises the three coils 26, 27 and 28 (Figs. 3 and 4), which are connected at one side through the capillary tubes 30, 31 and 32 respectively, to the three coils 34, 35 and 36 of the heat exchanger 15. The capillary tubes contain the strainers 40. The heat exchangers 14 and 15 are connected at their other sides through the pipes 42 and 43 respectively, to the reversing valve 20.

The evaporator and condenser are seen to have an equal number of refrigerant paths, the expansion of the refrigerant taking place in each path, through its individual capillary tube, instead of through the usual expansion valves, which will not permit reverse flow, and which when used in a reverse cycle system, have to have check valves and by-pass pipes, and which are much slower acting than the capillary tubes. The capacity of the heat pumps may be varied by varying the number of paths. Each path may, for example, provide one ton of refrigeration effect.

The air flows over the coils of each heat exchanger in parallel. Thus, with reference to Figs. 3 and 4 of the drawing, the outdoor air flows first over the coil 26, then over the coil 27 and then over the coil 28. The indoor air flows first over the coil 34, then over the coil 35, and then over the coil 36. Thus air flow could be reversed when required by duct locations without affecting the performance of the heat exchangers.

Since the capillary tubes interconnecting the heat exchangers are wrapped around the suction pipe, they add superheat to the gas passing there-through and at the same time the liquid in the capillary tubes is sub-cooled.

The filter 163 is arranged across the inlet to the heat exchanger 15, and the indoor air and booster electric heaters 44 and 45 respectively, are arranged across its outlet. The electric outdoor air heater 46 is arranged across the inlet of the heat exchanger 14, and the screen 47 is arranged across the inlet to the heater 46.

Using the control system of Fig. 9 of the drawing, the booster heater 45 and the outdoor air heater 46 are not used.

The heat exchangers 14 and 15 are centrally located between the channels 13, with space on opposite sides thereof for the electric heaters, and in the case of the heat exchanger 15, for the air filter. This permits the electric heaters and the filter to be properly placed for air flow in either direction.

The centrifugal fan 48 driven by the electric motor 49 draws outdoor air through the screen 47, the electric heater 46 and the heat exchanger 14, and then discharges this air back to outdoors, this flow being in the same direction in both the heating and cooling cycles.

The centrifugal fan 50 driven by the electric motor 51 recirculates indoor air through the heat exchanger 15 and the electric heaters 44 and 45 in the same direction in both the cooling and heating cycles.

The fans 48 and 50 are contained in the racks 9 which are bolted to the channels 13, and may be so connected to the channels that their outlets and inlets may be reversed or so that they discharge vertically instead of horizontally.

The reversing valve 20 (Figs. 5-8) comprises the cylinder wall 52 providing a cylinder in which is slidably positioned the piston 53. The coil spring 54 is between the bottom of the piston and the base 55 of the valve and opposes down movement of the piston. The base is secured to the cylinder wall by the machine screws 56.

The removable head 57 of the valve is secured to its cylinder wall by the machine screws 58, and has the aligning pin 59 attached thereto and which extends slidably into the piston for preventing its rotation. The head has an inlet opening in its center in which is threaded the coupling 60 to which the tube 25 (Fig. 1) is connected.

The cylinder wall has connected thereto intermediate its ends, the pipes 43, 18, 42 and 19. The piston 53 has the lower slot 64 therein which lines up with the inner ends of the pipes 42 and 19 when, during the heating cycle, the piston is in its normal upper position illustrated by Figs. 5 and 7, permitting fluid to flow through these pipes in the direction indicated by the arrows of Fig. 7. The piston also has the lower slot 65 which lines up at this time with the pipes 43 and 18 permitting fluid flow through these pipes in the direction indicated by the arrows of Fig. 7.

The piston has the upper slots 66 and 67 which extend at right angles to the slots 64 and 65. The slot 66 lines up with the pipes 43 and 19 when, during the cooling cycle, the piston is depressed under the pressure of the fluid admitted by the solenoid controlled valve 21 (Fig. 1), and permits fluid to flow through these pipes in the direction indicated by the arrows of Fig. 8. At this time the slot 67 lines up with the pipes 18 and 42 permitting fluid to flow through these pipes in the direction indicated by the arrows of Fig. 8.

#### Operation—Fig. 9

In the operation of the heat pump using the control scheme illustrated by Fig. 9 of the drawing, the operator by placing the switch 70 on its first contact 71 closes the circuit energizing the indoor air fan 50 from the electric line. Placing the switch on its second contact 72 closes a circuit connecting the relays 73 and 74 to one side of the line, to the other side of which the indoor thermostat 75 is connected. If the thermostat is in middle position only, the indoor air fan operates and provides ventilation without either heating or cooling.

If the thermostat calls for cooling at, for example, 78° F. it will touch the contact 76 completing the energizing circuit of the relay 73, causing it to pull up its armatures 77 and 78. The armature 77 will strike the contact 79 and connect the solenoid 22 across the line, causing it to be energized and to admit gas from the compressor 10 into the reversing valve means 20, causing the piston 53 to be depressed and to route the fluid flow as illustrated by Figs. 3 and 8. At the same time the armature 78 will strike the contact 80 and will close the energizing circuits of the relays 81 and 82, which circuits include the normally contacting armature 83 and contact 84 of the relay 85. The energizing circuit of the relay 81 also includes the normally contacting armature 86 and contact 87 of the high-low pressure cut-out 88 of the compressor 10.

5

The relay 81 then pulls up its armature 89 against the contact 90 and closes the energizing circuit of the compressor 10. At the same time, the relay 82 pulls up its armature 91 against the contact 92 closing the energizing circuit of the outdoor air fan 48.

The heat pump is then in full operation in its cooling cycle, the refrigerant flow being illustrated by Fig. 4 of the drawing. The compressed refrigerant vapor from the compressor is cooled in the condenser 14 over which the fan 48 moves outdoor air, and is liquefied. The liquid refrigerant is then expanded through the capillary tubes 30, 31 and 32 into the evaporator 15 which absorbs heat from the indoor air moved thereover by the fan 50.

When the thermostat 75 calls for heating, at for example, 72° F. while the switch 70 is on its second contact 72, it will close the circuit including the contact 93, the relay 74 and the electric mains, causing the relay 74 to be energized and to pull up its armatures 95 and 96. The armature 95 will then strike the contact 97, closing energizing circuits for the relays 81 and 82, causing the compressor and outdoor air fan to operate.

At this time, the solenoid 22 is deenergized so that the piston of the reversing valve means 20 rises and routes the refrigerant in the heating cycle as illustrated by Fig. 3 of the drawing, with the heat exchanger 15 acting as the condenser and the heat exchanger 14 acting as the evaporator.

The armature 96 at the same time strikes the contact 98 partially closing the deenergizing circuit of the relay 99. The low level, indoor thermostat 100 completes the energizing circuit of the relay 99 if the operation of the heat pump does not provide sufficient heating, and the indoor temperature falls to, for example 68° F., causing the relay 99 to be energized and to pull up its armature 102 against the contact 103 and closing the energizing circuit of the indoor air heater 44.

While the load is within the capacity of the heat pump, the thermostat 75 will cycle the compressor and outdoor air fan. If the heat load exceeds the capacity of the heat pump, the thermostat 100 will cycle the indoor heater 44 while the heat pump operates continuously.

If frost forms on the heat exchanger 14 during the heating cycle, the frost switch 105 which may be in contact with same, or responsive to a pressure drop resulting from frost therein, will strike its contact 106, closing the energizing circuit of the solenoid 22, causing the reversing valve means 20 to switch from the heating to the cooling cycle, and causing the heat exchanger 14 to operate as the condenser and to heat up sufficiently to melt the frost, following which, the switch 105 opens and the cooling cycle is changed back to the heating cycle. The outdoor air fan continues in operation at this time since the outdoor air will normally be at a higher temperature than the heat exchanger 14 when frost forms on it.

Should the outdoor temperature drop to a point at which the heat pump cannot supply heat, the outdoor thermostat 107 will strike its contact 108, closing the energizing circuit of the relay 85, causing it to pull up its armatures 83 and 109. The armature 83 will then leave the contact 84 and open the previously described energizing circuit of the compressor and outdoor air fan, causing them to cease operation. At the

6

same time, the armature 109 will strike the contact 110 and close the energizing circuit of the relay 99 which will pull up its armature 102 against the contact 103 and close the energizing circuit of the indoor air heater 44. The heater 44 is then cycled under control of the indoor thermostat which energizes, through the relays 74 and 99, the heater 44, when the indoor temperature falls to 72° F.

The control system described in the foregoing thus provides automatic switchover from ventilation to heating or cooling as required; provides automatic protection against ice formation on the evaporator during the heating cycle; provides automatic change over from heat pump operation to electric heat operation should the outdoor temperature fall too low for heat pump operation to be practical, and provides automatic supplementary, electric heat if necessary, during the operation of the heat pump during the heating cycle.

#### Operation—Fig. 10

In the operation of the control system illustrated by Fig. 10 of the drawing, the operator closes the switch 112 to energize the indoor air fan 50 and to place the heat pump in operation if either cooling or heating is required. If the indoor thermostat 113 is satisfied within the range of say 72° F. to 78° F., the indoor fan alone operates and provides ventilation without heating or cooling. If the thermostat 113 calls for cooling, at say 78° F. its armature 114 will strike the contact 115, closing the energizing circuit of the relay 116 which will then pull up its armatures 117 and 118. At this time the armature 118 strikes the contact 119 closing the energizing circuit of the solenoid 22, causing it to place the reversing valve means 20 in cooling position. At the same time, the armature 117 strikes the contact 120 closing the energizing circuit of the relay 121, the contacts of the high-low-pressure cut-out 122 being closed at this time and the armature 133 of the relay 134 touching the contact 135 at this time. The relay 121 then pulls up its armature 123 against the contact 124, closing the energizing circuits of the compressor 10 and of the outdoor air fan 48.

If the indoor temperature falls to 72° F. so that the thermostat 113 calls for heat, its armature 114 first strikes the contact 125 closing the energizing circuit of the relay 126, causing it to pull up its armatures 127 and 128. The armature 128 then strikes the contact 129 closing the energizing circuit of the relay 121 which pulls up its armature 123 against the contact 124 and closing the energizing circuits of the compressor 10 and of the outdoor fan 48. The solenoid 22 is not energized at this time so that the reversing valve means 20 is in the heating position. At the same time the armature 127 strikes the contact 130 and partially completes the energizing circuit of the relay 132, the energizing winding of which is connected in series with the armature 155 and contact 156 of the relay 135, and is energized when the relay 135 pulls down its armature 155 as will be described later.

If the indoor temperature falls to 68° F., the armature 136 of the thermostat 113 will strike the contact 137 closing the energizing circuit of the relay 138 causing it to pull up its armature 139 against its contact 140 and closing the energizing circuit of the booster, electric indoor heater 45.

The outdoor air thermostat 141 has its arma-

7  
 ture 142 and contact 143 connected in series with the energizing winding of the relay 144, and when the outdoor temperature falls below a predetermined temperature, which may be 33° F., the armature 142 strikes the contact 143 closing the energizing circuit of the relay 144, the relay armature 133 touching its contact 134 at this time. The relay 144 then pulls up its armature 145 against its contact 146, closing the energizing circuit of the outdoor air heater 45, which adds heat to the outdoor air passing over the evaporator and enables the heat pump to work at a higher capacity. This action may be understood by the following example. Without adding heat to the outdoor air passing over the evaporator, the outdoor air could, for example, enter the evaporator at 40° F., and be cooled thereby to 32° F. at an evaporator temperature of 25° F. If heat is added to the outdoor air, say 25% of that required, then the outdoor air could leave the evaporator at 34° F. at an evaporator temperature of 27° F. Thus there would be more capacity by a difference of 2° F. evaporator temperature. There would be no frost and there would be a coefficient of performance greater than one as long as the air leaving the evaporator is not warmer than the outdoor air.

If the outdoor temperature drops to a still lower predetermined temperature which may be 28° F., one at which adding electric heat by the outdoor air heater 46 loses its value, the armature 150 of the outdoor thermostat 141 strikes the contact 151 completing the energizing circuit of the relay 135 causing it to pull up its armature 133 away from the contact 134 and to open the energizing circuit of the relay 121 and thereby open the energizing circuits of the compressor and the outdoor air fan.

At the same time the relay 144 is deenergized, causing the energizing circuit of the outdoor air heater to be opened.

At the same time the relay 135 pulls down its armature 155 against the contact 156 and completes the energizing circuit of the relay 132 which then pulls up its armature 152 against the contact 153 and closes the energizing circuit of the indoor air heater 44. The operation of the heater 44 is controlled by the indoor thermostat through the relay 126.

The indoor thermostat will cycle the heat pump during light heating loads, will cycle the booster indoor heater while continuing the operation of the heat pump during heavier heat loads, and will cycle the booster heater during the operation of the main indoor heater when the outdoor temperature requires that the heat pump be shut down, and the heat from the main indoor heater is insufficient.

Advantages of the control system of Fig. 10 are that defrosting is never necessary since no frost is ever formed; with limited electric heat at the heat exchanger 14, more B. t. u.'s per watt input are obtained when heating with the heat pump at low outdoor temperatures, and indoor booster electric heat is always available for providing modulated heating when either the heat pump or the indoor heater is in operation.

Since the normal position of the reversing valve means 20 is for heating cycle operation, it will return to this position upon failure of any components which might otherwise result in the continuous operation of the heat pump in the cooling cycle, during the heating season. While this might also result, under some conditions, in the operation of the heat pump in the heating cycle

during the cooling season, this is far less serious than where the heat pump would operate in the cooling cycle during the heating season, causing damage to health and freeze-up of equipment.

Since the heat exchangers 14 and 15 are located in vertically extending racks over the compressor, the space required by the heat pump is reduced, piping is simplified, and drainage of the refrigerant back to the compressor is expedited. Locating the heat exchanger 15 which functions as the evaporator in the cooling season, directly over the heat exchanger 14 which functions as the condenser at that time, not only enables condensate to drip on the condenser as previously referred to, but facilitates the connection of ducts to the spaces supplied with conditioned air, since these can be extended over the outdoor air duct as required, without cross-overs. By mounting the indoor and outdoor air fans on the exterior of the rack, they can be placed on either side thereof for moving the indoor and outdoor air in desired directions.

It should be understood, of course, that the invention is not limited to the exact apparatus and arrangement of apparatus illustrated, since modifications thereof may be suggested by those skilled in the art without departure from the essence of the invention.

What we claim as our invention, is:

1. In a heat pump having an indoor air heat exchanger, an outdoor air heat exchanger and a refrigerant compressor, the combination of refrigerant reversal valve means comprising a cylinder having an inlet port connected to the discharge side of said compressor, and having an oppositely disposed outlet port connected to the suction side of said compressor, said cylinder having a third port and having a fourth port located opposite said third port, said third and fourth ports being located between said inlet and outlet ports, said third port being connected to one end of said outdoor air heat exchanger, said fourth port being connected to one end of said indoor air heat exchanger, means including refrigerant expansion means connecting the other ends of said heat exchangers, a piston slidable in said cylinder from a first to a second position, said piston having a first transverse slot aligned with said inlet and fourth ports when said piston is in said one position whereby gas passes from said compressor through said inlet port, said slot and said fourth port into said one end of said indoor air heat exchanger, said piston having a second transverse slot spaced transversely of the piston from said first slot and aligned with said outlet and third ports when said piston is in said one position whereby gas flows from said one end of said outdoor air heat exchanger through said third port, said second slot and said outlet port to said suction side of said compressor, said piston having a third transverse slot spaced longitudinally of the piston from said first and second slots, said piston having a fourth slot spaced transversely of the piston from said third slot, said piston being slidable to said second position where said third slot is aligned with said inlet and third ports and said fourth slot is aligned with said outlet and fourth ports whereby discharge gas from said compressor passes through said inlet port, said third slot and said third port into said one end of said outdoor air heat exchanger, and gas from said one end of said indoor air heat exchanger passes through said fourth port, said fourth slot and said outlet port to said suction side of said compressor, and means for moving said piston to

said first position for indoor air heating and to said second position for indoor air cooling.

2. The invention claimed in claim 1 in which the first position is the normal position of the piston, and in which means is provided for biasing said piston to said first position. 5

3. The invention claimed in claim 2 in which the biasing means is a spring acting against one end of the piston; in which means including a solenoid operated valve is provided for supplying discharge gas from the compressor into the cylinder against the other end of the piston for moving the piston from the first to the second position, and in which means is provided for energizing the solenoid for opening the valve operated by it. 10 15

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