

Sept. 5, 1961

M. C. REESE
HEAT PUMP

2,998,710

Filed June 5, 1959

2 Sheets-Sheet 1

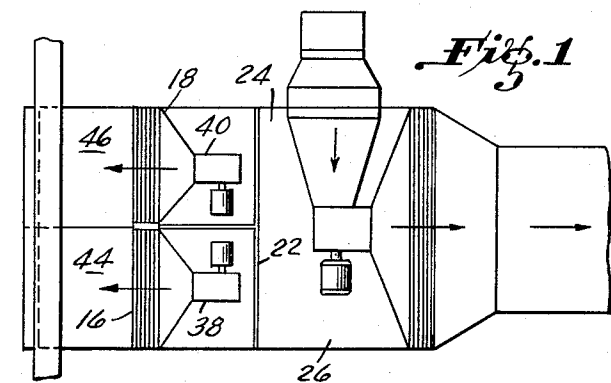


Fig. 1

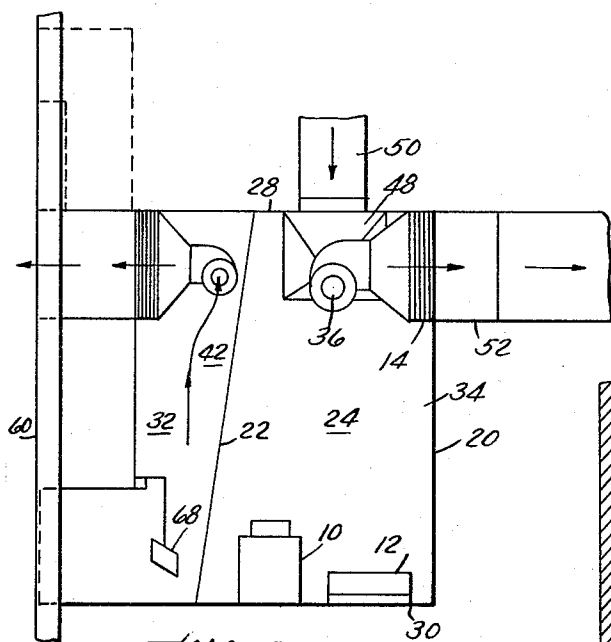


Fig. 2

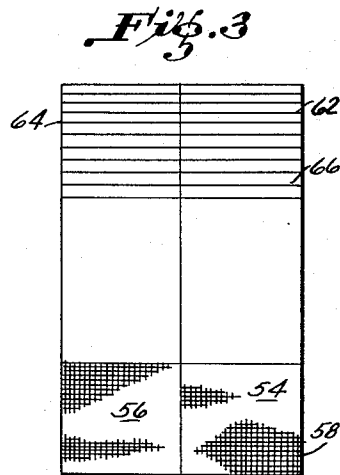


Fig. 3

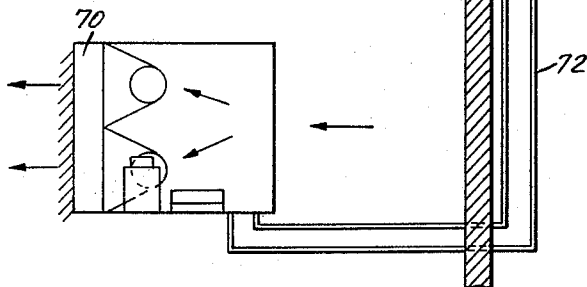


Fig. 4

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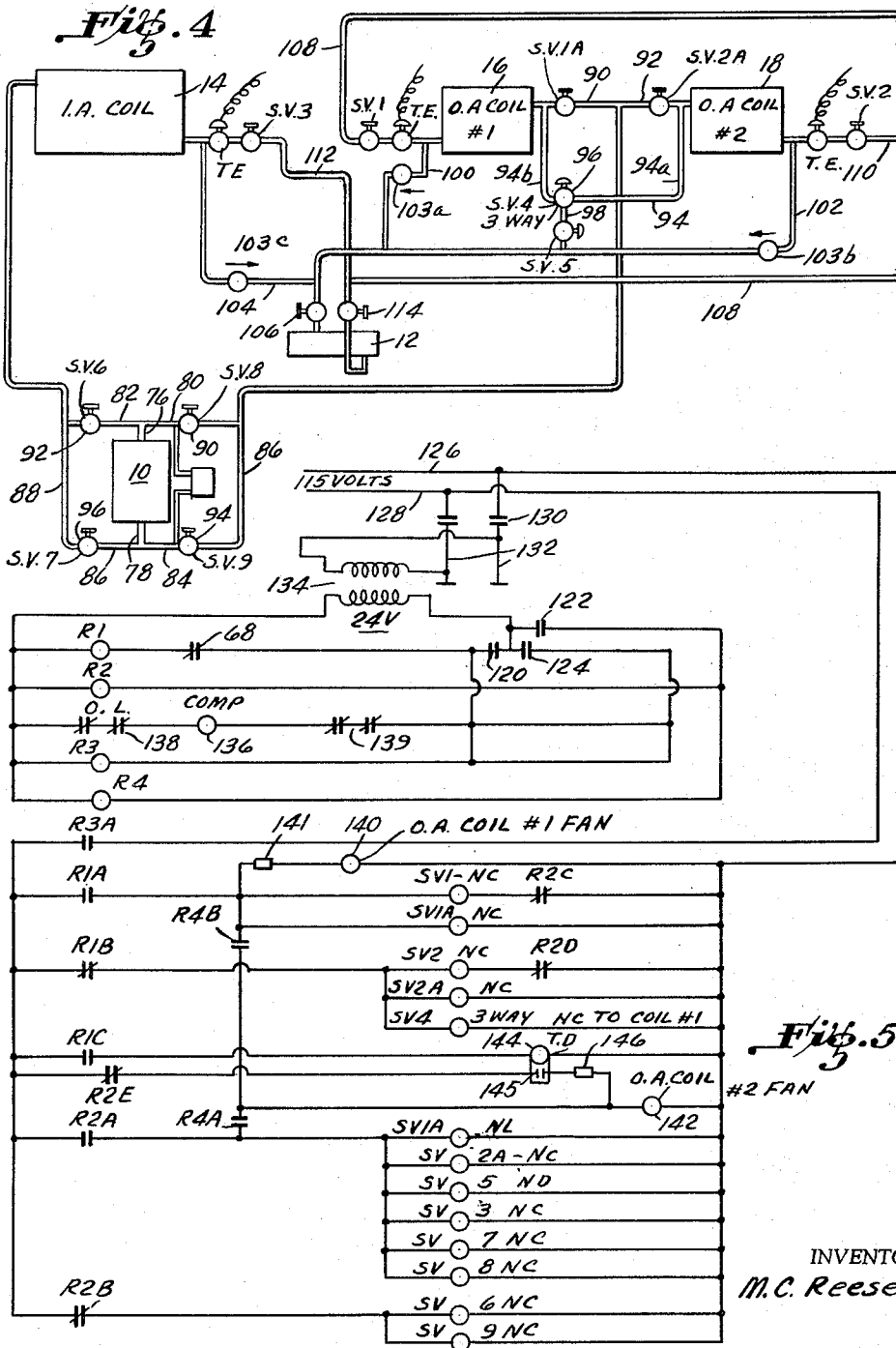
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2 Sheets-Sheet 2



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2,998,710

HEAT PUMP

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11 Claims. (Cl. 62-155)

This invention relates to heating and cooling apparatus and particularly to a heat pump having a multiple outside air coil arrangement and an automatic alternating de-icing system formed as an inherent part of the pump.

Heat pumps have come into considerable use of late years and the number of installations is rapidly increasing.

The heat pump it should be borne in mind is a desirable device because it provides the means for air conditioning a home for example in the summer and heating in the winter with installation of a single type of equipment. Heating and air conditioning of homes are not new in most areas and in most known prior installations a separate furnace and a separate cooling system are employed with one being operable in the winter and the other in the summer. The obvious advantage of having a single unit which performs both functions is apparent in so far as the first cost of installation is used. There is further a sought for advantage to public utilities companies in equalizing the summer and winter power loads. Air conditioning has generally put summer power load considerably out of line with winter load. Heat pumps were considered an answer to this problem.

However, the prior installations known in the art of the single outside air coil type utilize heating strips or strip heaters as a means of supplementary heat in the winter and from time to time rely on the heaters entirely when the outside air temperature is low enough to cause considerable icing on the outside air coil.

In fact very often this strip heater load becomes a considerable portion of the power consumed and in so far as the power company is concerned results in a peak load in the winter instead of the summer. Whereas power companies as indicated above have been promoting the sale of heat pumps in order to balance their heavy air conditioning loads in the summer. In other words, to have a more uniform load the year round and thus make the installation and operation of generator equipment more economical.

One factor in this is that the refrigeration equipment capacity in single coil systems have all heretofore been designed and sized to handle the cooling load only, so when a system of this type is used, electric heater strips of sufficient capacity to handle the maximum heating load are a necessity. These strips are usually controlled so that they can be energized in three steps of approximately 33 1/3 percent each. One or two steps are used as supplementary heat while the heat pump is operating and all the strips are used while the coil is being de-iced.

In most sections of the country if three tons of summer air conditioning equipment is needed for summer cooling approximately three kw. is used for cooling. The heating kw. used to heat the same building will be approximately 10 kw. while the single coil is being de-iced and approximately 5 kw. as supplementary heat while the heat pump is operating. Bear in mind while the latter condition exists that the three kw. required to operate the refrigeration equipment is also being used making a minimum of 8 kw. approximately whereas my heat pump can do the same job with a maximum of five kw. All strip heaters and the refrigeration equipment on conventional heat pumps will be in operation at the same time for a big percentage of the time using a total of approximately 13 kw. as compared to five kw. with my heat pump.

Accordingly an object of this invention is to provide a means of de-icing heat exchangers such as evaporators on the outside air coils while maintaining adequate heat

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entirely from an outside air source wherein increased power load for these purposes will be less than one-third the increase compared with known equipment of a comparable size where auxiliary electric heater strips are used.

Yet a further object of the invention is to provide a heat pump having self contained de-icing means and wherein no equipment other than the heat pump itself is needed. According to the instant invention two or more if desired outside air coils are necessary but the strip heater installations previously required and their controls are not necessary.

Still another object of the invention is to provide a simplified control system for automatically controlling the operation of the improvement which provides the automatic de-icer cycles.

Still a further object of the invention is to provide an automatic de-icer without the use of electrical strip heaters or any auxiliary heat source and to furnish a continuous uninterrupted heat supply from the outside air alone.

A still further object of the invention is to provide equipment which will start either on heating or cooling without manual change over switches or attention of any kind.

A further object of the invention is to provide a heat pump wherein all motors and controls except inside fan motors are de-energized when the thermostat is satisfied.

Another object of the invention is to provide heat pump equipment which has automatic self contained de-icing means and provision for recovering heat used with the de-icing rather than permitting the loss of this heat to the outside air.

These and other objects and advantages will become apparent from the following description and the accompanying drawings wherein:

FIGURE 1 is a top plan view of a heat pump constructed in accordance with the invention installed in a building.

FIGURE 2 is a side elevational view.

FIGURE 3 is a front elevational view.

FIGURE 4 is a schematic diagram of the heat pump.

FIGURE 5 is a schematic diagram of the electrical system employed with the pump.

FIGURE 6 is a side elevational view similar to that of FIGURE 2 but showing the installation of a split type unit with the compressor, receiver and heat exchanger located outside of the building but connected by suitable piping to a heat exchanger located within the building.

Referring now in particular to FIGURES 1, 2 and 3:

A heat pump constructed in accordance with the instant invention comprises a compressor 10, a receiver 12, and an inside air coil 14, an outside air coil No. 1 designated by the numeral 16, and an outside air coil No. 2 designated by the numeral 18. According to the invention the heat pump is provided as a neat compact unit within a housing 20. The housing has a partition 22 co-operating with side walls 24 and 26 and top and bottom walls 28 and 30 to divide the housing into two compartments. The outer compartment 32 contains the outside air coils and the inner compartment 34 contains the inside air coil and the compressor and receiver. The air coils are provided with suitable enclosures and each are provided with fan means such as 36, 38 and 40. The housing comprises another partition 42. This joins partition 22 and top and bottom walls 28 and 30 to divide the outer compartment 32 into two chambers 44 and 46. Each of the air coils is mounted in one of the chambers and extends completely thereacross adjacent the upper end. It is to be understood that more than one inside air coil or heat exchanger may be employed as well as more than two outside air coils or heat exchangers, as well as several

compressors, depending upon the size of the building or area that is to be either heated or cooled.

Suitable baffling means around the air coils and the fan housings provide for direction of the air over the coils. Each of the fans illustrated are squirrel cage type blowers although any type can be used. The inner fan 36 is provided with a plenum 48 and can be connected to conduit 50 to take in air from the area being heated or cooled. The sheet metaling applied to the inside coil 14 also directs the air from this coil and from the fan to an inner plenum 52 which is connected to the various lead-offs to different areas as is well known in the art.

The two outside coil fans 38 and 40 have their intakes within their respective housing chambers 44 and 46. These chambers have lower inlets 54 and 56 protected by suitable removable insect screening such as 58 and adapted to be extended through the outside wall 60 of a building, for example. The outlets of the fans are connected by suitable sheet metal work so as to force the air from the fans over the outside air coils through the two outlets or discharges 62 and 64. These are each provided with air louvers 66 which are of a known type which automatically close when the fans shut down and open when the fans start.

A sail switch 68 is located in the intake portion of the outside air coil chamber 46. The sail switch is exposed to the force of the air being sucked in by the fan 40 and adapted to have its contacts opened or closed in accordance with the amount of air passing over the surface of the heat exchanger or air coil located within the compartment 46. The switch is normally closed so that when the air flow starts this switch will open. If the weather is mild and the heating load is low, no ice will form on the heat exchanger or outside air coil 18 located within compartment 46 and the sail switch contacts will remain open allowing the heat exchangers outside air coil 18 to continue in operation. When the outside air temperature drops to a point whereby ice forms on the heat exchanger or outside air coil 18, the flow of air through said heat exchanger is consequently reduced, thereby causing the sail switch to close its contacts which eventually results in the fan associated with the heat exchanger or outside air coil 18 being stopped, which action permits or causes the heat exchanger and/or outside air coil 16 to be brought into operation while at the same time, through the actuation of various valves, enables the heat to be delivered to the heat exchanger or outside air coil 18 for the purpose of de-icing.

It is apparent from FIGURES 1, 2 and 3 that the heat pump package is adapted to be installed adjacent the outside wall of the building or with ducts to the outside air intakes and discharges flush and the inside intakes and discharges being adapted to be connected to the air conduit system of the building.

FIGURE 6 illustrates an installation of a package type unit where the compressor, receiver and outside air coils are mounted in a unit 70 placed at any desirable distance from the building or adjacent to it. Suitable refrigerant piping 72 extends from this package unit into the interior of the area to be heated or cooled. Inside air coils 74 are mounted wherever desired and provided with fan and conduit structure such as 36, 48, 50 and 52 as will be apparent to those skilled in the art.

Referring now in particular to FIGURE 4:

The compressor, receiver and outside and inside air coils are interconnected by known types of refrigerant and heat pump piping.

The compressor is schematically indicated to have a discharge side 76 and an intake or suction side 78. Two lines 80 and 82 lead from the discharge and similarly two lines 84 and 85 lead up to the suction. Lines 80 and 84 are connected to a common header 86 and lines 82 and 85 connect to a common header 88. Valves 90, 92, 94 and 96 are positioned in the lines intermediate the suction and discharge connections of the compressor and the

headers 86 and 88. The compressor of course runs continuously in one direction. It is not reversible. Through means of the lines, header and valve structure disclosed, however, it is possible to direct the discharge into either one of the headers 86 and 88, and likewise to cause either one of these headers to become a suction header (alternately). Thus by closing valve 90 and opening valve 92 and closing valve 96 and opening valve 94 the compressors will suck from header 86 and discharge into header 88. Conversely when the valve 92 is closed, the valve 90 is opened, and the valve 96 is opened while the valve 94 is closed, header 88 will become the suction side and header 86 will become the discharge side.

Header 88 leads directly to the inside coil 14 and header 86 leads to the outside air coils. The latter header 86 is split into lines 91 and 93 leading to coils No. 1 and No. 2, respectively. The solenoid valve 1A is interposed in line 91 between it and its coil and solenoid valve 2A is interposed in line 93 between it and coil No. 2. Intermediate the valves and their respective coils there is a cross connecting line 95 which connects the two coils and is parallel to lines 91 and 93. A three-way valve designated S.V.4 is interposed in this line 95. The valve S.V.4 is connected to a third line 98. Line 98 has interposed in it a solenoid valve S.V.5. Like the other solenoid valves this is designated by the initials S.V. The three-way valve 97 is adapted to connect either side of the line 95 to the line 98 and shut off the other side. Thus lines 95A and 98 are connected while line 95B is shut off, or line 95B is connected to line 98 while line 95A is disconnected from line 98.

The opposite sides of the coils 16 and 18 are connected by lines 100 and 102 to receiver 12. Similarly inside air coil 14 is connected by line 104 to receiver 12. Each of these lines are joined and each has its own check valve 103. Manual valve 106 is interposed in the common line. This leads to the top of the receiver. All the coils have duplicating lines leading from the bottom of the receiver. These lines are designated by numerals 108, 110 and 112. Each of these lines has interposed therein solenoid valves designated as solenoid valve 1 in the line leading to coil 1, solenoid valve 2 leading to coil 2, and solenoid valve 3 leading to inside air coil 14. These lines are all joined and have a manual shutoff valve 114 in the joined lines. Further each of these lines have interposed therein a thermal expansion metering valve as known in the art. Each is designated by T.E.

Referring now to FIGURE 5:

The control circuit comprises four relays designated as R1, R2, R3 and R4. Their coils are represented by circles beneath their numeral designations. The thermostatic control means for heating comprises the contacts 120 whereas the cooling thermostatic control means comprises the paired contacts 122 and 124. These are embodied in suitable thermostats not shown on the drawings but can obviously be of known types.

The power leads 126 and 128 are connected through suitable protective devices 130 directly to the inside air fan by lines 132. Transformer 134 having a 24 volt secondary is connected across the lines 132. This supplies the current for the relay coils and the thermostatic contacts hereinafter described. Leads 126 and 128 are directly connected to other portions of the wiring diagram and particularly to the contacts of the various relays and to the valve solenoids. The latter have their operating coils designed to be operated by the main power source which in this instance is selected to be at 115 volts.

The coil of relay R1 is connected across the secondary of the 24 volt transformer in series with the thermostatic heating contacts 120. The latter are normally open. The operating coil for relay R3 is similarly connected. In other words, it is parallel with the coil of relay R1. The coil of relay R3 is also connected in series with the secondary of the transformer and normally opened contacts of the cooling thermostat 124.

The compressor 10 is controlled by a coil operated (solenoid) switch the coil of which is indicated by the numeral 136. This coil is connected to the transformer in parallel with the relay coil R3 both in its connection to the contacts 120 and its connection to contacts 124. The compressor solenoid is in series with the overload and high-low cutouts 138 and 139. The coil of relay R2 is connected directly in series with the secondary of the transformer and the normally open contacts 122 of the cooling thermostat. The coil of relay R4 is parallel with the relay coil R2. The relay coil of relay R1 is in series with the switch 68 which is the sail switch positioned in the chamber 46.

The relay 1 has three sets of contacts R1A, R1B and R1C. R1A are normally open, R1B are normally closed, and R1C are normally open. Contacts R1A have in series with them coil S.V.1 of the solenoid valve S.V.1 which is normally closed. This coil is further in series with the relay contacts R2C. Contacts R2C are controlled by the relay R2 as described below. A coil 140 of a solenoid for operating the control switch for the outside air fan No. 1, which is also designated by numeral 38, is also in series with the relay contacts R1A and an adjustable time delay device 141. The adjustable time delay device can be any device that is satisfactory for operation on 115 volts or any other selected voltage for the control circuit. It does not have to be operated on 115 volts.

The following additional solenoid coils are also in series with the relay contacts R1A, and relay contacts R4B and R4A, and in parallel with each other: The operating coil S.V.1A of solenoid valve 1A; the operating coil S.V.2A of solenoid valve 2A; the operating coil S.V.5 of solenoid valve 5; the operating coil S.V.7 of solenoid valve 7, and the operating coil S.V.8 of solenoid valve 8. These coils will be placed in parallel with S.V.1 and 140 whenever R4A and R4B are closed. S.V.1 is also in parallel with R4A and R4B and will be energized when R1A closes even though R4A and R4B are open.

The relay R2 has in addition to contacts R2E, normally open contacts R2A; normally closed contacts R2B, normally closed contacts R2C; and normally closed contacts R2D. Contacts R2A, which are normally open, are in parallel with the contacts R1A and in series with all the coils that are in series with R1A. Contacts R2B are normally closed and normally connect to the parallel connected coils of solenoid valves 6 and 9.

The normally closed contacts R1B are in series with the contacts R2D and the coil S.V.2 of solenoid valve 2. The coil S.V.2 of solenoid valve 2 and contacts R2D are in parallel with the coils S.V.2A of solenoid valve R2A and the coil S.V.4 of solenoid valve 4. Thus the latter two coils are in series with the contacts R1B.

Contacts R1C are in series with the time delay motor 144. The motor 144 has contacts 145 which are in turn in series with the normally closed contacts R2E, an adjustable thermal time delay device 146 and the coil 142. Coil 142 is the operating coil for the switch for outside air fan 40 which is the fan for outside air coil No. 2. Thus, with respect to the latter coil, contacts R2E, 145 and delay device 146 are in parallel with the contacts 2A and R4A and also with R1A and R4B. It should be noted that coil 142 will also be placed in series with contacts R1A when the contacts R4B closes.

All valves of the described coils are normally closed with the exception of valve 5. This is a normally open valve, and energization of the coil of this valve serves to close it. Whereas the energization of the coils of all the other valves except S.V.4 serves to open the corresponding valves. Solenoid operated valve 4 is normally closed, but it is normally closed only to outside air coil or heat exchanger No. 1. When the coil of valve 4 is energized the three-way valve closes to coil No. 2 and opens to coil No. 1. The valve remains open to line 98 at all times.

Relay 4 has a pair of contacts, described above. Relay

3 has a single set of contacts R3A. These are normally open and interposed in the line leading to the contacts controlled by the other relays, the solenoid valve coils, the outside air fan switches and the time delay device. All of these are deenergized when the coil R3 is deenergized.

OPERATION

Heating

It will be noted from the circuit that no controls for the inside air fan are shown. It is normally operating whenever the system is in operation. It can be controlled by separate thermostatic means or manually controlled as is well known in heating and cooling. However, this forms no part of the instant invention. Now assuming that the inside fan is continuously running and the thermostat calls for heat. This closes the contacts 120 which are the heating thermostatic contacts. This in turn energizes the coils of relays R1 and R3 and compressor switch coil 136. This starts the compressor and energizes the portion of the control circuit connected directly to the 115 volt line. When R1 operates contacts R1A close, R1B open, and R1C close. When contacts R1A close they place the coil 140 of the outside air fan 1 and the coils of valves S.V.1 and S.V.1A across the line, opening the ports in these valves. The thermal time delay 141 delays the start of the fan for the heat exchanger or outside air coil No. 1 for a few seconds to allow refrigeration equipment to reclaim part of the heat used in de-icing the heat exchanger or outside air coil No. 1 rather than dissipate this heat to the outside air.

The energization of relay R1 also closes contacts R1C, starting time delay clock 144 and immediately opening T.D. contacts 145 through the clock mechanism while also opening contacts R1B and thus de-energizing and closing the ports in S.V.2 and S.V.2A, also de-energizing the 3-way valve S.V.4, thus closing its port to the outside air coil No. 1 line 98 and line 95B, and opening its port to outside air coil No. 2, line 98 and line 95A. S.V.5 is normally open and thus remains open during the heating cycle, thereby allowing hot gas to travel from the high pressure side of the system to the outside air coil being de-iced as being selected or determined by contacts R1B. The port in S.V.4 to which line 98 is connected is continuously open.

The result of this is that valves S.V.1 and S.V.1A open, fan No. 1 (38) starts running and time delay clock motor 144 starts running. Solenoid valves 6 and 9 are opened while valves 7 and 8 remain closed. The heating unit runs in this condition with the outside air coil No. 1 picking up heat while the outside air coil No. 2 is being de-iced until contacts 145 are closed by clock motor 144. When that occurs adjustable thermal time delay 146 will be energized and after a few seconds delay OA fan No. 2 (142) will start to operate. The adjustable thermal time delays 140 and 146 for the two outside air fans are set for a delay of a few seconds only, in order to recover part of the heat used to de-ice the outside air coils.

When fan No. 2 starts sail switch 68 will open its contacts 145 and relay R1 will be deenergized. This will stop fan No. 1 and close valves S.V.1 and S.V.1A and open valves S.V.2 and S.V.2A. Also S.V.4 will close to coil No. 2 and open to coil No. 1. R1B operates S.V.2, S.V.2A and S.V.4 only. OA fan No. 2 is energized by R2E and time delay clock contacts 145 only on heating cycle and is operated without time delay through contacts R2A and R4A on cooling cycle.

Where previously the unit had been picking up heat from coil No. 1 the unit will now pick up heat from coil No. 2. Coil No. 1 is now receiving warm fluid or gas from the high pressure side of the system by way of inside air coil 14 through line 98 and line 95B but its fan is not running and its louvers 66 are closed. The coil is thus not picking up heat. It is instead, being de-iced by hot gas flowing from the high pressure side of the refrigeration system.

Coil No. 2 will be operated until it ices. When sufficient ice forms switch 68 will close due to reduced air flow through the coil to energize R1. Then the cycle described will repeat.

The time delays 140 and 146 provide for recapture of some of the heat of de-icing before the outside air fans start.

Normally coil No. 2 is the operating coil with No. 1 a standby coil in case de-icing of coil No. 2 is necessary. In mild winter weather OA coil No. 2 will supply sufficient heat and OA coil No. 1 will not operate until ice forms on OA coil No. 2.

Cooling

The inside air fan is continually running (or as pointed out above it can also be thermostatically controlled).

When the thermostat contacts 122 and 124 close the coils of relays R2, R3 and R4 are energized and the relays are operated. The compressor switch is also closed by coil 136. R1 will be deenergized now by the sail switch contacts being opened on cooling cycle also by normal closed contacts R4C being open on the cooling cycle.

R2A closes while R2B, R2C, R2D and R2E are opened. Both outside air fans run (No. 2 through R2A). S.V.3 opens, as do valves S.V.1A and S.V.2A, S.V.6 and S.V.9 remain closed due to operation of relay 2, S.V.7 and S.V.8 open. Valve S.V.5 closes. The inside air coil will now become the evaporator while coils 1 and 2 will act as condensers. If desired fan No. 1 can be stopped or started during mild weather (low load conditions) by a high pressure switch or manually. Both outside air fans will continue to run even though the compressor might stop because of high head pressure.

If desired the paired compressor manifold valves which close or open simultaneously can be wired in series. Doubling of the voltage on these series wired coils would of course be necessary.

All motors, except inside air fan, stop and all solenoid coils are deenergized when the thermostat is satisfied.

It is important to note that the equipment will automatically start on heating or cooling without manual change-over switches or attention of any kind.

While I have shown and described a preferred form of my invention, it will be understood that variations in details of form may be made without departure from the invention as defined in the appended claims.

I claim:

1. A heat pump comprising a compressor, a first heat exchanger means in series with said compressor and a second heat exchanger means in series with the first heat exchanger means and said compressor, means for alternately connecting said compressor to both of said heat exchanger means to alternately cause first one and then the other of the latter means to act as an evaporator, said second heat exchanger means comprising a pair of coil members arranged in spaced parallel relation with one another and means for automatically connecting one of the latter pair and simultaneously disconnecting the other of said pair from series connection with the first mentioned heat exchanger means and said compressor in accordance with changes in a selected operating condition.

2. The heat pump of claim 1 wherein the last named means is sensitive to icing conditions of one of said pair of coil members, and is automatically operable when a selected icing condition is reached to automatically simultaneously connect one of said coil members into and disconnect the other of said coil members from, respectively, said series connection with the first mentioned heat exchanger means and said compressor.

3. The system of claim 1 including control means comprising thermostatic means for automatically initiating operation of said system either as a heating or cooling system with respect to said first mentioned heat exchanger means, the last named said control means further comprising means automatically operative to change said

system from a heating to a cooling system and from a cooling to a heating system upon a change in temperature alone.

4. The system of claim 3 wherein said control means includes means operative to completely deenergize the control means whenever said thermostatic means is inoperative.

5. The heat pump of claim 2 including fan means for directing air over one of said coil members for transfer of heat to or from the latter, in accordance with the operation of said system, means associated with said fan means comprising a switch sensitive to the amount of air being driven over the said one of said coil members and effective upon a reduction of the volume of air delivered by said fan over the latter coil member to disconnect the latter coil member from said system and connect the other of said coil members into said system.

6. In a heat pump apparatus having in series a compressor and a pair of heat exchanger means, usable alternately as evaporators and condensers, conduit means interconnecting said pair of heat exchanger means and compressor, one of said heat exchanger means comprising a pair of coil members arranged in spaced parallel relation with one another and adapted to function as evaporator means, means for automatically de-icing one of said evaporator means while continuing the functioning of said heat pump apparatus through use of the other of said evaporator means.

7. The apparatus of claim 6 including means for automatically de-icing comprising a sail switch means subject to the influence of the flow of air over said one of said evaporator means and sensitive to the reduction in the flow of air and operative to effect de-icing and alternate use of said other of the latter evaporator means.

8. In a heat pump having a compressor, a first heat exchanger means and a second heat exchanger means, means for associating the first and second heat exchanger means in series with said compressor and for switching automatically said connections of said compressor to said heat exchanger means to effect alternately heating and cooling operation of alternately first one and then the other of the means, one of said heat exchanger means including a pair of coil elements, and means for alternately switching one or the other of said coil elements into and out of operative connection with said compressor, the last named means including automatic means sensible to icing conditions of said coil elements of at least one of said second heat exchanger means.

9. The heat pump of claim 8 including the latter automatic means comprising a switch sensitive to the flow of air by a powered fan means over the latter element and effective upon the reduction of the flow of air to cause said alternate switching.

10. The heat pump of claim 8 including a control circuit associated with said heat pump and including automatic thermostatically controlled means for automatically effecting operation of said system to cause alternately one or the other of said heat exchanger means to function as a heat supplying means or a heat withdrawing means.

11. The apparatus of claim 8 including a control circuit having means including a timing device operative to initiate action of said system utilizing one of said heat exchanger elements and then upon the passage of a pre-selected time to switch over to the other of said coil elements.

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