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AIR CONDITIONER WITH CONTROLLED REHEAT

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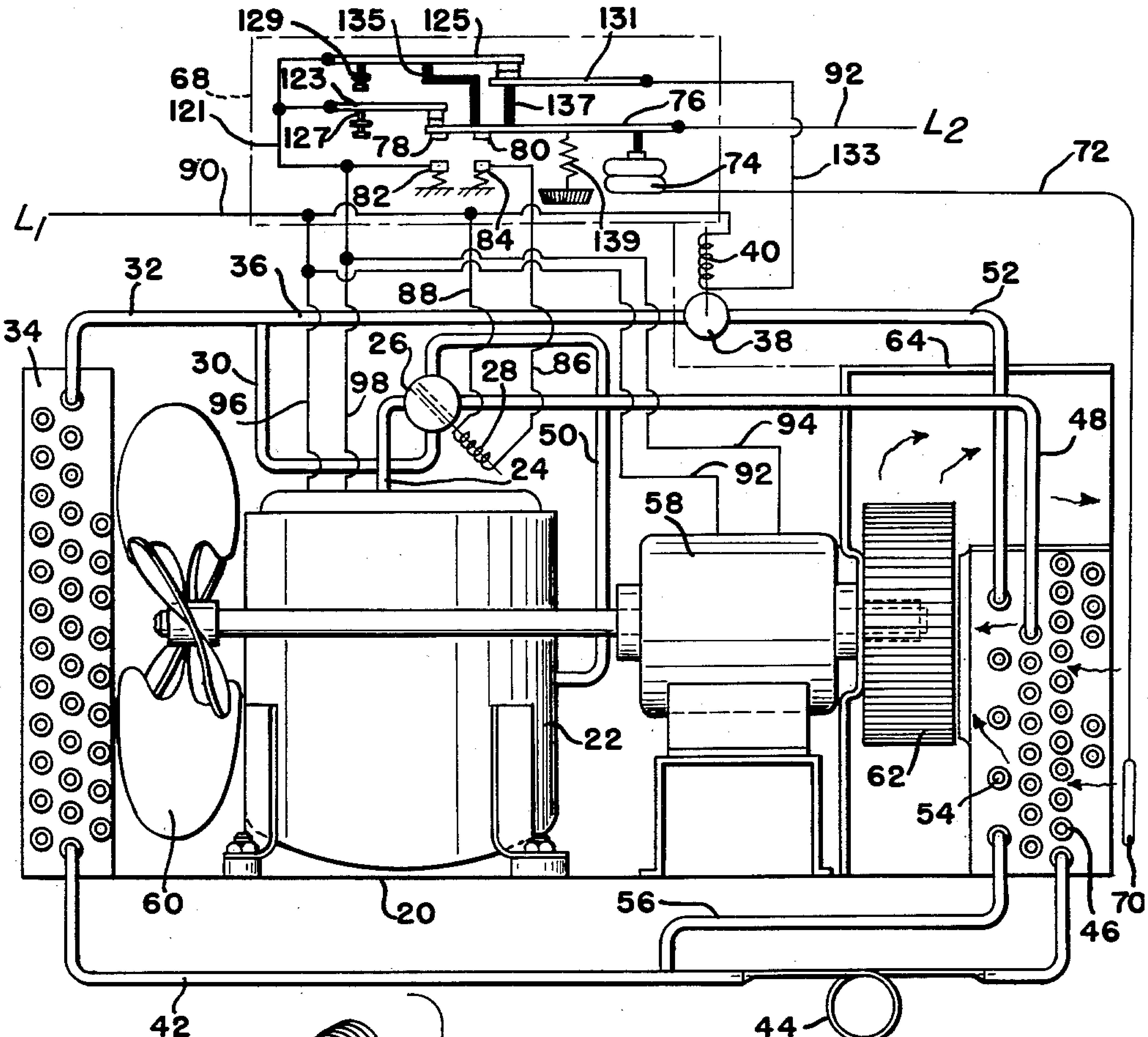

Fig. 1

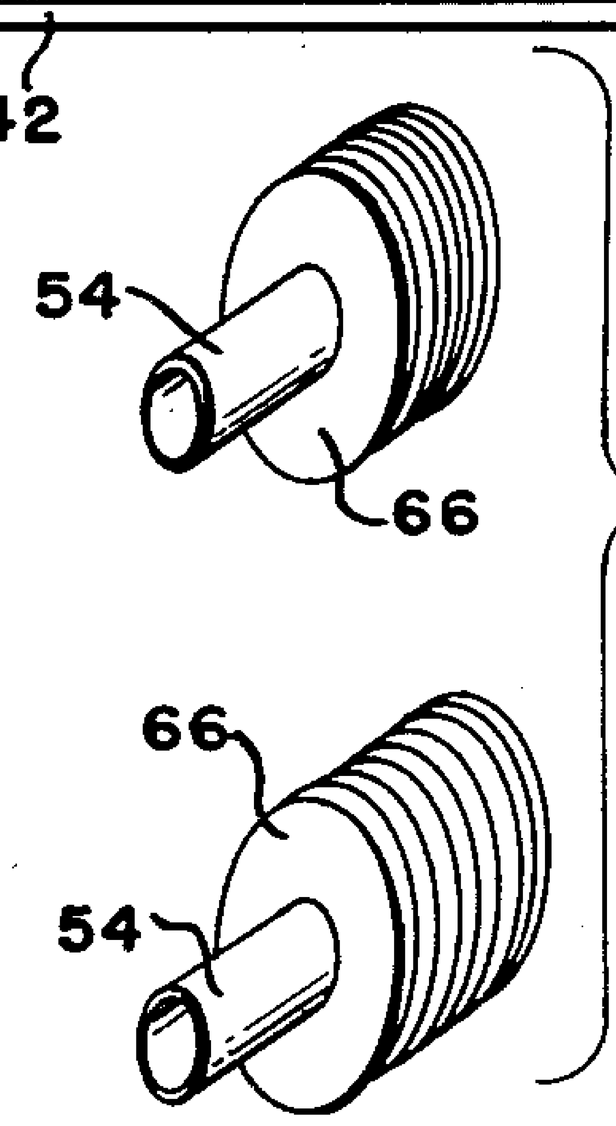

Fig. 2

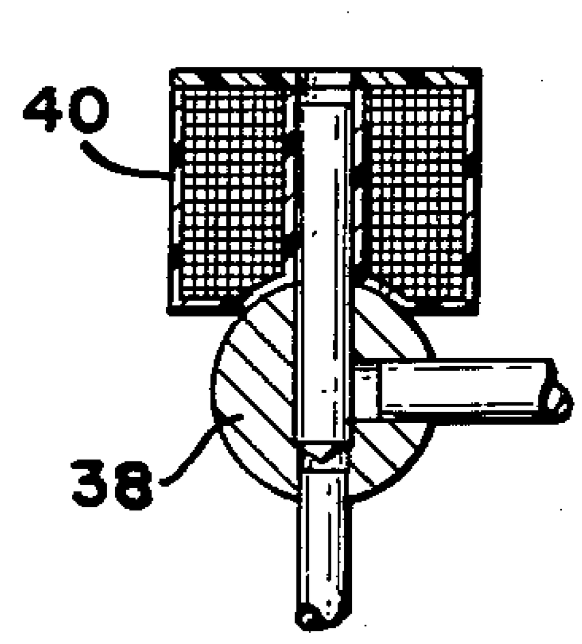

Fig. 3

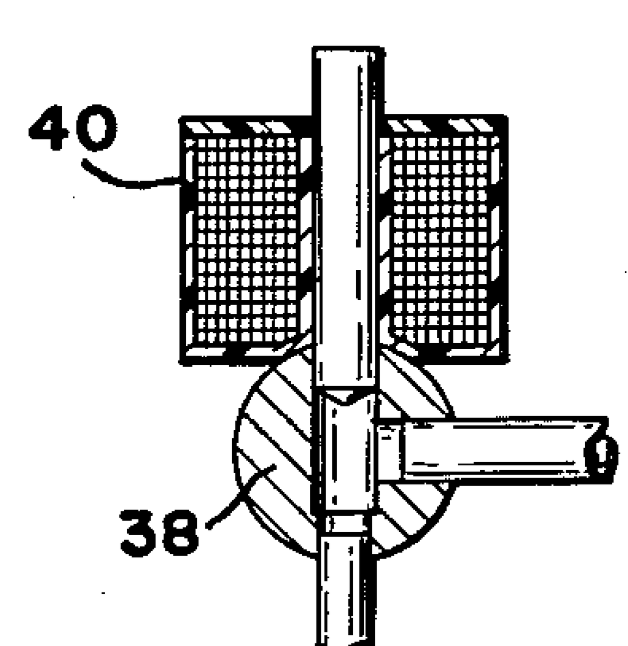

Fig. 4

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AIR CONDITIONER WITH CONTROLLED REHEAT

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This invention pertains to refrigerating apparatus and more particularly to air conditioning apparatus for both cooling and heating rooms.

Conventional air conditioners are satisfactory for warm and hot weather. However, in damp weather which is too warm to require heating, the normal operation of an air conditioner makes the space too cold. It is desirable to remove this dampness without making the room too cold. When it is still cooler, it is desirable to provide some heating.

It is an object of this invention to provide a simple, effective, reliable, easily manufactured air conditioning system which will provide either maximum cooling or less cooling with more dehumidification or heating as desired or required.

It is another object of this invention to provide a simple, effective reheating arrangement which can be efficiently eliminated for high cooling requirements and also for reversed cycle heating as required but which can be readily made effective when less cooling and more dehumidification is required.

It is another object of this invention to provide a simple, easily controlled, inexpensively manufactured reheating arrangement in which a predetermined ratio is kept between the reheating and the cooling of the air.

It is another object of this invention to provide a simple, inexpensive control which will control an air conditioner to provide reversed cycle heating, or cooling with reheating, or cooling without reheating as required according to different temperature requirements.

These and other objects are attained in the form shown in the drawings in which a single row reheat coil is placed in series with the evaporator in the room cooling air stream. This reheat coil is placed in parallel with the condenser and has a simple solenoid valve located between it and the common connection with the outlet of the compressor. The combined restriction of the reheat coil and its solenoid valve at the rate of refrigerant flow desired through the reheat coil is made equal to the restriction through the condenser by suitable selection of both the reheat coil and the valve. A single solenoid four-way valve may also be provided so that the system can be operated for heating. A single thermostatic control is provided which at low temperatures energizes the four-way solenoid reversing valve and the motor-compressor unit at low room temperatures while at slightly higher room temperatures the entire system is idle. At higher room temperatures, the system operates to provide refrigeration with the reheating coil in operation; while at still higher room temperatures, the system operates to refrigerate without reheating to provide maximum refrigeration.

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

In the drawing:

Figure 1 is a view in elevation partly in section and partly diagrammatic of an air conditioner embodying one form of our invention;

Figure 2 is an enlarged perspective view showing the fins and tubing of the heat transfer units;

Figure 3 is a sectional view partly diagrammatic of the reheat solenoid valve shown in the closed position; and

Figure 4 is a similar view showing the solenoid valve in the open position.

Referring now more particularly to Figure 1, there is shown an air conditioner **20** provided with a sealed motor-compressor unit **22** which, for example, may be nominally of 1½ H.P. The refrigerant used may be mono- or dichlorodifluoromethane (F–22 or F–12). The motor-compressor unit discharges the compressed gas through an outlet **24** connecting with a four-way valve **26** operated by a single solenoid **28**. During normal refrigeration operations, the four-way valve **26** connects the outlet **24** to a conduit **30** which branches into a conduit **32** connecting with the air cooled outdoor coil **34** which is a condenser during normal refrigeration and a conduit **36** connecting with the reheat solenoid valve **38** provided with an operating solenoid **40**. The outdoor coil **34** has thirty-four passes of ⅜ inch tubing provided with button type fins spaced fifteen to the inch.

The lower outlet of the outdoor coil **34** is connected to a conduit **42**. This conduit connects to a capillary restrictor tube **44** connecting with the bottom of the indoor coil **46** having twenty-four passes provided with button fins spaced twelve to the inch. There are five passes in the first vertical row grouped in two's and three's, eleven passes in the middle row and eight passes in the third row. During normal refrigeration, the indoor coil **46** serves as an evaporator. The top of the third row of passes of the indoor coil **46** is connected by the conduit **48** with the four-way valve **26** and during normal refrigeration operations connects with the suction conduit **50** extending into the inlet of the sealed motor-compressor unit.

According to this invention, the solenoid valve **38** is connected by a conduit **52** with the top of the reheat coil **54** provided immediately adjacent the indoor coil so that it appears as a fourth vertical row of indoor coil **46**. This may likewise have twelve button fins per inch. The bottom pass of the reheat coil **54** is connected by the conduit **56** to the conduit **42** adjacent the capillary restrictor **44**.

A single fan motor **58** is provided having a four blade propeller fan **60** connected to one end of its shaft for circulating outdoor air through the outdoor coil **34**. The opposite end of the shaft of the fan motor **58** is provided with a centrifugal fan **62** which draws room air in through the indoor coil **46** and the reheat coil **54** and discharges this air through a discharge duct **64** which returns the tempered air to the room.

In this particular apparatus, all the coils and conduits excepting the capillary restrictor tube **44** are of nominal ⅜ inch copper tubing and the outdoor coil or condenser has a normal capacity of 21,600 B.t.u. per hour while the indoor coil or evaporator has normal capacity of 15,600 B.t.u. per hour. This will provide excellent cooling when the room is warm or hot. On cool damp days, the air discharged from this unit would feel uncomfortably cold yet the room would feel too muggy for comfort. To remove a maximum amount of moisture and yet prevent the objectionable discharge of cold air from the conditioner, the reheat coil **54** is provided. For example, if it is desired to discharge the air from the conditioner at a temperature of 75° into a room which is at 80°, a sufficient amount of heat must be provided by the reheat coil **54** to raise the temperature from the temperature of the air passing through the indoor coil 46 (evaporator) sufficiently to raise its temperature to 75°. In the particular arrangement shown, the air will be cooled to a temperature of about 62° F. by the indoor coil 46 when the room temperature is 80° F. The evaporator capacity will be about 15,600 B.t.u. To raise the temperature of this air to about 75° F., the reheat coil 54 will be required to have a capacity of about 6,000 B.t.u. per hour.

This is controlled by designing the restriction in the evaporator and the restriction through the reheat coil 54 and the solenoid valve 38 to provide a flow at the rate required to provide the 6,000 B.t.u. per hour or whatever amount is desired or required to reheat the air to the desired temperature. In this particular form and under such conditions, the condenser 34 has a restriction of about six pounds and to obtain the proper flow through the reheat coil 54, the total restriction of the reheat coil 54 and the solenoid valve 38 should approximately equal six pounds at the rate of flow desired. In the arrangement shown, the reheat coil has a pressure drop of approximately one and a half pounds and the solenoid valve 38 has a pressure drop of four and a half pounds at the desired rate of flow making the total drop through the reheat circuit six pounds. The reheat coil 54 as shown in Figure 2 is provided with button fins 66 spaced twelve per inch. This provides reheating of the air without any appreciable reduction in air flow through the indoor coil 46. As alternative construction, the reheat coil may be made of eleven passes having, however only six fins per inch. This arrangement will give approximately the same refrigerant flow and reheat capacity. Any added restriction in the reheat coil may be compensated by a proportionate reduction in the restriction of the solenoid valve 38.

The reheat coil and reheat circuit may be designed to produce any desired amount of reheating and to raise the temperature any desired amounts within the capacity of the system. The amount selected can be obtained by providing the desired amount of surface in the reheat coil and adding or reducing the restriction of the solenoid valve 38 to provide less or greater flow of refrigerant through the reheat circuit to provide operation of the reheat coil at its full capacity for the particular pressure drop in the condenser of the system. The total drop of the reheat coil and its reheat solenoid valve must equal the total pressure drop in the outdoor coil (normally the condenser). In this way, the amount of reheat desired may be readily obtained.

According to this invention, there is also provided a suitable control 68 which automatically provides for a cycling reverse cycle heating when the temperature of the thermostat bulb 70 is at a low value and which stops the operation of the system and fan motor at a higher temperature, such as 72° to 75° F., at which neither heating nor cooling is desired. At a still higher temperature of the bulb 70, the system is operated with the reheat coil 54 in operation, and at a still higher temperature, the system operates to refrigerate without reheat to provide maximum cooling. The bulb 70 is connected by a capillary tube 72 to the metal bellows 74 operating the primary lever 76. This bellows 74 may contract sufficiently to cause the two contacts 78 and 80 upon the lever 76 to engage the spring mounted contacts 82 and 84.

The spring mounted contact 84 is connected by the conductor 86 to the solenoid 28 which is connected by a second conductor 88 to a supply conductor 90 connecting with the supply line L1. The primary lever 76 is conducting throughout and connects to the conductor 92 connecting with the supply line L2. The engagement of the contacts 78 and 80 with the contacts 82 and 84 provides an energization of the sealed motor-compressor unit 22 as well as the solenoid 28 of the valve 26 to reverse the valve 26 and cause the system to operate as a reversed cycle refrigeration system with the indoor coil 46 becoming the condenser and the outdoor coil 34 becoming the evaporator. The fan motor 58 is also energized through the conductors 92 and 94 which connect with the conductors 96 and 98 extending between the sealed motor-compressor unit 22 and the conductors 90 and 121. The conductor 121 connects with the spring contact 82 as well as the lever contacts 123 and 125. The spring contact 84 is preferably located nearer the contact 80 than the contact 82 is to the contact 78 so that the reversing solenoid 28 of the valve 26 will be energized before the energiztaion of the sealed unit 22 and will be deenergized after the deenergization of the sealed unit 22.

The lever contact 123 is provided with an adjustable stop screw 127 which limits its downward movement. On its end it carries a contact adapted to cooperate with a contact on top of the lever 76 when the temperature of the bulb 70 is in the refrigeration region. Below this temperature, the lever 76 will be out of contact with the lever contact 123. The lever contact 125 is provided with an adjustable stop screw 129 allowing a limited downward movement from the position shown in Figure 1. The conductor 121 connects through the lever contact 125 and a second lever contact 131 and a conductor 133 with the solenoid 40 for the reheat solenoid valve 38. The other terminal of the solenoid 40 connects with the conductor 90.

The engagement of the lever contact 123 with the lever 76 energizes the sealed motor-compressor unit 22 in parallel electric circuit with the fan motor 58 and with the solenoid 40 so that the solenoid 40 moves the valve 38 to the open position shown in Figure 4 while the motor-compressor unit 22 and the fans 60 and 62 operate. This causes the compressed refrigerant discharged from the sealed motor-compressor unit through its outlet conduit 24 to flow through the valve 26 and the conduit 30 and thence to divide with part flowing through the conduits 32, the outdoor coil 34 and the conduit 42 while the other part flows through the conduit 36, the reheat solenoid valve 38, the conduit 52, the reheat coil 54 and the conduit 56 to join the conduit 42 adjacent its connection with the capillary restrictor tube 44. Condensation will take place both in the condenser 34 and in the reheat coil 54. Condensed liquid will flow through both the conduit 42 and the conduit 56 into the capillary tube 44 and thence flow through the capillary tube 44 to the indoor coil 46 where it will evaporate to cool the air to about 62° F. flowing to the left through both the indoor coil 46 and the reheat coil 54 which reheats the air to about 75° F. which then is drawn into the interior of the centrifugal fan 62.

If the air should become cooler, the lever 76 will move downwardly to separate from the lever contact 123 to stop the operation of the motor-compressor unit 22 and the fan 58 and to close the valve 38. Under proper conditions, the primary lever 76 may cycle in this condition. Under cold conditions, the primary lever 76 may cause the contacts 78, 80, 82 and 84 to cycle to provide reverse cycle heating. In between these two conditions, the primary lever 76 will be out of contact with all of the contacts so that all operation will cease when no heating or cooling is required.

The primary lever 76 has an offset spacer 135 connected to it which extends into contact with a mid point of the lever contact 125. Also fastened to the lever 76 is a second spacer 137 extending into contact with the lever contact 131. Both of these spacers 135 and 137 are of insulating material. The lever contacts 123, 125 and 131 are all conductors.

As the temperature of the bulb 70 raises to raise the primary lever 76 beyond the position shown in Figure 1, the spacer 135 will raise the lever contact 125 faster than the spacer 137 will raise the lever contact 131 to cause the lever contacts 125 and 131 to be separated to deenergize the solenoid 40 and close the valve 38 as shown in Figure 3. This will prevent the flow of hot gas into the reheat coil 54 and cause the apparatus to operate as a simple refrigerating system with all condensation taking place in the outdoor coil 34 and all evaporation in the indoor coil 46 to provide maximum cooling. The closing of the valve 38 will prevent any hot gas from reaching the reheat coil 54. Whatever hot gas may be in the conduit 52 and the reheat coil 54 at the time of closing of the valve 38 will be quickly condensed in the reheat coil 54. Since liquid is present in the conduits 42 and 56, no hot gas can reach the reheat coil 54 as long as the valve 38 is closed. Should the condensation of the gas in the conduit 52 cause the reduction of pressure therein, some liquid refrigerant may be drawn into the reheat coil 54. This liquid refrigerant, however, will have only a slight heating effect for a short period of time and will not interfere with the attainment of maximum cooling of the air drawn through the evaporator 46.

The withdrawal of a small portion of the liquid refrigerant from recirculation in the refrigerating system during the cooling cycle is beneficial. No excess amount of lubricant will collect in the reheat circuit. The system therefore provides for the tempering of air by either heating the room air or cooling the room air with or without reheat so that three different tempering conditions for the air are provided automatically in accordance with variations in the temperature of the room air. The temperature at which the different types of operation take place may be adjusted by adjusting the tension of the adjusting spring 139 which connects to the primary lever 76 and opposes the expansion of the bellows 74. The adjustable stop screw 127 determines the lowest temperature at which the system operates and cycles as a refrigerating system. The adjustable stop screw 129 sets the lowest temperature at which the contacts 125, 131 will engage to energize the solenoid 40.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. Air conditioning apparatus including a motor-compressor unit having a refrigerant inlet and a refrigerant outlet, a condenser having a refrigerant inlet and a refrigerant outlet and having a restriction to refrigerant flow, an evaporator having a refrigerant inlet and outlet for cooling a stream of air, a reheat coil in the stream of air following the evaporator having a refrigerant inlet and a refrigerant outlet, a valve having only fully open and fully closed positions and having an inlet and an outlet, conduit means connecting the outlet of said motor-compressor unit to the inlet of said condenser and to the inlet of said valve, conduit means connecting the outlet of said valve and the inlet of said reheat coil, an expansion device having inlet means connected to the outlets of said condenser and said reheat coil and having outlet means connected to the inlet of said evaporator, the combined restrictions of said valve in its open position and said reheat coil to refrigerant flow at the desired rate being substantially equal to said restriction of refrigerant flow of said condenser.

2. Air conditioning apparatus including a motor-compressor unit having a refrigerant inlet and a refrigerant outlet, a condenser having a refrigerant inlet and a refrigerant outlet and having a restriction to refrigerant flow, an evaporator having a refrigerant inlet and outlet for cooling a stream of air, a reheat coil in the stream of air following the evaporator having a refrigerant inlet and a refrigerant outlet, a valve having only fully open and fully closed positions and having an inlet and an outlet, conduit means connecting the outlet of said motor-compressor unit to the inlet of said condenser and to the inlet of said valve, conduit means connecting the outlet of said valve and the inlet of said reheat coil, a capillary tube expansion device having inlet means connected to the outlets of said condenser and said reheat coil and having outlet means connected to the inlet of said evaporator, the combined restrictions of said valve in its open position and said reheat coil to refrigerant flow at the desired rate being substantially equal to said restriction of refrigerant flow of said condenser, a solenoid for moving and holding said valve in the open position, and control means for concurrently energizing said solenoid and motor-compressor unit to obtain cooling with reheating and for deenergizing said solenoid to close said valve to exclude compressed gaseous refrigerant from said reheat coil and energizing said motor-compressor unit to obtain cooling without reheating.

3. Air conditioning apparatus including a motor-compressor unit having a refrigerant inlet and a refrigerant outlet, a reversing four-way valve having normal refrigeration and reversed cycle positions and having separate connections to said inlet and said outlet and having two additional separate connections, a condenser having a refrigerant inlet and a refrigerant outlet, an evaporator having a refrigerant inlet and a refrigerant outlet, a refrigerant expansion device having an outlet connected to the refrigerant inlet of said evaporator and having an inlet, a reheat coil having a refrigerant inlet and outlet, means for circulating air to be tempered consecutively in heat transfer relation with said evaporator and said reheat coil, means connecting the outlets of said condenser and said reheat coil with the inlet of said expansion device, a second valve having its outlet connected to the inlet of said reheat coil and having an inlet, means connecting one of said additional separate connections of said four-way valve to the inlets of said condenser and second valve, and means connecting the other additional separate connection of said four-way valve to the outlet of said evaporator, temperature responsive means responsive to a low temperature for closing said second valve and moving said four-way valve to its reversed cycle position and operating said motor-compressor unit and responsive to a higher temperature for moving said four-way valve to its normal position and opening said second valve and operating said motor-compressor unit and responsive to a still higher temperature for keeping said four-way valve in its normal position and operating said motor-compressor unit and closing said second valve.

4. Air conditioning apparatus including a motor-compressor unit having a refrigerant inlet and a refrigerant outlet, a reversing fourway valve having normal refrigeration and reversed cycle positions and having separate connections to said inlet and said outlet and having two additional separate connections, a condenser having a refrigerant inlet and a refrigerant outlet, an evaporator having a refrigerant inlet and a refrigerant outlet, a refrigerant expansion device having an outlet connected to the refrigerant inlet of said evaporator and having an inlet, a reheat coil having a refrigerant inlet and outlet, means for circulating air to be tempered consecutively in heat transfer relation with said evaporator and said reheat coil, means connecting the outlets of said condenser and said reheat coil with the inlet of said expansion device, a second valve having its outlet connected to the inlet of said reheat coil and having an inlet, means connecting one of said additional separate connections of said four-way valve to the inlets of said condenser and second valve, and means connecting the other additional separate connection of said four-way valve to the outlet of said evaporator, a first electrical operating means for operating said four-way valve from its normal position to its reversed cycle position, a second electrical operating means for operating said second valve from its closed position to its open position, a thermostatic switch means responsive to low temperatures for energizing said motor-compressor unit and said

first electrical operating means and responsive to higher temperatures for deenergizing said first electrical operating means and energizing said motor-compressor unit and said second electrical operating means and responsive to still higher temperatures for deenergizing both said first and second electrical operating means and energizing said motor-compressor unit.

5. Air conditioning apparatus including a motor-compressor unit having a refrigerant inlet and a refrigerant outlet, a reversing four-way valve having normal refrigeration and reversed cycle positions and having separate connections to said inlet and said outlet and having two additional separate connections, a condenser having a refrigerant inlet and a refrigerant outlet, an evaporator having a refrigerant inlet and a refrigerant outlet, a refrigerant expansion device having an outlet connected to the refrigerant inlet of said evaporator and having an inlet connected to the outlet of the condenser, a reheat refrigerant circuit having its inlet and outlet connecting with the inlet and outlet of said condenser and having its intermediate portion in the form of a reheat coil, means for circulating air to be tempered consecutively in heat transfer relation with said evaporator and said reheat coil, a second valve connected in said reheat refrigerant circuit in series with said reheat coil, means connecting one of said additional separate connections of the four-way valve to the inlets of said condenser and reheat circuit, means connecting the other additional separate connection of the four-way valve to the outlet of said evaporator, temperature responsive means responsive to a low temperature for closing said second valve and moving said four-way valve to its reversed cycle position and operating said motor-compressor unit and responsive to a higher temperature for moving said four-way valve to its normal position and opening said second valve and operating said motor-compressor unit and responsive to a still higher temperature for keeping said four-way valve in its normal position and operating said motor-compressor unit and closing said second valve.

6. Air conditioning apparatus including a motor-compressor unit having a refrigerant inlet and a refrigerant outlet, a reversing four-way valve having normal refrigeration and reversed cycle positions and having separate connections to said inlet and said outlet and having two additional separate connections, a condenser having a refrigerant inlet and a refrigerant outlet, an evaporator having a refrigerant inlet and a refrigerant outlet, a refrigerant expansion device having an outlet connected to the refrigerant inlet of said evaporator and having an inlet connected to the outlet of the condenser, a reheat refrigerant circuit having its inlet and outlet connecting with the inlet and outlet of said condenser and having its intermediate portion in the form of a reheat coil, means for circulating air to be tempered consecutively in heat transfer relation with said evaporator and said reheat coil, a second valve connected in said reheat refrigerant circuit in series with said reheat coil, means connecting one of said additional separate connections of the four-way valve to the inlets of said condenser and reheat circuit, means connecting the other additional separate connection of the four-way valve to the outlet of said evaporator, a first electrical operating means for operating said four-way valve from its normal position to its reversed cycle position, a second electrical operating means for operating said second valve from its closed position to its open position, a thermostatic switch means responsive to low temperatures for energizing said motor-compressor unit and said first electrical operating means and deenergizing said second electrical operating means and responsive to higher temperatures for deenergizing said first electrical operating means and energizing said motor-compressor unit and said second electrical operating means and responsive to still higher temperatures for deenergizing both said first and second electrical operating means and energizing said motor-compressor unit.

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