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2,844,946

AIR CONDITIONING DEVICE WITH REHEAT MEANS

Filed March 16, 1955

3 Sheets-Sheet 1

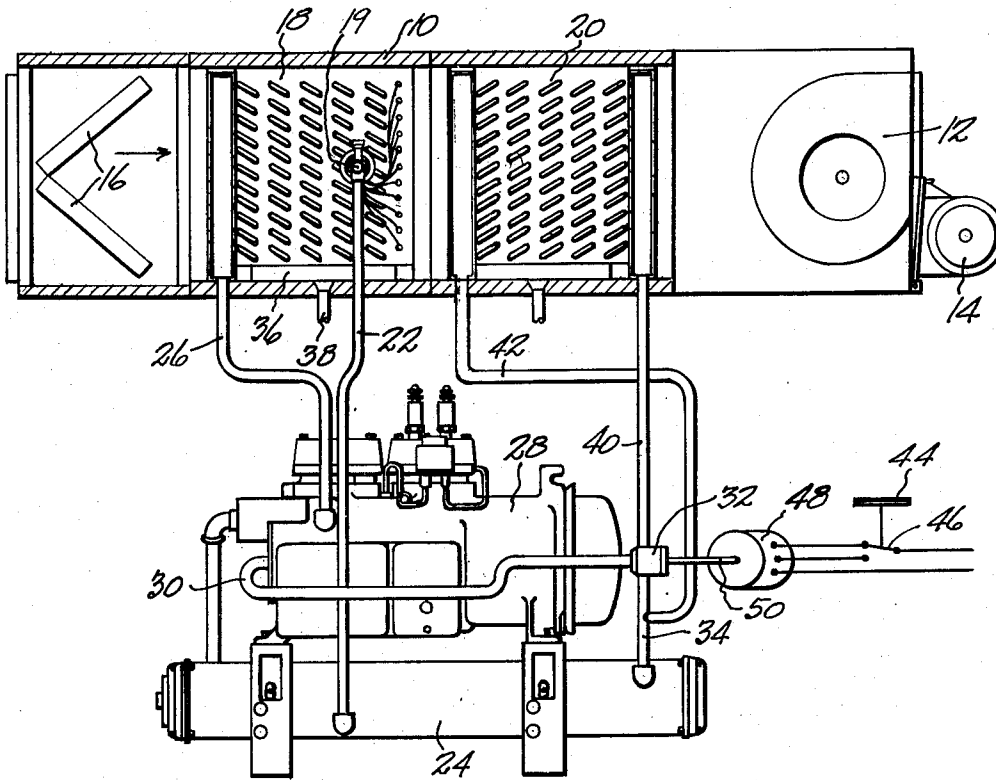


Fig. 1.

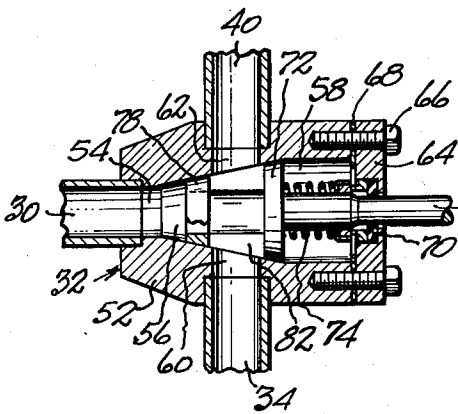


Fig. 2.

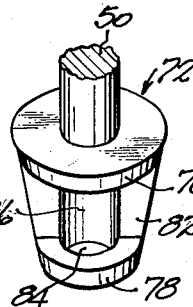


Fig. 3.

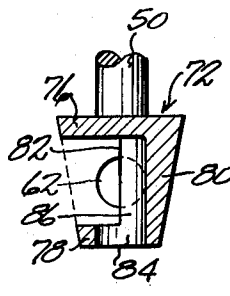


Fig. 4.

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3 Sheets-Sheet 2

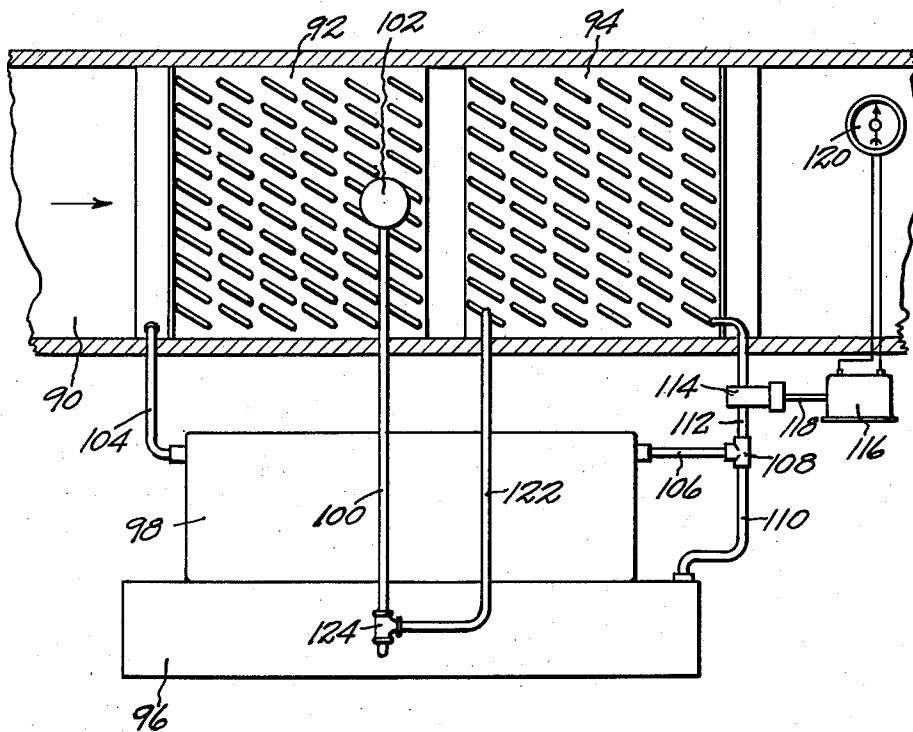


Fig. 5.

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3 Sheets-Sheet 3

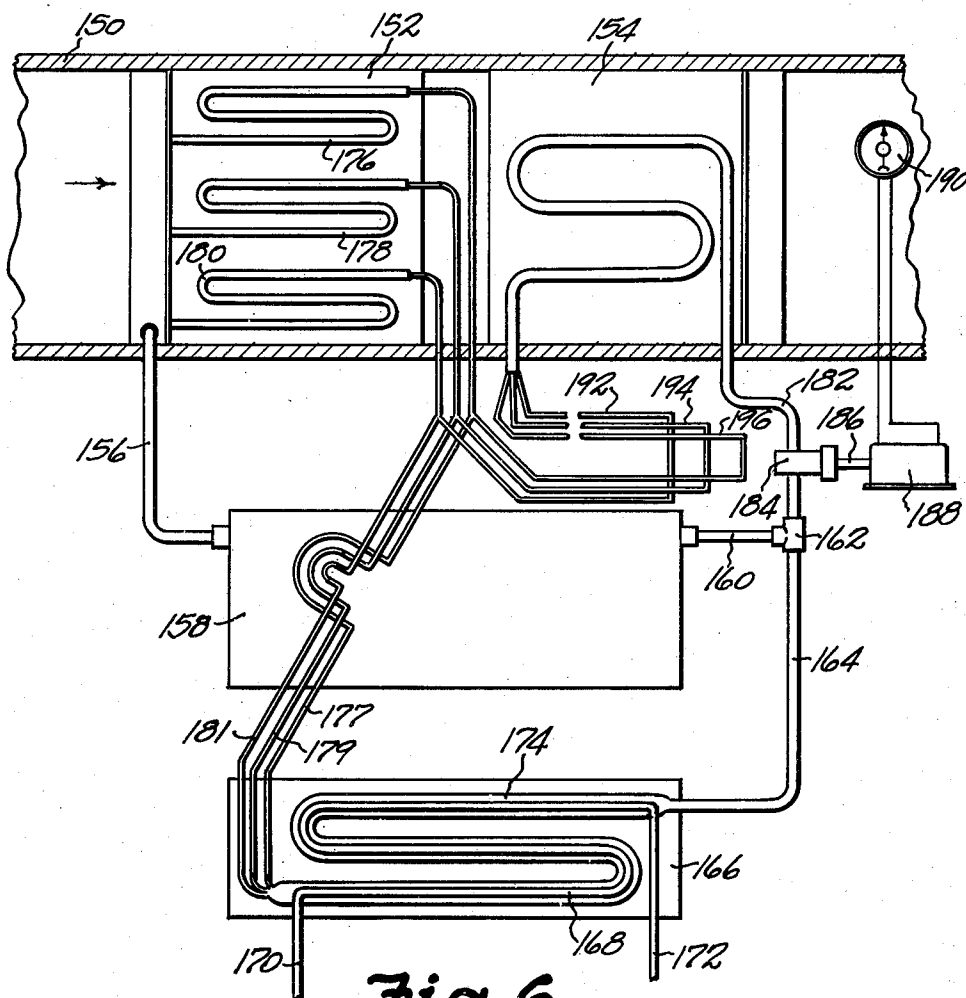


Fig. 6

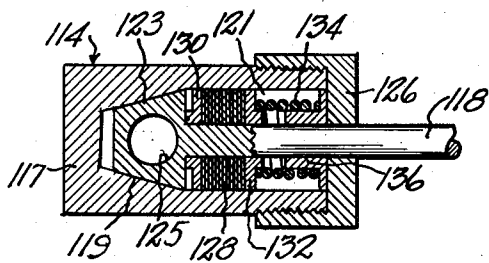


Fig. 7.

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AIR CONDITIONING DEVICE WITH REHEAT MEANS

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Application March 16, 1955, Serial No. 494,745

1 Claim. (Cl. 62—173)

This invention relates to improvements in air conditioning devices and methods.

The primary object of this invention is to provide a device and method of this character in which air cooling means and air reheating means are associated through suitable controls to operate upon a refrigerating medium for the purpose of maintaining a desired temperature within a space to be conditioned.

A further object is to provide a device of this character having a cooler operative to cool air and to reduce the humidity of air, and reheating means operative by the same medium employed in the cooling means, and adapted to temper or warm air which has been cooled excessively incident to operation of the cooler to reduce humidity of the air to desired level.

A further object is to provide a device of this character having a cooling coil unit and a heating coil unit positioned in the path of air drawn through the system by a fan, said cooling and heating units being operative by means of a refrigerating agent which discharges from the cooling unit to a compressor and a condenser for return to the cooling unit, and a portion of which may be diverted in its flow from the compressor to by-pass through the reheating coil to deliver heat absorbed from the air in the cooling unit back to the air passing through the reheating unit.

A further object is to provide a device of this character having a cooling coil, a heating coil, a compressor and a condenser, with means responsive to air temperature in the space to be conditioned, adapted to divert any selected portion of a refrigerant discharged from the compressor to cause it to flow through the reheating coil to restore air temperature to desired condition without requiring the operation of an auxiliary heating unit for the purpose and in a manner to effect a saving of the amount of cooling water normally required in a water cooled condenser for condensing a refrigerating agent after the same has been compressed.

A further object is to provide a device of this character which is adapted to control the temperature of air at a constant comfortable value without substantial variation in rate of flow.

A further object is to provide a device of this character which is capable of cooling and dehumidifying air at one hundred percent capacity, or dehumidifying alone at one hundred percent of capacity while cooling to any desired extent between zero and one hundred percent of capacity.

Other objects will be apparent from the following specification.

In the drawings:

Fig. 1 is a schematic view illustrating one embodiment of the invention;

Fig. 2 is an axial sectional view of a diverter valve employed in the device;

Fig. 3 is a perspective view of a shiftable plug element of the valve;

Fig. 4 is an axial sectional view of the plug element of the valve;

Fig. 5 is a schematic view illustrating another modification of the invention;

Fig. 6 is a schematic view illustrating a third embodiment of the invention; and

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Fig. 7 is an axial sectional view of another valve construction.

Referring to the drawing, and particularly to Fig. 1 which illustrates one embodiment of the invention, the numeral 10 designates a passageway through which air is drawn by means of a fan 12 operated by a motor 14 under suitable control in the manner well understood in the art. One or more filter elements 16 will preferably span the passage 10 and will be removably mounted therein. A cooling coil 18, commonly referred to as a direct expansion coil, is mounted in the passage 10. A reheat coil 20 is also mounted in the passage 10 and preferably is located between the direct expansion coil 18 and the discharge end of the passage 10, as illustrated. The direct expansion coil 18 will be provided with an expansion valve 19 connected in a line 22 leading from a condenser and receiver unit 24 of any suitable character, such as a combination water cooled condenser and receiver of the type well known in the art. A suction line 26 connects the discharge end of the expansion coil 18 with a compressor 28. A gas discharge line 30 leads from the compressor 28 to a valve 32, and a line 34 leads from valve 32 to the condenser 24.

A refrigerating agent or medium of any suitable type well known in the art, one example of which is Freon, is employed in the system. A refrigerant in condensed state passes from the condenser 24 through the conduit 22 to the expansion valve 19 and thence through the direct expansion coil 18 which is impinged by the air flowing through the passage 10 and thereby is cooled by delivering its heat to the refrigerant to gasify the same within the direct expansion coil 18. The gas from coil 18 is drawn therefrom through the conduit 26 by the operation of the compressor which serves to increase the pressure of the refrigerant. The high pressure refrigerant is discharged from the compressor 28 through the conduit 30 and the line 34 for delivery to the condenser 24. The operation of the refrigerating unit of the device further entails condensation of moisture in the air passing through the device upon contact thereof with the direct expansion coil 18. This moisture precipitates to a collector vessel 36 and is discharged through a drain 38.

A conduit 40 extends from the valve 32 to the reheat coil 20 at the end of that coil adjacent the air discharge, high pressure gas which is diverted by the valve 32 into the conduit 40 thus enters the reheat coil 20 and flows therethrough in a counterflow direction compared to the direction of flow of air within the chamber 10. The conduit 42 is connected with the opposite end of the reheat coil 20 and is tapped or connected to the conduit 34 between the valve 32 and the condenser 24. The air in casing 10, which has been cooled by the direct expansion coil 18, picks up heat from the reheat coil 20 with incident condensation of the refrigerant which then passes through the conduit 42 and into the condenser 24.

Control of the device is effected in any suitable manner, as through a thermostatic element 44, controlling a switch 46 in the leads to a reversible motor 48 for positioning the valve element of valve 32 with which the motor shaft 50 is connected. The arrangement will be such that the valve 32 will be positioned to direct all of the high pressure gas passing through conduit 30 to the conduit 34 when the ambient temperature to which the thermostat 44 responds exceeds a predetermined setting. When ambient temperature falls below the predetermined setting, the thermostat operates the valve 46 to reverse the controlling or positioning motor 48 to open the valve for the purpose of dividing the high pressure gas led thereto by the conduit 30 so that a predetermined portion thereof may pass through conduit 40 to the reheat coil 20 through which it circulates for ultimate re-

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turn through line 42 to the conduit 34 leading to the condenser 24. The rate of flow of gas to the reheat coil 20, and the duration of such flow, is directly controlled by the thermostat 44 through the medium of the positioning motor 48, and as soon as ambient temperature again raises to the desired value for which the thermostat is set, the thermostat will operate the switch 46 to control the positioning motor 48 for movement to a position closing the line 40.

By reason of the fact that the refrigerating agent, and particularly Freon, is highly susceptible of leakage, a construction of the diverter valve 32 is important. One form of valve which I have found suitable is illustrated in Figs. 2, 3 and 4. The valve 32 has a body 52 having a passage 54 with which the conduit 30 communicates. A tapered or frusto conical valve seat portion 56 communicates with the passage 54 and a comparatively large bore portion 58 is open at the opposite end of the housing 52. A cross-bore 60 with which conduit 34 communicates branches from the tapered valve seat 56 intermediate the length thereof and cross-bore 62, with which conduit 40 communicates, likewise branches from valve seat 56 intermediate the length thereof. A centrally apertured closure plate 64 spans the open end of the valve housing to which it is secured by screws or other securing means 66 and with which it is sealed by gasket means 68. A packing gland 70 is seated in the aperture of the plate 64 and encircles and sealingly engages the motor shaft 50. A valve element 72 is carried by shaft 50, the same being frusto conical in general outline and adapted for a snug rotative fit within the tapered valve seat 55 to which it is urged by the coil spring 74.

The valve element 72 is best illustrated in Figs. 3 and 4 and constitutes a disk portion 76 at its large diameter end and a disk portion 78 at its small diameter end, the same being spaced apart and interconnected by a longitudinal portion 80 defined by cutting away approximately one-half of the plug between the portions 76 and 78 along the plane 82. An aperture 84 is formed in the disk 78 and the face 82 is preferably recessed at 86 in register with the aperture 84 to accommodate full and substantially unrestricted flow from conduit 30 into the space between the disk portions 76 and 78. The longitudinal portion 80 is of sufficient extent to span and completely close the cross-passage 62 leading to the conduit 40 in one position of the valve element, namely, the position occurring when ambient temperature exceeds the temperature for which the thermostat 44 is set. Rotation of the valve element from that position to a position, such as illustrated in Figs. 2 and 4, will permit at least partial communication or opening of each of the passages 60 and 62. Rotation of the valve serves a proportioning function regulating or proportioning the percentage of gas entering the valve through the conduit 30 which passes to each of the conduits 34 and 40. Thus, when ambient temperature falls below the temperature for which the thermostat 44 is set, the valve will be set to permit a part of the gas from conduit 30 to pass through conduit 40. Likewise, the greater the temperature drop at the thermostat, the greater the extent to which the valve opens into communication with the conduit 40.

Control of the valve 32 from the thermostat 44 can occur independently of any variation of the rate of flow of air through the passage 10 effected by operation of the fan 12. Thus a substantially constant flow of air can occur, and the heating and cooling thereof can vary without varying the rate of air flow.

A modified embodiment of the invention is illustrated schematically in Fig. 5. In this construction a housing or passage 90 open for passage of air therethrough by a fan or like means has a direct expansion coil 92 and a reheating coil 94 positioned therein in sequence. Air

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will be taken from the space to be conditioned and passed through the member 90 to be sequentially acted upon by the direct expansion or cooling coil 92 and the reheating coil 94 and then returned or delivered to the space to be conditioned. A condenser 96 and a compressor 98 are connected with the coils 92 and 94 to accommodate circulation of Freon or other refrigerating agent there-through.

A conduit 100 leads from the condenser 96, which may be of any suitable type and which preferably is a water cooled condenser or receiver, to the expansion valve 102 of the direct expansion coil 92. The conduit 100 delivers the refrigerant in liquid form to the coil 92 in which the refrigerant is exposed to flow of warm air through the passage 90 and picks up heat from the air and thereby becomes gasified. The gasified refrigerant is discharged from the coil 92 at a suction line 104 leading to the intake of the compressor 98. The compressor 98 serves to compress the gas from a low pressure state in which it exists in the coil 92, for example, at a pressure of approximately thirty-seven pounds per square foot, to a pressure which is much greater, for example, pressure in the order of 105 pounds per square foot. The operation of the compressor serves to draw the gas from the coil 92 and thus produces the flow in the system.

Gas at high pressure which is discharged by the compressor 98 passes through the conduit 106 to a T-fitting 108 with which is connected a conduit 110 leading to the condenser 96. High pressure gas thus flows from the compressor to the condenser through conduits 106 and 110.

A second conduit 112 branches from the T-fitting 108 and has a modulating valve 114 interposed therein. The modulating valve has a control or operating member 116 which may be a reversible modulating motor whose shaft 118 is connected to the shiftable valve element of the valve 114. The modulating member 116 is under the influence of a controller 120, such as a thermostatic switch, while the controller 120 has been illustrated as located within the passage 90, it will be understood that this is not essential and that it may be located within the space to be conditioned. The conduit 112 leads to the reheat coil 94 at the end thereof remote from the direct expansion coil 92. A conduit 122 constitutes a discharge line leading from the reheat coil 94. As here illustrated, the discharge line 102 is connected at a T-fitting 124 with the conduit 120 adjacent to the condenser 96. If desired, the line 122 may lead to the condenser 96, as illustrated in Fig. 1.

The valve 114 employed in this construction is preferably of the character illustrated in Fig. 7, having a cup-shaped housing 117 whose bore has a tapered inner end portion 119 and a cylindrical bore portion 121. Passages are formed in the body 117 transversely thereof to intersect the bore 119 at the tapered portion thereof preferably intermediate the length of said tapered portion. A frusto conical valve element 123 is rotatable in and has a snug fit in the tapered bore 119 and has a passage 125 extending therethrough perpendicular to its axis and adapted for register with the passages which communicate with conduit 112. The valve element 123 is mounted upon the motor shaft 119 which passes through an aperture in the end plate 126 of a screw-threaded cap fitting over and closing the open end of the cup-shaped housing 117. A plurality of packing members or washers 128 encircle the shaft 119 and effect a seal around the shaft and at the bore 121. The washers 128 are clamped between an inner plate 130 and an outer plate 132 by means of a coil spring 134 which encircles the shaft 118 and preferably is held spaced from said shaft by means of a bushing sleeve or tubular positioning member 136.

This embodiment of the invention relies upon the affinity of hot gases for cooling surfaces and upon the fact

that the condenser 96 will normally operate at a higher pressure than the pressure within the reheat coil 94 to produce flow of gas through the conduit 112 to the extent permitted by the modulating valve 114. Consequently, in the operation of this device, the natural flow path for the hot refrigerant gases discharged from the compressor 98 is through the reheat coil 94 to the extent that the valve 114 permits flow of such gases therepast. This factor permits the use of the comparatively simple valve 114 illustrated in Fig. 7 and eliminates the necessity for a valve of the construction illustrated in Fig. 2.

Another embodiment of the invention is illustrated in Fig. 6. In this construction the air passage 150 receives the direct expansion coil 152 and the reheat coil 154 shown schematically and arranged in sequence with respect to the direction of air flow which is as indicated by the arrow.

The suction line 156 leading from the direct expansion coil 152 extends to the compressor 158. Hot gases at high pressure discharged from the condenser pass through conduit 160 to T-fitting 162, having conduit 164 connected therewith and leading to condenser 166. The condenser 166 is preferably of the counterflow water cooled type having a water coil 168 whose inlet 170 is located adjacent the discharge end of the condenser and whose outlet 172 is located adjacent the inlet end of the condenser. The water coils 168 preferably pass through the gas coil 174 of the condenser to provide cooling action upon the gas within the coil 174.

The direct expansion coil 152 is of the type having a plurality of individual coils, here shown as three coils 176, 178 and 180. The outlet from the condenser 166 consists of a plurality of capillary tubes equal in number to the number of coils in the direct expansion coil unit 152. Thus as here shown, three capillary tubes 177, 179 and 181 branch from the discharge end of the gas conduit 174 of the condenser and extend in parallel relation for connection, respectively, to the coils 176, 178 and 180. The capillary tubes will be of identical properties with respect to size of bore and also with respect to the length thereof.

The reheat coil 154 will be connected at the end thereof remote from the direct expansion coil 152 with a conduit 182 leading to the T-fitting 162 and having modulating valve 184 interposed therein, and operated by the shaft or other output member 186 of a controller 188, such as a reversible motor which in turn operates in response to a control element 190 responding to the ambient temperature or to the output temperature or to any other property associated with the condition to be controlled. The valve 184 will operate to modulate and control the proportion of the hot gases discharged from the compressor 158 which passes to the reheat coil 154. The discharge end of the reheat coil 154 has connected thereto a plurality of capillary tubes equal in number to the capillary tubes extending between the condenser and the direct expansion coil. Thus three capillary tubes are here shown, consisting of tube 192 which connects with capillary tube 181 intermediate the latter, tube 194 which connects with capillary tube 179, and capillary tube 196 which connects with capillary tube 177. The capillary tubes 192, 194 and 196 have the same properties as the capillary tubes 177, 179 and 181. In other words, each has a bore similar to the bore of the others and to the bores of the other set, and each of the tubes 192, 194, 196 is exactly the same length as the others, and also exactly of the same length as the capillary tubes 177, 179 and 181 leading from the counterflow condenser.

Each of the three embodiments of the invention illustrated operates upon the principle that a selected portion of high pressure refrigerant gas discharged from the compressor is diverted from the line leading to the condenser to be delivered to the reheating coil. This high pressure gas has a high temperature due to its compression and due to the concentration of heat at the compressor.

Consequently, as air flows through the device, it first is cooled at the direct expansion coil and then is reheated at the reheating coil, where heat transfer occurs with the air taking up heat from the refrigerating gas in the reheating coil to the extent required or called for by the control element which actuates the modulating valve in the line leading to the reheat coil. Thus the gas which is discharged from the reheat coil will have been cooled by heat transfer to the air and may be directed either to the receiver of the condenser or to the line leading to the direct expansion coil, as the demands of the system may require.

By this apparatus the air is cooled and also dehumidified. Moisture contained in the air is condensed by the direct expansion coil and is drained therefrom. Subsequent reheating of the air at the reheat coil does not embody or entail any humidifying effect so that dehumidifying action of the system is efficient at all times and can be accomplished in all settings of the controller, that is, in settings which require reheating of the air at the reheating coil in addition to settings in which the reheating coil is not operative because the control elements call for a cooling effect equal to the capacity of the direct expansion coil.

The operation of the modulating control in the modulating valve responds to temperature or to any condition selected for control purposes. A constant control is effected so that, assuming a demand for cooling which results in shutting off flow to the reheat coil, and assuming further that this cooling proceeds beyond the extent required so that a higher temperature is called for, the valve will modulate to permit enough hot gas to enter the reheat coil to effect the reheating required to raise the temperature to the desired point. Consequently, the control secured by the system utilizes any selected percentage of the cooling capacity of the direct expansion coil required to maintain the selected condition. Thus it may be said that each of these devices operates to control temperature through a range from zero percent to one hundred percent of the cooling capacity of the direct expansion coil while maintaining at all times the dehumidifying action of the device at one hundred percent of the dehumidifying capacity of the coil tube.

While the preferred embodiments of the invention have been illustrated and described herein, it will be understood that changes in the construction may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim:

An air conditioning device comprising a housing having an air inlet and an air outlet, a direct expansion coil, a reheat coil, said coils being mounted in said housing in sequence, a compressor connected to said expansion coil, a condenser, a line connecting said condenser to said compressor, a line connecting said condenser and said direct expansion coil, a line connected to said reheat coil and branching from the line between said compressor and condenser, a line connecting said reheat coil to the line between said expansion coil and said condenser, a modulating valve in said branch line, and means responsive to a variable for modulating said valve said expansion coil comprising a plurality of sections, said second named line and said last named line cooperating to define a supply of condensed refrigerant to said expansion coil divided equally between said sections.

References Cited in the file of this patent

UNITED STATES PATENTS

1,837,798	Shipley	Dec. 22, 1931
2,154,136	Parcaro	Apr. 11, 1939
2,170,072	Hartig	Aug. 22, 1939
2,257,975	Miller	Oct. 7, 1941
2,515,842	Swinburne	July 18, 1950
2,679,142	McGrath	May 25, 1954
2,702,456	Ringquist	Feb. 22, 1955