

April 22, 1941.

J. C. CHAMBERS

2,239,190

AIR CONDITIONING METHOD AND APPARATUS

Filed Dec. 1, 1933

5 Sheets-Sheet 1

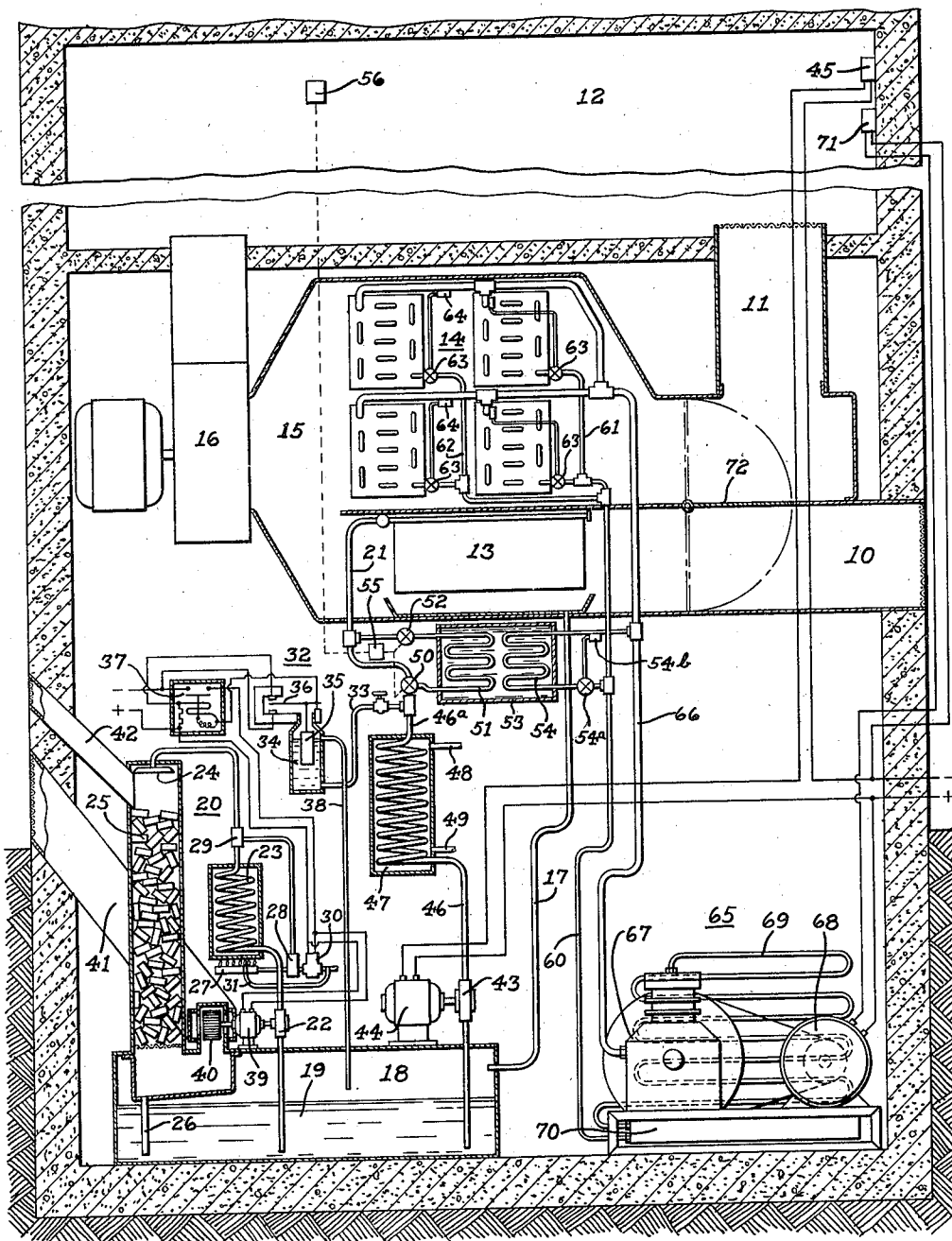


Fig. 1

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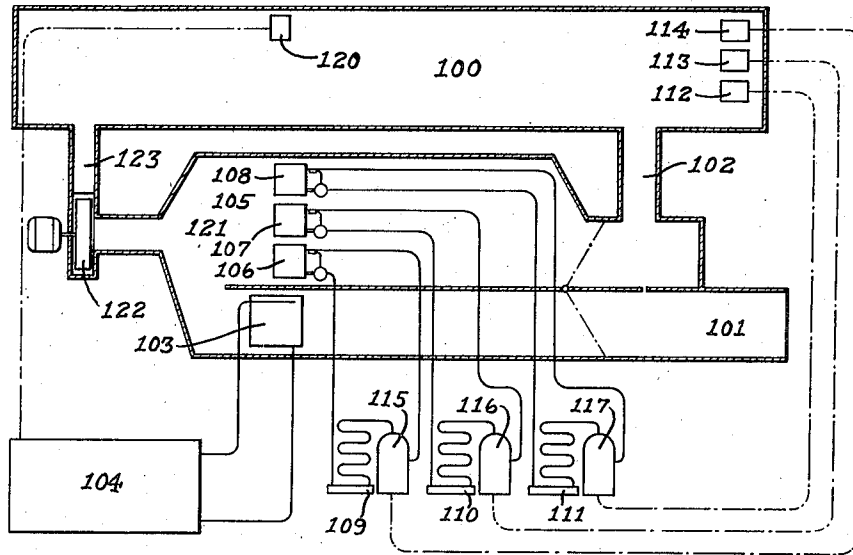


Fig. 2

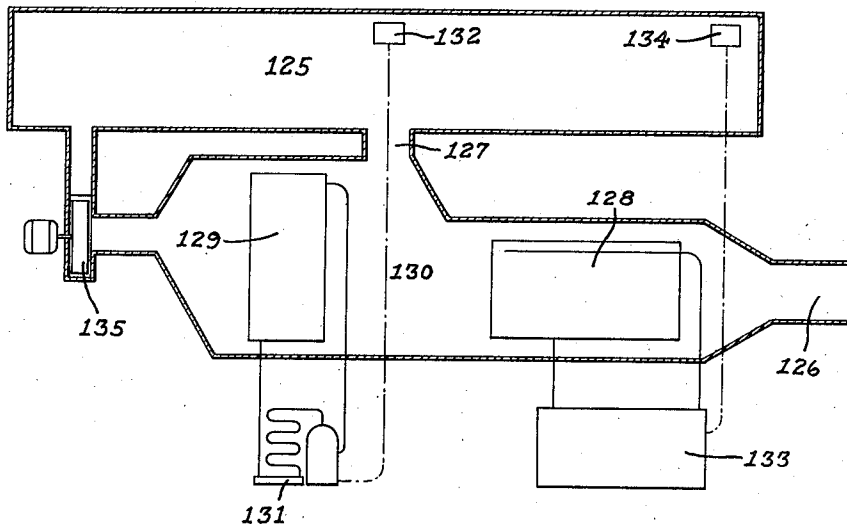


Fig. 3

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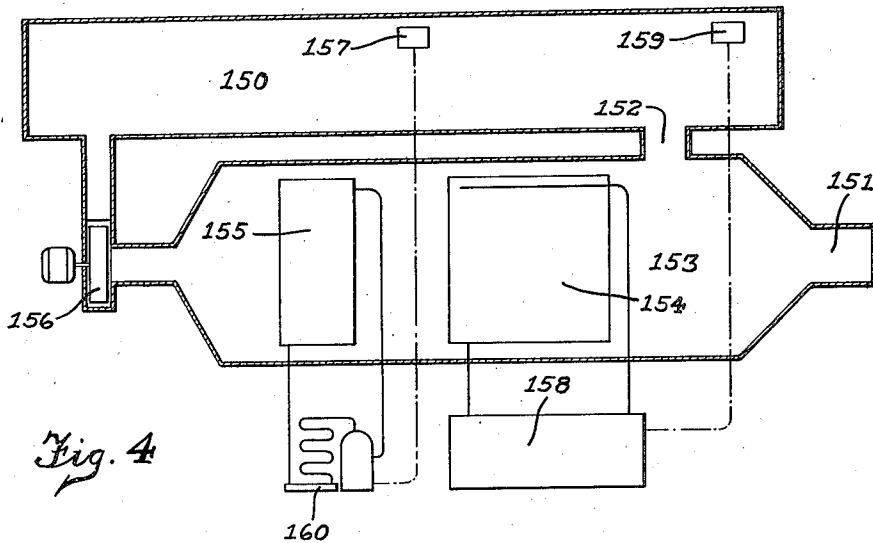
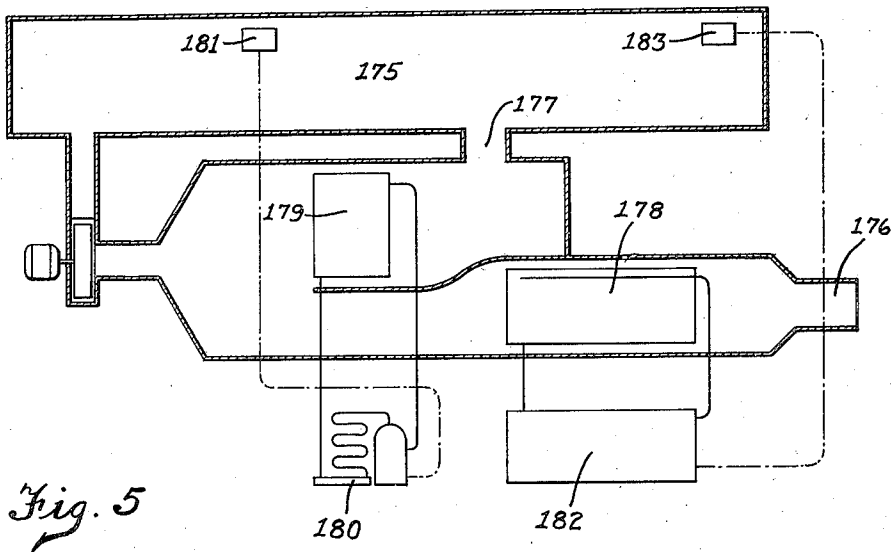
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AIR CONDITIONING METHOD AND APPARATUS

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5 Sheets-Sheet 3



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AIR CONDITIONING METHOD AND APPARATUS

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5 Sheets-Sheet 5

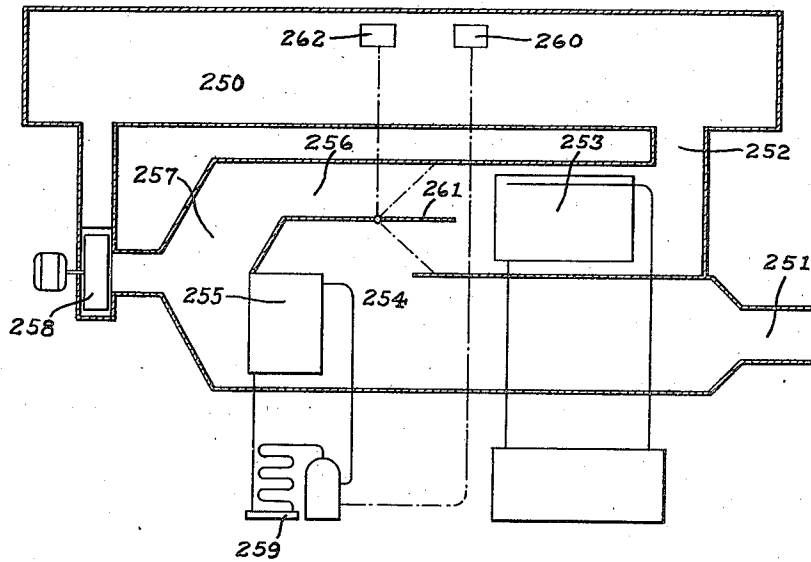


Fig. 8

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UNITED STATES PATENT OFFICE

2,239,190

AIR CONDITIONING METHOD AND APPARATUS

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mesne assignments, to General Motors Corpo-
ration, a corporation of Delaware

Application December 1, 1933, Serial No. 700,452

4 Claims. (Cl. 62—6)

This invention relates to a method and apparatus for conditioning air.

It is among the objects of this invention to provide an improved method and apparatus for conditioning air in which the dehydrating function of the apparatus is performed by a hygroscopic liquid; and the cooling action is performed, in the major part, by an expanded and enclosed refrigerant.

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 form of the present invention is clearly shown.

In the drawings:

Fig. 1 is a view, partly in cross-section and partly diagrammatic, of an apparatus embodying the features of my invention;

Fig. 2 is a view, somewhat similar to Fig. 1, showing a modified form of the invention; and

Figs. 3 to 8 inclusive are views somewhat similar to Fig. 1, but also showing other modifications of the invention.

In practicing my invention, a stream of fresh air and a stream of air, recirculated from the enclosure in which the air is to be conditioned, are subjected to the drying action of a hygroscopic liquid and to the action of an expanded and enclosed refrigerant. The manner in which the streams of air are treated may be varied somewhat as indicated by the various modifications shown in the various figures.

In the modification shown in Fig. 1, the stream of fresh air 10 is subjected to the drying or dehumidifying action of a controlled solution of a lithium halide-like salt, such as lithium chloride, lithium bromide, lithium iodide, and other lithium salts having water vapor pressure reducing characteristics similar to these halides, at the air and liquid contact apparatus 13. The stream of recirculated air 11, from the enclosure 12, is subjected to the action of a controlled, expanded and enclosed refrigerant by passing it through the bank of coils 14. The two streams of air thus treated are mixed at 15 and are delivered by the electrically driven fan 16 into the enclosure 12. While I have indicated that the hygroscopic liquid is preferably a solution of a lithium halide-like salt, it is to be understood that many of the advantages of my invention may be obtained by a hygroscopic liquid made of a different chemical.

The hygroscopic liquid is controlled to provide desired characteristics to the stream of air passing in contact therewith. This control may in-

clude means for automatically imparting to the solution a predetermined degree of concentration and/or temperature. To this end, the hygroscopic leaving contact apparatus 13 flows through a pipe 17 to a concentrating apparatus generally indicated as 20. This includes a tank 18 in which the main body 19 of hygroscopic liquid is maintained. This tank 18 is connected to the remainder of the concentrating apparatus in such a manner that liquid is withdrawn from the main body 19, is concentrated, and is returned to the main body 19. Another portion of liquid from the body 19 is returned to the contact apparatus 13 at the proper concentration and/or temperature through the pipe 21.

The concentrating apparatus 20 may be of any desired construction, but preferably, it is of the character disclosed in Fig. 1. In this apparatus, a portion of the liquid from the body 19 is withdrawn by means of the pump 22 and is forced through a heating coil 23 where a predetermined temperature is imparted thereto and from whence it is delivered through the spray-head 24 to be contacted with a stream of air passing upwardly through the contact or evaporating apparatus 25 where the liquid gives off a predetermined amount of water vapor to the air passing upwardly there-through and from whence the liquid returns through the pipe 26 to the main body 19.

The coil 23 is heated by any suitable means, such as a gas burner 27 which is controlled jointly by means of a thermostatic valve 28 controlled from the thermostatic bulb 29 in contact with the discharge from the coil 23. The gas flame is also controlled by means of a solenoid valve 30, which is controlled in accordance with the concentration of the hygroscopic liquid in the body 19 in a manner more fully to be described. The burner 27 is ignited by means of the pilot 31.

The control for the solenoid valve 30 is indicated at 32. This includes a bleeder pipe 33 through which flows a small amount of liquid, representative of the liquid in body 19, taken from the pipe 21 and which is discharged into the chamber 34. In this chamber, there is provided a hydrometric float 35 which is responsive to the concentration of the liquid. This float operates an electric contact arm 36 which energizes and deenergizes the electric control apparatus or relay 37 in such a manner that when the arm 36 rises in response to concentration of the hygroscopic liquid, then the solenoid valve 30 closes and extinguishes or reduces the flame at the burner 27. When the hygroscopic liquid weakens and permits the float 35 to sink, the arm

36 drops and causes the electric apparatus 37 to open the solenoid valve 36 to ignite or increase the flame 27. The level of the hygroscopic liquid in the receptacle 34 is maintained by means of the overflow pipe 38. Relays of the type indicated at 37 are well known, and therefore are not further described.

When the solenoid valve 30 is opened, the motor 39 is simultaneously started and drives the pump 22 and the blower 40 to cause the circulation of hygroscopic liquid through the concentrating apparatus, and to force air upwardly from the air intake 41, through the contact apparatus 25, and out through the air discharge duct 42. This removes water vapor from the liquid flowing through 25 to maintain a substantially constant degree of concentration of the liquid in tank 18.

The hygroscopic liquid from the body 19 is delivered to the contact apparatus 13 by means of a pump 43 driven by a motor 44 which is controlled by means of the wet bulb thermostat or hygrosat 45 in the space 12 which opens and closes the circuit to the motor 44. The liquid being pumped through the pipe 46 is cooled in the cooler 47. The cooling medium flowing through this device may be ordinary city water coming from the pipe 48 and leaving through the pipe 49.

For normal or light loads, the cooling action of city water in cooler 47 may be sufficient, but for abnormal or heavy loads, this cooling action may be supplemented or substituted by the cooling action of a refrigerating apparatus. Thus the hygroscopic liquid leaving the cooler 47 at 46a may pass through a valve 50 into a coil 51 where it is artificially cooled and returns to the pipe 21 through the valve 52. The coil 51 may be submerged in water or brine in the tank 53 which is cooled by the evaporator 54 which may be connected with the refrigerant liquefying unit 65 or may be provided with an individual liquefying unit controlled by a thermostat in the tank 53. If desired, refrigerant may be fed to the evaporator 54 through the thermostatic valve 54a controlled by a thermostatic bulb 54b at the outlet of the evaporator 54.

The valves 50 and 52 may be actuated simultaneously by an actuator 55 which is controlled by means of a wet bulb thermostat or hygrosat 56 in the enclosure 12. The instrument 56 may be calibrated so that it has a temperature setting above that of the instrument 45. Thus when a relatively light load or a normal load occurs on the apparatus, the cooler 47 cools the hygroscopic liquid to a sufficient degree, but when an abnormal or heavy load occurs, then the cooling action of cooler 47 is supplemented or substituted by that of the tank 53 which imparts a predetermined temperature to the hygroscopic liquid before it reaches the contact apparatus 13.

The stream of recirculated air 11 is cooled by means of a bank of coils 14. Liquid refrigerant is fed to this bank through the liquid refrigerant pipe 60, which is provided with branches 61 and 62 connected to various expansion valves 63 which feed expanded refrigerant to the various coils of the bank. Thermostatic bulbs 64 are placed at the outlets of each coil and these bulbs operate their respective expansion valves 63 to maintain the coils substantially flooded with liquid refrigerant. The bank of coils 14 derives its liquid refrigerant from a refrigerant liquefying unit 65 to which the expanded or evaporated refrigerant flows through the pipe 66. The liquefying unit 65 may include a compressor 67 driven by a motor

68. The compressed refrigerant is discharged into a condenser 69 from whence the refrigerant flows to the receiver 70 and from whence the liquid refrigerant flows through the pipe 60 to the bank 14. The refrigerant liquefying unit 65 is controlled by means of the dry bulb thermostat 71 which starts and stops the motor 68. The thermostat 71 thus maintains the temperature of the air within the enclosure 12 within predetermined dry bulb temperature limits.

The valves 63 need not have thermostatic controls 64, but may be set to maintain a predetermined pressure, and therefore temperature within the coils of the bank 14.

If desired, a damper 72 may be provided, which may be manually or automatically controlled, to cause a portion of the stream 11 to flow into the contact apparatus 13 or to cause a portion of the stream 10 to flow into contact with the bank of coils 14.

In the modification shown in Fig. 2, the air in the enclosure 100 is to be conditioned. Fresh air enters through the duct 101, and recirculated air through the duct 102. The dehydrating contact apparatus 103 is substantially the same as the contact apparatus 13 of Fig. 1 and the concentrating apparatus 104 is substantially the same as apparatus 20 of Fig. 1. The bank of coils 105 is modified, however. This bank includes coils 106, 107 and 108 which are connected to individual refrigerant liquefying units 109, 110 and 111 respectively. Preferably the coils are arranged so that the stream of air flows through them in parallel as indicated diagrammatically in Fig. 2. The dry bulb thermostats 112, 113 and 114 control the starting and stopping of the motor compressor units 115, 116 and 117 respectively. The thermostats 112, 113 and 114 are calibrated so that their settings or actuating temperatures are slightly different. One liquefying unit thus starts when the temperature in the enclosure 100 rises to a certain predetermined temperature, the second liquefying unit starts when the temperature rises to a second and slightly higher predetermined temperature and the third thermostat operates when the temperature rises to a third and still higher temperature. The stopping temperatures of the various thermostats are also calibrated, so that one liquefying unit stops when the temperature drops to a predetermined temperature, the second liquefying unit stops when the temperature reaches a second and also predetermined temperature, and the third liquefying unit stops when the temperature reaches a third and still lower predetermined temperature. Each of the liquefying units may be substantially the same as the unit 65 shown in Fig. 1. The concentrating unit 104 may be controlled by one or two wet bulb thermostats or hygrosats 120 substantially in the same manner that the unit 20 is controlled in Fig. 1, it being understood, that two wet bulb thermostats or hygrosats may be used for the control of the concentrating unit 104 exactly as unit 20 is controlled in Fig. 1.

The air streams are mixed at 121 and are forced by motor driven fan 122 through duct 123 into enclosure 100.

In Fig. 3 a space 125 is to be conditioned. Fresh air enters through duct 126 and recirculated air is drawn through the duct 127. The dehumidifying or contact apparatus 128 acts on the fresh air stream while the bank of coils 129 acts on the dehydrated fresh air mixed with recirculated air at 130. The bank of coils 129 is provided with a refrigerant liquefying unit 131 which is con-

trolled in accordance with the dry bulb temperature in the enclosure 125 by means of the dry bulb thermostat 132. The concentrating apparatus 133 is controlled by means of the wet bulb thermostat or hygrometer 134 in the enclosure 125. It is to be understood that the bank of coils 129 may be connected to a single liquefying unit substantially as shown in Fig. 1, or that it may be connected to a plurality of liquefying units substantially as indicated in Fig. 2, the refrigerant liquefying unit or units being controlled respectively as described in connection with those figures. Also, the concentrating apparatus 133 may be of the character and is controlled as described with respect to apparatus 20 in Fig. 1. The treated air is delivered by the motor-driven fan 135 into the enclosure 125.

In Fig. 4, the air in space 150 is to be conditioned. Fresh air enters at 151 and recirculated air flows through duct 152. The fresh air and the recirculated air are mixed in the chamber 153 and pass through the contact apparatus 154. Thereafter the mixed air passes through the bank of coils 155 and is returned by means of the motor-driven fan 156 to the enclosure 150. The bank of coils 155 is connected to a refrigerant liquefying unit 160 which is controlled by means of the dry bulb thermostat 157 in the space 150. The concentrating apparatus 158 is controlled by means of one or more wet bulb thermostats or hygrometers 159. In this instance also, the bank of coils 155 may be operated by a single liquefying unit in the same manner as the bank 14 in Fig. 1 or by a plurality of liquefying units in the same manner as the bank 105 in Fig. 2, it being understood that the proper number of thermostats, if necessary, and liquefying units are to be provided if the bank of coils 155 is to operate in the same manner as the bank 105. The concentrating apparatus 158 may be similar to the apparatus 20 and may be controlled in the same manner as that apparatus is controlled, it being understood that two wet bulb thermostats or hygrometers may be provided for the control in the same manner as described in Fig. 1.

In Fig. 5, the air in enclosure 175 is to be conditioned. Fresh air enters through the duct 176 and recirculated air flows through the duct 177. The fresh air is dehydrated by the contact apparatus 178 and the recirculated air is cooled by the bank of coils 179. The bank 179 is connected to the liquefying unit 180 which is controlled by the dry bulb thermostat 181. The concentrating apparatus 182, which supplies the contact apparatus 178, is controlled by one or more wet bulb thermostats or hygrometers 183. Here again, the liquefying unit 180 and the bank of coils 179 may be operated as described with respect to Fig. 1 or may have the plural structure and operation of Fig. 2. The concentrating apparatus 182 may be identical with and may be controlled exactly the same as the apparatus 20 in Fig. 1, having, if desired, a double control from the enclosure as in Fig. 1.

In Fig. 6, the air in enclosure 200 is to be conditioned. Fresh air flows through the duct 201. One stream of return air flows through the duct 202 and mixes with the fresh air in the chamber 203. This mixture is cooled by means of the bank 204. Another stream of recirculated air flows through the duct 205 to the drying or contact apparatus 206. The air thus conditioned is mixed in the chamber 207 and is delivered by the fan 208 into the enclosure 200. The contact

apparatus 206 is provided with a concentrating apparatus 209 which is controlled by one or more wet bulb thermostats or hygrometers 210, the control and concentrating apparatus being identical with the concentrating apparatus 20 and its control as described in Fig. 1. The bank of coils 204 is connected to one or more refrigerant liquefying units 211 controlled by one or more thermostats 212 in a manner similar to the corresponding controls in Figs. 1 and 2 respectively.

In Fig. 7, the air in enclosure 225 is to be conditioned. Fresh air enters through the duct 226 and recirculated air enters through the duct 227. These streams of air are mixed in the chamber 228. One portion of the mixture is dried by the contact apparatus 229 and another portion of the mixture is cooled by means of the bank of coils 230. The portions thus conditioned are mixed in the chamber 231 and the mixture is delivered by the fan 232 into the enclosure 225. The drying or contact apparatus 229 is connected to a concentrating apparatus 233 which is controlled by means of one or more wet bulb thermostats or hygrometers 234, the concentrating apparatus and its control being substantially identical to the apparatus 20 and its control in Fig. 1. The bank of coils 230 is connected to one or more refrigerant liquefying units 235 controlled by one or more dry bulb thermostats 236, the bank of coils, the liquefying units and the controls being substantially identical with the corresponding apparatus in Figs. 1 and 2 respectively.

In Fig. 8 the air in enclosure 250 is to be conditioned. Fresh air flows through the duct 251 and recirculated air flows through the duct 252. The recirculated air is dehydrated by the action of the drying or contact apparatus 253. A portion of the dried recirculated air is mixed with the fresh air at 254. Another portion of dried recirculated air passes through the duct 256 and is mixed in the chamber 257 with the air from bank 255, the mixture being delivered by the fan 258 into the enclosure 250. The bank of coils 255 is connected to one or more refrigerant liquefying units 259 which are controlled by one or more dry bulb thermostats 260 substantially in the same manner as described in Fig. 1 or 2. A damper 261 may be controlled by the wet bulb thermostat or hygrometer 262 to cause more air to enter the mixing chamber 254 or the duct 256 as desired.

I have shown several embodiments of my invention. It is to be seen that, by my invention, it is possible to provide air in an enclosure, by maintaining a stream of air flowing into the enclosure and by subjecting all or portions of the air in said stream to a refrigerating action and to a drying action, and, if desired, by varying the intensities of said actions. Thus the intensity of the refrigerating action may be varied in accordance with certain conditions, such as dry bulb temperature conditions, and the intensity of the drying action may be varied in accordance with these or other conditions such as relative humidity conditions. Thus, air may be maintained in an enclosure to create satisfactory comfort or industrial conditions which has a sufficiently constant dry bulb temperature and a sufficiently constant relative humidity, as desired, by automatically varying the intensities of the refrigerating action and the drying action independently of each other.

While the form of embodiment of the invention

as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. The method of conditioning air for an enclosure which comprises contacting a stream of air with a bank of individual heat exchange units, operating varying numbers of said units in proportion to the temperature change required, contacting another stream of air with a hygroscopic medium, controlling a hygroscopic function of said medium in accordance with relative humidity conditions within said enclosure and discharging said streams in said enclosure.

2. The method of conditioning air for an enclosure which comprises contacting a stream of air derived from said enclosure with a dehydrating medium, mixing a portion of said air with fresh air, contacting said mixture with a cooling medium, controlling said cooling medium in accordance with psychrometric conditions in said enclosure, and combining said cooled mixture with the remaining portion of said dehydrated air.

3. The method of conditioning air for an enclosure which comprises contacting a stream of air derived from said enclosure with a dehy-

drating medium, mixing a portion of said air with fresh air, contacting said mixture with a cooling medium, controlling said cooling medium in accordance with psychrometric conditions in said enclosure, combining said cooled mixture with the remaining portion of said dehydrated air, and controlling said proportions in accordance with the wet bulb temperature of the air in the enclosure.

4. Heat exchange apparatus for supplying conditioning air to a space to be served comprising means for drying air by contacting air with a hygroscopic medium, a plurality of air cooling coils, a refrigerant compressor for each of said coils for supplying a refrigerant to be evaporated therein, means for passing air to be conditioned simultaneously in contact with all of said coils, means for varying the flow of air over said coils, means responsive to the temperature of the refrigerant returning from each of said coils for controlling the supply of refrigerant thereto, means for discharging the air thus cooled and dried into a space to be conditioned and means responsive to the thermal condition of the air in said space for controlling the operation of the compressors.

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