

Nov. 25, 1941.

H. F. SMITH
CONDITIONING APPARATUS HAVING MEANS FOR CONTROLLING THE
TEMPERATURE AND RELATIVE HUMIDITY OF AIR
Filed March 31, 1937

2,264,221

3 Sheets-Sheet 1

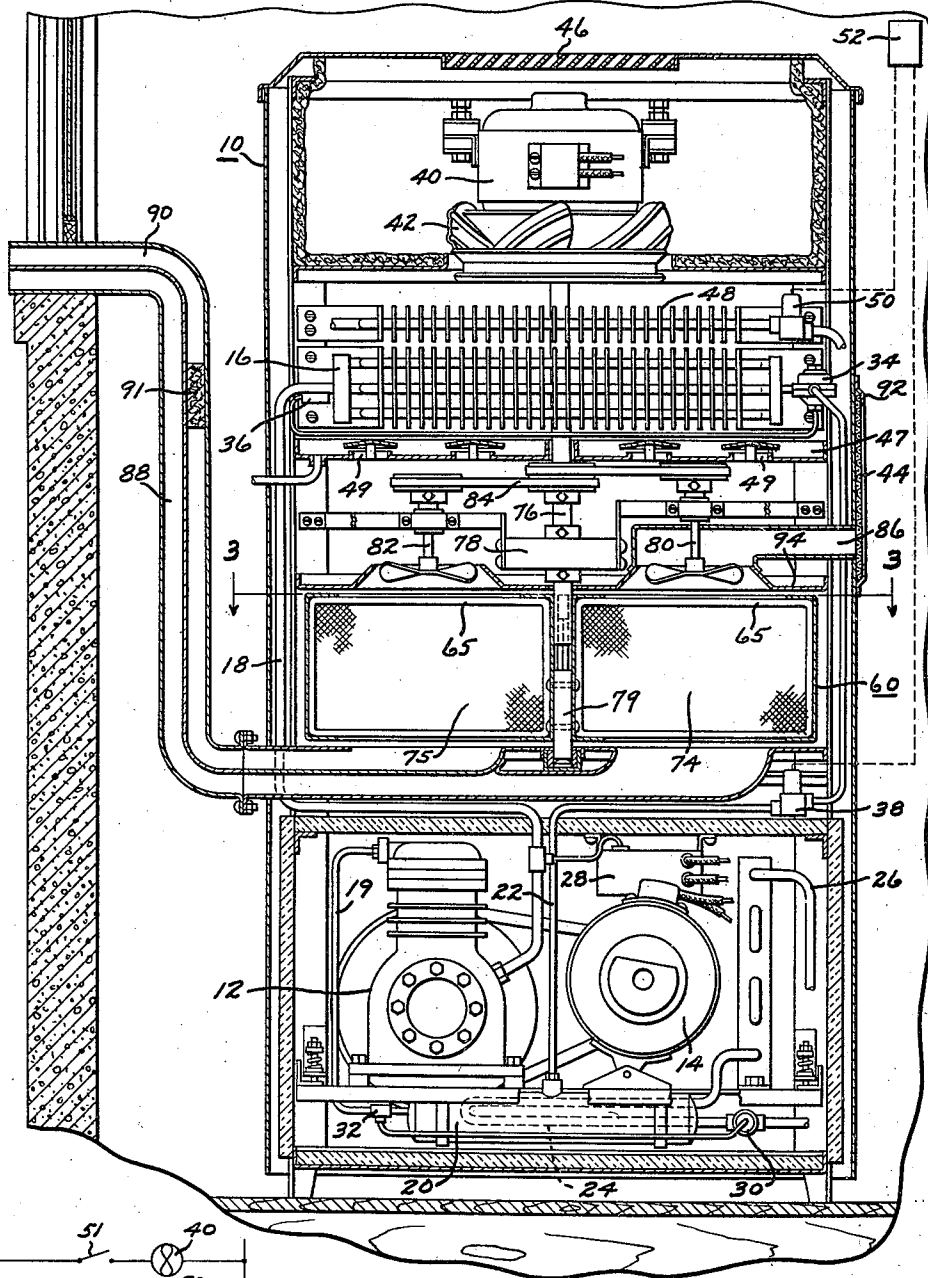


Fig. 1

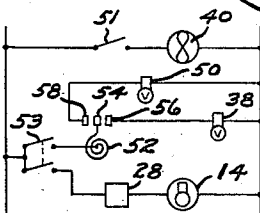


Fig. 2

INVENTOR.

Harry F. Smith

BY

Spencer, Hardman & Teln

ATTORNEYS

Nov. 25, 1941.

H. F. SMITH
CONDITIONING APPARATUS HAVING MEANS FOR CONTROLLING THE
TEMPERATURE AND RELATIVE HUMIDITY OF AIR

2,264,221

Filed March 31, 1937

3 Sheets-Sheet 2

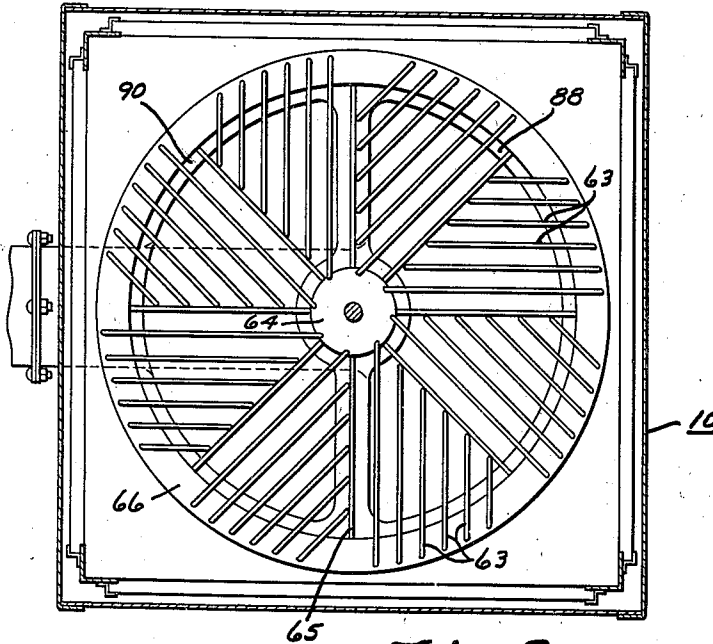


Fig. 3

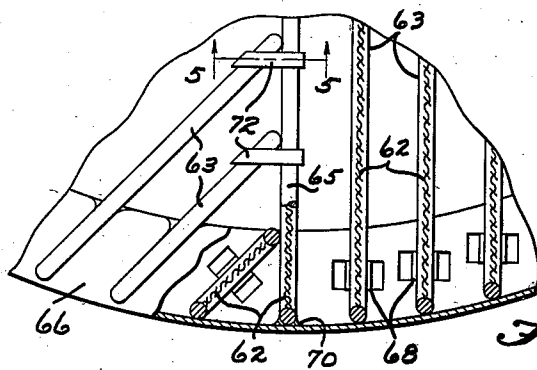


Fig. 4

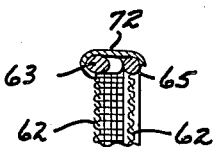


Fig. 5

INVENTOR.

Harry F. Smith

BY

Spencer, Hardman & Fitch

ATTORNEYS.

Nov. 25, 1941.

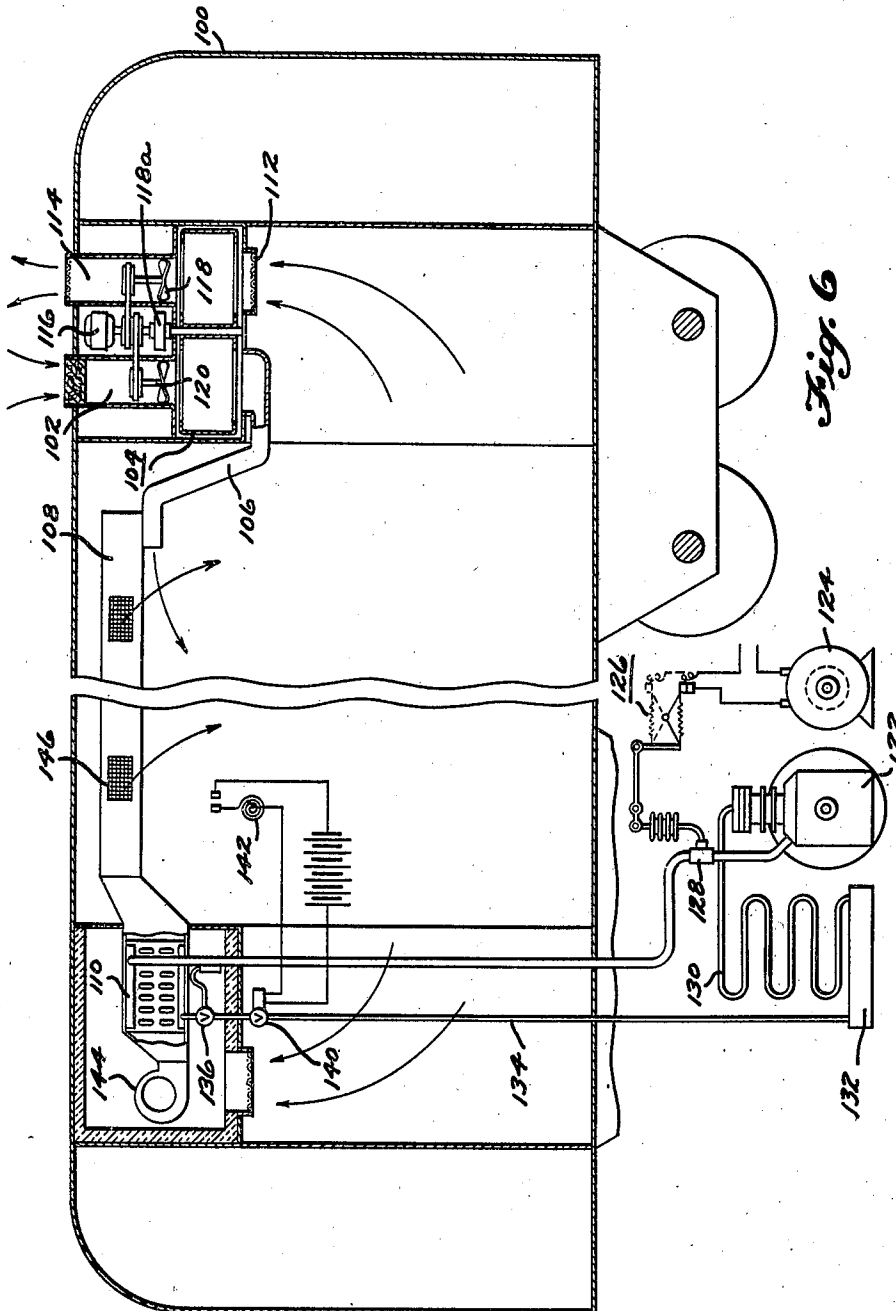
H. F. SMITH

2,264,221

CONDITIONING APPARATUS HAVING MEANS FOR CONTROLLING THE
TEMPERATURE AND RELATIVE HUMIDITY OF AIR

Filed March 31, 1937

3 Sheets-Sheet 3



INVENTOR.

Harry F. Smith

BY

Spencer, Hardman & Fehr

ATTORNEYS.

UNITED STATES PATENT OFFICE

2,264,221

CONDITIONING APPARATUS HAVING MEANS
FOR CONTROLLING THE TEMPERATURE
AND RELATIVE HUMIDITY OF AIRHarry F. Smith, Dayton, Ohio, assignor to Gen-
eral Motors Corporation, Dayton, Ohio, a cor-
poration of Delaware

Application March 31, 1937, Serial No. 134,063

4 Claims. (Cl. 62—140)

This invention relates to refrigerating apparatus and more particularly to an air conditioning system for a room or the like.

One object of this invention is to provide a means for effectively ventilating conditioned rooms without materially increasing the conditioning load.

Another object of this invention is to provide a means for changing the temperature and/or humidity of fresh air entering a room.

A further object of this invention is to utilize the energy content of air leaving a room for conditioning air entering the room.

Still another object is to provide an apparatus, the surfaces of which are alternately exposed to contact with the incoming and the outgoing air.

Another object of this invention is to provide means for insuring that the amount of air entering a room is substantially equal to the amount of air leaving the room.

A further object of this invention is to provide an air conditioning system which is capable of either cooling or heating air for a room.

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 cross sectional view of one embodiment of my invention;

Fig. 2 is a view showing a wiring arrangement for the apparatus shown in Fig. 1;

Fig. 3 is a cross sectional view taken on line 3—3 of Fig. 1;

Fig. 4 is a fragmentary view of the main disc with parts broken away;

Fig. 5 is a fragmentary, cross sectional view taken on line 5—5 of Fig. 4 showing a detail of the disc structure; and

Fig. 6 is another modification showing one form of my apparatus applied to a railway car.

Referring now to the apparatus shown in Fig. 1, a main casing 10 is provided in which is mounted the usual form of refrigerating apparatus comprising a compressor 12 driven by a motor 14, an evaporator 16, and a condenser 20. The evaporator is connected to the compressor by means of pipe 18. The compressed refrigerant leaves the compressor through pipe 19 which conveys the compressed refrigerant to the condenser 20, and the condensed refrigerant flows through the pipe 22 to the evaporator 16. The condenser shown is a water-cooled condenser in

which water is circulated through the coil 24 in thermal exchange relationship with the refrigerant in the condenser 20. Cooling water is also caused to circulate through the cooling coil 26 located in the motor-compressor compartment so as to carry away heat generated by the motor-compressor unit.

The motor is controlled by the switch 28 which is responsive to the suction pressure in line 18. The flow of water through the condenser-cooling coil is controlled by a valve 30 which is responsive to the head pressure at 32. A restrictor 34 restricts the flow of refrigerant into the evaporator and is provided with the usual form of thermostatic means 36 placed adjacent to the outlet from the evaporator. A motor 40 operates a blower 42 which causes room air to enter the casing 10 through the screened opening 44 and discharges the conditioned air through the opening 46. A steam coil 48 which may be connected to any convenient source of steam is placed immediately above the evaporator 16. A drip pan 47 is provided below the evaporator so as to prevent condensate from dripping onto the mechanism below the evaporator. This drip pan is provided with shielded apertures 49 which permit the upward flow of air through the evaporator compartment.

As shown in Fig. 2, I have provided a manual control switch 51 which is used for turning on the motor 40 and a second manually operated switch 53 which is used for energizing the automatic control circuits. A temperature responsive member 52 is mounted within the room and carries a movable contact 54 which cooperates with a pair of stationary contacts 56 and 58. Whenever the contact 54 engages the contact 56 a circuit is closed through the solenoid valve 38 which controls the flow of refrigerant to the evaporator. Likewise when the contact 54 engages the contact 58 a circuit is closed through the solenoid valve 50 which controls the flow of steam, or any other heating medium, to the heating coil 48. The manual switch 53 also closes the circuit leading to the control switch 28 and the compressor motor 14. With this arrangement, it will be seen that the evaporator 16 and the heating coil 48 are automatically controlled in accordance with temperature conditions within the room.

While I have shown diagrammatically a dry bulb thermostat, an effective temperature device may be substituted for the thermostat 52; in which case, the conditioning apparatus would

maintain the effective temperature in the room within predetermined limits.

Adequate ventilation for rooms which are refrigerated or otherwise air conditioned has been a difficult matter because of the large amount of additional refrigeration which has been required to reduce the temperature and humidity of the entering air to desirable levels. It has been repeatedly suggested that heat exchangers might be used for this purpose, but the relatively small temperature differentials available together with the large volumes of air to be handled have resulted in the apparatus being prohibitively expensive and not especially effective.

This lack of effectiveness is partially due to the fact that a considerable proportion of the air conditioning effect in summer is due to lowering of the moisture content of the air, and no successful method has heretofore been devised to compensate for this energy of dehumidification.

Inasmuch as it is very essential to properly ventilate a room which is being air conditioned, I have provided means whereby the room may be ventilated without unduly increasing the conditioning load of the apparatus. This means comprises a heat exchange mechanism 60 which is in the form of a horizontally disposed wheel or drum like member having a plurality of vertical cloths 62 carried by frame members 63 and frame members 65 which serve as spokes, as shown in Figs. 3 and 4. The frames 63 are supported by the spokes 65 and the outer rim 66. The lower flange of the outer rim is provided with a plurality of struck-out portions 68 which serve to position the lower edges of the frames 63. The outer rim 66 is also provided with an upper inturned flange having slots 69 for positioning the upper edges of the frames 63. The spokes 65 which may also support cloths may be welded or otherwise secured to the rim 66 as shown at 70. As shown in Fig. 3 there are eight of these spokes which extend from the hub 64 to the outer rim 66.

In Fig. 5 I have shown the construction of the clamping means 72 which may be used to position the inner ends of the frames 63. The clamps 72 are secured to the frames 63 and removably engage the stationary frames 65 which serve as spokes. The brackets 72 have been omitted from the showing in Fig. 3 for the sake of clarity. Means are provided for slowly rotating the drum so as to bring different portions thereof successively through the air treating sections 74 and 75.

In order not to increase the refrigeration load I utilize the energy content of air leaving the room for both cooling and dehumidifying the air entering the room. The energy content of the air leaving the room is made use of in a manner which automatically utilizes both the low temperature and low humidity of the air passing from the room. This is accomplished by coating the cloths 62 with a slightly hygroscopic material. By slightly hygroscopic I mean a material in which the energy of combination with water is low and in which the equilibrium with moisture in the air depends both upon the concentration of the hygroscopic material with respect to water content and the temperature of the same with respect to entering air. Glycerin is a material having approximately these qualifications and also having the property of being sufficiently gummy to remain in place on the cloths 62 and also provide a suitable surface for the entrainment of dust. Other hygroscopic solutions such

as calcium chloride could also be used for conditioning the incoming air. Steel wool, glass wool, fiber, or the like, could also be substituted for the cloth 62. The apparatus is so arranged that the surfaces are alternately exposed in contact with the incoming and outgoing air as will be explained hereinafter.

As best shown in Fig. 1, the motor 40 has a shaft 76 which projects downwardly to a gear reduction box 78. The drum 60 is carried by a shaft 79 which is driven at a reduced speed through the gear reduction mechanism 78.

A pair of fans 80 and 82 are driven directly from the shaft 76 by means of belts 84. Room air is withdrawn from the room by the fan 80 which is mounted in the duct 86 and is caused to circulate through one side of the drum 60 and from thence through the outlet duct 88 leading to the outside of the room. Outside air is caused to circulate in through the duct 90, past a filter 91, through the other side of the drum 60, and past the fan 82 which is instrumental in circulating an amount of air substantially equal to the amount of air circulated by the fan 80. After leaving the fan 82, the air flows into the upper portion of the cabinet 10 where it flows in thermal contact with the evaporator 16 and mixes with the room air being circulated by the fan 42.

It is essential, for the most efficient operation of this device, that all the room air which is discharged pass through the drum 60 on its way to the outside of the room in order to utilize all of its available energy. The arrangement of the fans 80 and 82 and the ducts 88 and 90 is such that substantially the same amount of air circulates through the one duct as through the other duct.

By virtue of the fact that the drum 60 is slowly rotating at all times, the surfaces 62 are alternately exposed to contact with the incoming and outgoing air. During summer operation the outgoing air is cool and relatively dry with the result that the hygroscopic material has a tendency to come into equilibrium with the outgoing air both with respect to temperature and humidity. The air passing through the structure and contacting with its extended surfaces is warmed by such contact and tends to evaporate moisture from the hygroscopic material thereby lowering the temperature and increasing the concentration of the hygroscopic material. Both of these actions tend to increase the moisture absorption capacity of the hygroscopic substance; and the apparatus, consequently, stores some of the total energy of refrigeration of the outgoing air, whether this be in the form of lowered dry bulb temperature or lowered humidity.

This cooled and concentrated hygroscopic material is then transferred to the incoming current of air which is relatively warm and moist. This incoming air is cooled by contact with the cooler surfaces and tends to deposit some of its moisture because of the increased moisture absorbing capacity of the concentrated hygroscopic substance. The result of this contact is, therefore, to both cool and dry the incoming current of air.

As pointed out hereinabove the structure is also suitable to favor the entrainment of dust from the incoming air so that the air is cleansed as well as cooled and dried by passing through the apparatus. This process continues throughout the period of operation, the hygroscopic material obtaining an equilibrium concentration which is determined by the relative humidity and

temperature of the incoming and outgoing air streams.

It is apparent that if the external air were at approximately 100% relative humidity the apparatus would operate without the presence of any hygroscopic material since any lowering of temperature of the air would immediately result in condensation of moisture on the heat transfer surfaces, and this moisture would be re-evaporated on the outgoing side by the drier room air, the energy of re-evaporation being left behind in the form of lowered temperature, which in turn would produce the condensation of additional moisture on the fresh air side. However, this condition could exist only when the entering air is at, or near, 100% humidity.

With the introduction of hygroscopic material which is capable of changing its equilibrium relationship with air by change of concentration, a method is provided for automatically adjusting the moisture precipitating power to whatever condition or relative humidity exists at the time. The only condition during summer operation being that the outgoing air should be relatively drier than the air entering the room.

It is, therefore, seen that this construction provides means which automatically adjusts itself to the existing humidity conditions and provides a maximum energy transfer between the incoming and the outgoing air, whether this energy consists of temperature differences or differences in relative humidity. In this manner, the energy potential available for operating the equipment is much greater than that available in any apparatus depending upon temperature differences.

Inasmuch as the drum 60 and its associated parts serve to clean the air, it is necessary to clean the cloths 62 from time to time. Access may be had to the drum 60 by removing the closure member 92 and removing the fans 80 and 82, the air duct 86, and the shield 94. In cases where it is necessary to frequently clean the cloths 62, a side door may be arranged in the wall of the casing 10 through which the drum structure 60 may be withdrawn for cleaning purposes.

In Fig. 6 I have shown my invention applied to a railway car 100. As shown therein, outside air is circulated in through the inlet duct 102 and is caused to pass through a drum member 104 corresponding to drum 60 shown in Fig. 1. The incoming air, after having passed through the drum 104 is caused to flow through the duct 106 which discharges immediately below the cold air duct 108 which leads from the main conditioning chamber 110. The room air which is to be expelled enters my apparatus through opening 112 and passes through one side of the drum 104 on its way out through the duct 114.

A motor 116 is provided for driving the fans 118 and 120 which corresponds to fans 80 and 82 in the modification shown in Fig. 1. This motor 116 also drives the drum 104 at a reduced speed by virtue of the gear reduction means 118a. The main air conditioning apparatus comprises a compressor 122 driven by a motor 124 which is controlled by switch 126 which operates in response to suction pressure at 128. Compressed refrigerant, leaving the compressor, enters a condenser 130 which may be cooled in any suitable manner. The condensed refrigerant collects in the receiver 132 and flows to the evaporator through pipe 134 which is provided with the usual form of restrictor valve 136. A solenoid

operated valve 140 is also placed in the line 134 and is opened and closed by the switch 142 which operates in response to temperature conditions within the car 100.

A blower 144 is provided for circulating car air over the evaporator 110. The cooled air, leaving the evaporator, is discharged through openings 146 in the air duct 108 located in the upper part of the car. Inasmuch as the fresh air discharged through the duct 106 is warmer than the air discharged through the openings 146, at least a portion of the air discharged through 106 will follow along the upper part of the car and will find its way into the main evaporator compartment without circulating into the lower portion of the car. The cold air discharged through the openings 146, however, will tend to circulate into the lower part of the car but will be tempered slightly by the fresh air entering through the duct 106.

While I have described the operation of this device when used for conditioning air in the summer time, it is obvious that the apparatus is equally effective for conditioning the air during the winter time. For winter operation, the coil 48, which is supplied with steam from any suitable source, heats the air for the room. Inasmuch as the air in the room is maintained at a temperature considerably above the temperature of the air outside of the room and inasmuch as the cold outside air is relatively much drier than the warm air in the room, the room air which passes over the hygroscopic medium will increase the temperature of the medium and will deposit moisture thereon, with the result that when the surfaces are subjected to the cold, dry incoming air the incoming air will absorb both heat and moisture from the interchanger 60.

It is also within the scope of this invention to utilize the heating coil as a means for reheating the air which has been circulated over the evaporator. In the spring and fall of the year, for example, it very frequently happens that the temperature within the room is satisfactory but the humidity is excessively high. In such a case, the coils 16 may be used for condensing moisture out of the air, and the coil 48 may be used for reheating the air so as to maintain the proper temperature conditions as well as humidity conditions.

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. In combination with an enclosure, air conditioning apparatus therefor comprising, a cabinet, juxtaposed fresh air inlet and room air outlet ducts in said cabinet, a carrier for adsorbent material, means for cyclically moving said adsorbent material from one duct to the other, a refrigerant evaporator in said cabinet, means for circulating air for said enclosure over said evaporator, and refrigerant liquefying means in refrigerant flow relationship with said evaporator.

2. A self-contained air conditioner comprising in combination, a cabinet, an evaporator in said cabinet, means for flowing air to be conditioned for a space in thermal exchange relationship with said evaporator, refrigerant liquefying means within said cabinet for supplying liquid refrigerant to said evaporator, means within said cabinet for contacting air to be conditioned with a

hygroscopic medium, and means for regenerating said hygroscopic medium by means of conditioned air from said space.

3. A self-contained air conditioner comprising in combination, a cabinet, an evaporator in said cabinet, refrigerant liquefying means for supplying refrigerant to said evaporator, means for circulating air to be conditioned over said evaporator, a hygroscopic medium within said cabinet arranged in the path of air to be conditioned, and means within said cabinet for reconditioning said hygroscopic medium.

4. A combined cooling and drying system comprising in combination, a cabinet, an evaporator in said cabinet, means for cooling air to be conditioned with said evaporator, means for supplying liquid refrigerant to said evaporator, thermal means for controlling the amount of refrigerant supplied to said evaporator, means within said cabinet for contacting air to be conditioned with a hygroscopic medium, and means for regenerating said hygroscopic medium by means of conditioned air from said space.

HARRY F. SMITH.