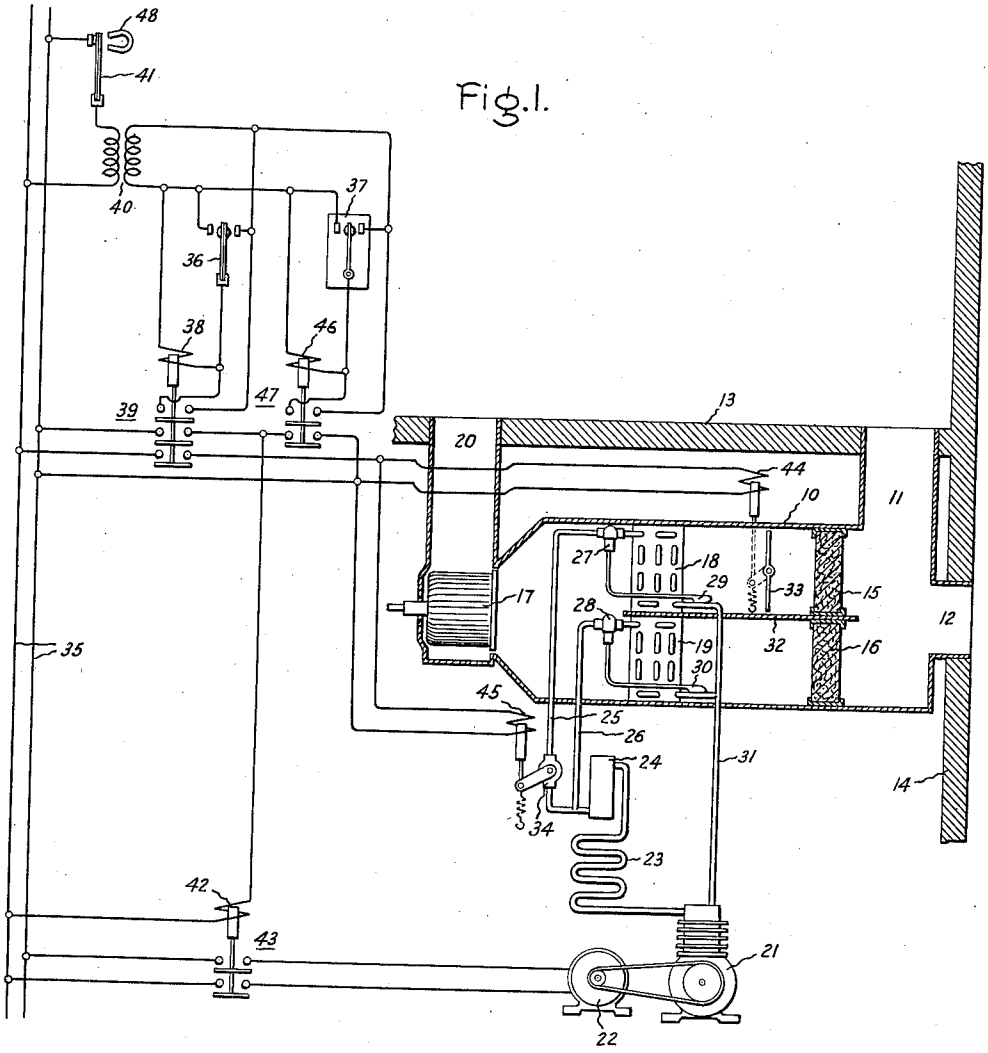
July 18, 1939. H. GIBSON 2,166,813

AIR CONDITIONING SYSTEM

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Fig. 1.



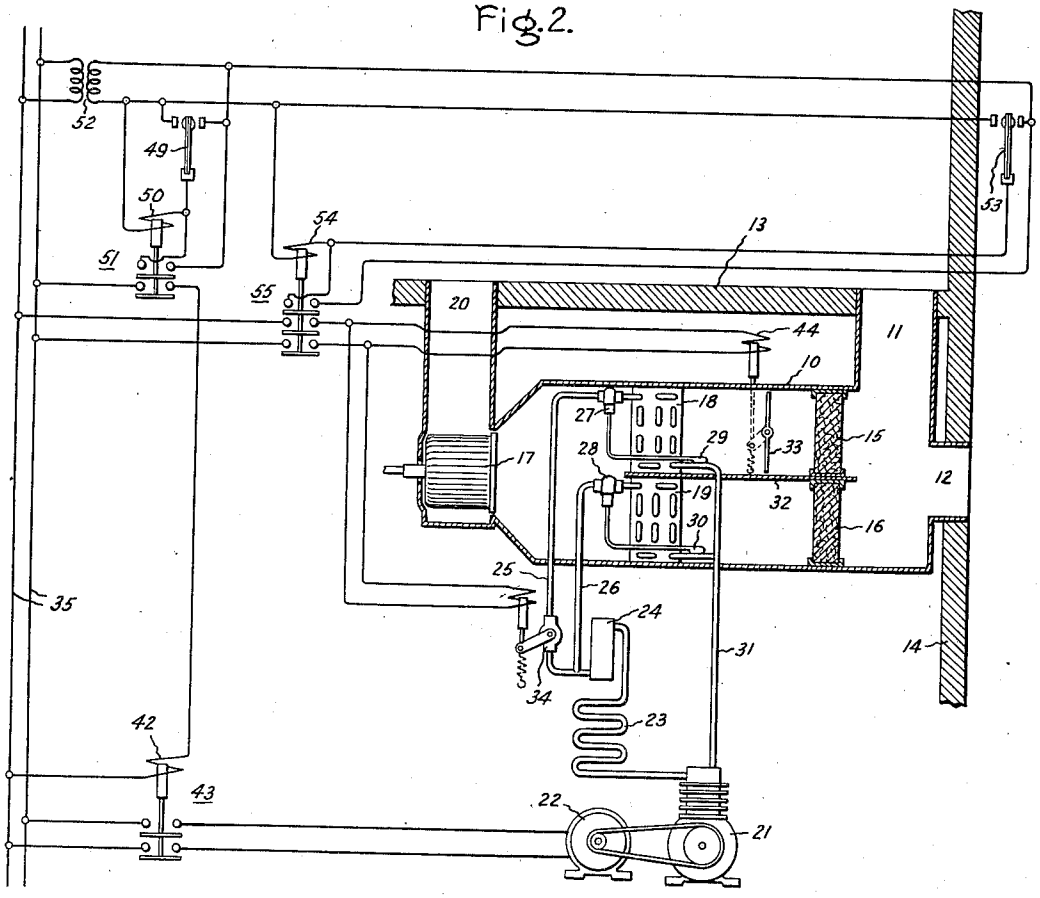

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Fig. 2.




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# UNITED STATES PATENT OFFICE

2,166,813

## AIR CONDITIONING SYSTEM

Hal Gibson, Dallas, Tex., assignor to General Electric Company, a corporation of New York

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7 Claims. (Cl. 62—6)

My invention relates to air conditioning systems and particularly to air cooling systems arranged to control both temperature and relative humidity.

Air condtioning systems using mechanical refrigerating machines for cooling air are frequently provided with a plurality of evaporator coils or cooling elements, some of which are utilized primarily to control the dry bulb temperature, and others of which are utilized to control the relative humidity. Such systems have included various arrangements for maintaining definite temperatures in the separate coils and frequently require completely separate refrigerating systems for operating the several evaporators. Accordingly, it is an object of my invention to provide an air conditioning system utilizing a single refrigerating machine for cooling and dehumidifying the air within an enclosure and including an improved arrangement for providing control of dry bulb temperature and relative humidity.

Further objects and advantages of my invention will become apparent as the following description proceeds, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention, reference may be had to the accompanying drawings in which Fig. 1 shows diagrammatically an air conditioning system embodying my invention, and Fig. 2 shows diagrammatically an air conditioning system embodying a modified form of my invention.

Referring now to the drawings, in Fig. 1 I have shown an air conditioning system including a duct 10 arranged to receive air from the enclosure to be conditioned through an inlet 11 and fresh air through an inlet 12, the wall of the enclosure being indicated at 13 and the outside wall of the building at 14. The mixture of fresh and recirculated air is cleaned by passing through filters 15 and 16, the air being drawn into the duct by operation of a fan 17 driven by a motor (not shown). In order to cool and dehumidify the air circulating through the duct 10, I provide cooling elements or evaporators 18 and 19. The air cooled and dehumidified in the duct 10 is returned to the enclosure through an outlet or return air duct 20. In order to supply refrigerant for cooling the coils 18 and 19, I provide a refrigerating machine including a compressor 21 driven by a motor 22, a condenser 23 and a liquid receiver 24. Gaseous refrigerant is compressed by the compressor 21 and discharged into the condenser 23 where it is cooled and liquefied, the liquid collecting in the liquid receiver 24. From the receiver 24, liquid refrigerant flows through parallel liquid lines 25 and 26 to the evaporators 18 and 19 respectively, the flows of refrigerant to the evaporators being controlled by thermostatic expansion valves 27 and 28 having thermostatic elements 29 and 30 adjacent the outlets of evaporators 18 and 19 respectively. The liquid refrigerant absorbs heat from the air passing through the duct 10 and cools the air and is thereby vaporized, the vaporized refrigerant being withdrawn from the evaporators and returned to the compressor through a suction line 31.

The evaporators 18 and 19 are arranged in parallel portions of the duct 10, the portions being divided by partition 32. A damper 33 is provided so that the flow of air may be prevented in the upper portion in which is arranged the evaporator 18. A solenoid valve 34 is provided in the liquid line 25 in order to interrupt the flow of liquid refrigerant to the evaporator 18. The damper 33 and the solenoid 34 are operated together, so that when the supply of air to the evaporator 18 is stopped, the supply of refrigerant is also stopped. Under normal operating conditions, when it is desired to remove only sensible heat in order to lower the dry bulb temperature of the air within the enclosure to be conditioned, both evaporators are operated in parallel in the refrigerant circuit and the capacity of the refrigerating machine is so selected that the evaporators will, for the most part, remove sensible heat rather than latent heat from the air passing through the duct. When the damper 33 and the valve 34 are closed, circulation of air over the evaporator 18 is prevented and also the supply of refrigerant thereto. Evaporator 19 is then the only evaporator surface in the refrigerant circuit, and the entire capacity of the machine is available to operate this one evaporator. Evaporator 19 then operates at a lower pressure and temperature than when both evaporators are operated in parallel, and the entire flow of air passes over the evaporator 19. The increased rate of air flow somewhat counterbalances the effect of the decreased temperature. However, there is a substantially greater cooling of the air and the evaporator 19 operating alone removes a much greater porton of latent heat from the air and, consequently, reduces the relative humidity thereof. A control system is, therefore, provided which operates the damper 33 and the valve 34 in response to the relative humidity of the air entering the duct 10 through the inlet 11; that is, in response to the humidity in the room to be conditioned. Power for driving the motor 22 and for energizing the control circuit is supplied by lines 35. In order to control the refrigerating machine, I provide a thermostat 36 and a humidostat 37, both dependent upon atmospheric conditions in the enclosure to be conditioned. The arrangement of the control circuit is such that the compressor is op-

erated continuously as long as there is a demand for refrigeration by either the thermostat or the humidostat. On a demand for a reduction of the dry bulb temperature in the enclosure, the thermostat 36 engages its right-hand contact and connects the coil 38 of a relay switch 39 across the secondary of a transformer 40, the primary of the transformer being connected across the lines 35 through a normally closed thermostat 41. Energization of the coil 38 picks up the switch 39 the top contacts of which close a holding circuit for the coil. The middle contacts energize a coil 42 of a motor switch 43 and connect the motor 22 across the lines 35 thereby starting the refrigerating machine. The bottom contacts energize coils 44 and 45 of the damper 33 and valve 34 respectively, thereby opening the damper and the valve to permit the flow of air over the evaporator 18 and of refrigerant to the evaporator. The air passing through the duct 10 is thereby cooled until the temperature within the enclosure reaches the desired value when the thermostat 36 will engage its left-hand contact, short circuit the coil 38, and cause the switch 39 to drop out and deenergize the motor and stop the operation of the refrigerating machine.

Should the relative humidity of the air within the enclosure be too high, the humidostat 37 will engage its right-hand contact to energize a coil 46 and a relay 47. The upper arm of the relay 47 closes a holding circuit for the coil 46 and the lower arm connects the coil 42 of the motor switch 43 across the lines 35 to start the refrigerating machine. The coils 44 and 45, however, are not energized and, consequently, the air passing through the duct 10 passes through the lower portion only and over the coil 19. A substantial portion of latent heat is thereby removed from the air and when the relative humidity of the air within the enclosure has been sufficiently reduced, the humidostat will engage its left-hand contacts to short-circuit the coil 46 and cause the relay 47 to drop out and stop the operation of the refrigerating machine.

Should the thermostat 36 operate upon a demand for cooling while the refrigerating machine is being operated in response to the humidostat, the thermostatic control will take precedence and energize the coils 44 and 45 to operate the damper 33 and the valve 34 and place the evaporator 18 in operation thereby making the entire evaporator surface available for cooling the air in the enclosure.

In the event the temperature of the room should be reduced to a predetermined minimum consistent with comfort due to the operation of the humidostat 37 in an effort sufficiently to reduce the relative humidity after the thermostat 36 is satisfied, the thermostat 41 will move to the right and open the circuit of the transformer 40 thereby deenergizing the control circuits and opening the switch 43 to stop the operation of the refrigerating machine. The thermostat 41 is of the snap-acting type, a suitable mechanism such as a stationary magnet 48 being provided to effect snap-acting operation.

It is to be noted that in the air conditioning system illustrated no separate temperature controlling device is necessary on the evaporators 18 and 19 in order to maintain predetermined different temperatures or pressures, and that the entire change in the ratio of latent heat to sensible heat removal is effected by a change in the evaporator surface of a single refrigerating machine. When a single compressor is arranged to operate the entire evaporator surface or a portion thereof, the total capacity of the system is available when the entire evaporator is connected in the circuit; that is, in the present arrangement, when both the evaporators 18 and 19 are connected to the compressor. When a portion of the evaporator surface, that is, the evaporator 18, is removed from the path of the air and from the refrigerant circuit, the remaining portion operates at increased capacity, but at less than the total capacity of the system.

The temperature of the remaining portion of the evaporator surface is lower than the temperature during operation of the entire available evaporator surface and the rate of flow of air thereover is greater. This increase in the rate of air flow somewhat compensates the decrease of the total system capacity. However, since the evaporator operates at considerably lower temperatures, the total heat removed from the air includes a greater percentage of latent heat. Consequently, the system when operated with a portion of the evaporator surface may be utilized to considerably reduce the latent heat content of the air while reducing the sensible heat content at a lesser rate than when the entire evaporator surface is being utilized. Those skilled in the art will readily understand that the relative amounts of latent and sensible heat removed under the two operating conditions of the system may be selected to suit any particular conditions of design, the factors involved in the design including the relative sizes of the thermostatic valves which control the flow of liquid refrigerant to the evaporators, and the relative surface areas of the evaporators.

When fresh air is circulated over the cooling coils of an air conditioning system either alone or mixed with re-circulated air, the dry bulb temperature of the fresh air or outdoor air may be used as a measure of the load requirements of the air conditioner. For example, when the outside air has a dry bulb temperature of 98° F. and a wet bulb temperature of 78° F., the absolute moisture content is substantially the same as when the dry bulb temperature is 85° F. and the wet bulb temperature is 75° F. However, the relative humidity at the lower temperature is much greater. Obviously, therefore, the demand for a decrease in sensible heat is less at the lower dry bulb temperature but the demand for decrease of latent heat is much greater. If an air conditioning system is designed to satisfactorily carry the load when the outdoor air has a dry bulb temperature of 98° F., then when the outdoor temperature is reduced to 85° F., the load may satisfactorily be carried with a reduced capacity provided there is an increased capacity for removing latent heat. In Fig. 2, I have shown an air conditioning system embodying my invention and arranged to control the load thereof in accordance with the temperature of the outside air admitted to the duct. When the outside air temperature is above a predetermined value, the entire capacity of the system is available for removing sensible heat, and when the outside temperature falls below a predetermined value, a portion of the evaporator capacity is cut out so that the remaining portion operates to remove a greater percentage of latent heat although the total capacity is reduced as described in connection with the system shown in Fig. 1.

Referring now to Fig. 2, I have shown an air conditioning system having the same circulating

duct and refrigerating machine connections as the system in Fig. 1, and I have designated the parts of the system which correspond to parts of Fig. 1 by the same reference numerals. The system shown in Fig. 2 is controlled by a room thermostat 49 which on a demand for cooling engages its right-hand contact and connects a coil 50 of a relay 51 across the secondary of a transformer 52, the primary of which is connected across lines 35. The relay 51 is, therefore, picked up and held in its pick up position by a holding circuit closed by the upper contact arm thereof. The lower contact arm connects the coil 42 of the motor switch 43 across the lines 35 to operate the motor switch and start the operation of the refrigerating machine. If the temperature of the outdoor air admitted to the duct 10 through the inlet 12 is above a predetermined value, an outdoor thermostat 53 will engage its right-hand contact to connect a coil 54 of a relay 55 across the secondary of transformer 52 thereby operating the relay and holding it in its operating position by a holding circuit closed by the top arm thereof. The two lower arms of the relay 55 connect the coils 44 and 45 of the damper 33 and valve 34 across the lines 35 thereby opening the damper and valve. The opening of the damper and valve as explained in connection with the system shown in Fig. 1 opens the evaporator 18 to the circulation of air and permits the flow of refrigerant therethrough. The entire capacity of the refrigerating system is, therefore, available to cool air circulating through the duct 10. When the temperature of the air within the enclosure has been sufficiently lowered, the thermostat 49 will engage its left-hand contact and short-circuit the coil 50 thereby dropping out the relay 51 and opening the motor circuit.

During the operation of the refrigerating machine, should the outdoor air be at a temperature below a predetermined value, the outdoor thermostat 53 will engage its left-hand contact and short-circuit the coil 54 to drop out the relay 55 and thereby close the damper 33 and valve 34. All the air circulating through the duct 10 then passes over the evaporator 19 which operates at a lower temperature and removes a greater percentage of latent heat than during its operation when both evaporators are connected in the refrigerant and air circuits. The air conditioning system is, therefore, operated under control of the thermostat 49 with the single evaporator 19 available to lower the dry bulb temperature in the enclosure. The refrigerating machine is controlled by the thermostat 49 in the same manner whether or not the evaporator 18 is being employed. It will be noted that at the lower outdoor temperatures a small evaporator capacity is available to reduce the sensible heat of the air circulating through the duct and consequently, the refrigerating machine will operate for longer intervals than if the entire capacity were utilized. Fewer starts and stops of the refrigerating machine are required and the system is, therefore, utilized more continuously than if the entire evaporator capacity were available to reduce the dry bulb temperature in the enclosure, resulting in a better control of temperature and relative humidity.

The system shown in Fig. 2 will normally give satisfactory operation and does not require a room humidostat and is preferable to the system shown in Fig. 1 when it is desired to use only thermostatic control. At the same time, except for extraordinary conditions of temperature and relative humidity, the system shown in Fig. 2 will give satisfactory control of humidity since it is to be expected that the relative humidity will normally be greater at the lower range of temperatures determined by the setting of the outdoor thermostat.

It is apparent from the foregoing that I have provided an air conditioning system utilizing a mechanical refrigerating machine for maintaining the desired temperature and relative humidity of the air within an enclosure and which includes an improved arrangement for controlling the operation of the refrigerating machine.

While I have described my invention in connection with air conditioning systems utilizing a single refrigerating machine, other applications will ready be apparent to those skilled in the art. I do not, therefore, desire my invention to be limited to the particular construction shown and described and I intend in the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A system for conditioning the air within an enclosure including a duct, means for admitting air to said duct, means for circulating air through said duct and into said enclosure, means including two refrigerant evaporators arranged in said duct in parallel with respect to the path of the air circulating through said duct for cooling air circulating through said duct, means including a condensing unit and having a single refrigerant circuit for supplying liquid refrigerant to both said evaporators and for withdrawing gaseous refrigerant from both said evaporators, means responsive to the temperature of the air within said enclosure for controlling the supply of refrigerant to said envaporators, means for preventing the flow of air over one of said evaporators, means for preventing the flow of liquid refrigerant to said one evaporator, and means dependent upon a condition of the air admitted through said air admitting means to said duct for actuating said air flow preventing means and said refrigerant flow preventing means to remove said one evaporator from said refrigerant circuit and from the path of the air circulating through said duct.

2. A system for conditioning the air within an enclosure including a duct, means for admitting to said duct air from said enclosure, means for admitting to said duct fresh air from outside said enclosure, means for circulating air through said duct and into said enclosure, means including two refrigerant evaporators arranged in said duct in parallel with respect to the path of the air circulating through said duct for cooling air circulating through said duct, means including a compressor and a condenser and having a refrigerant circuit for supplying liquid refrigerant to both evaporators and for withdrawing gaseous refrigerant from both said evaporators, said evaporators being connected in parallel in said refrigerant circuit, means responsive to the temperature of the air within said enclosure for controlling the supply of refrigerant to said evaporators, means for preventing the flow of air over one of said evaporators and for preventing the flow of liquid refrigerant to said one evaporator, and means dependent upon a condition of the air admitted through one of said air admitting means to said duct for actuating said flow preventing means to remove said one evaporator from said refrigerant circuit and from the path of the air circulating through said duct.

3. A system for conditioning the air within an enclosure including a duct, means for admitting to said duct air from said enclosure, means for admitting to said duct fresh air from outside said enclosure, means for circulating air through said duct and into said enclosure, means including two refrigerant evaporators arranged in said duct in parallel with respect to the path of the air circulating through said duct for cooling air circulating through said duct, means including a compressor and a condenser and having a refrigerant circuit for supplying liquid refrigerant to both said evaporators and for withdrawing gaseous refrigerant from both said evaporators, said evaporators being connected in parallel in said refrigerant circuit, means responsive to the temperature of the air within said enclosure for controlling the supply of refrigerant to said evaporators, means for preventing the flow of air over one of said evaporators and for preventing the flow of liquid refrigerant to said one evaporator, and means dependent upon the temperature of the fresh air admitted to said duct for actuating said flow preventing means to remove said one evaporator from said refrigerant circuit and from the path of the air circulating through said duct.

4. A system for conditioning the air within an enclosure including a duct, means for admitting to said duct air from said enclosure, means for circulating air through said duct and into said enclosure, means including two refrigerant evaporators arranged in said duct in parallel with respect to the path of the air circulating through said duct for cooling air circulating through said duct, means including a compressor and a condenser and having a refrigerant circuit for supplying liquid refrigerant to both said evaporators and for withdrawing gaseous refrigerant from both said evaporators, said evaporators being connected in parallel in said refrigerant circuit, means responsive to the temperature of the air within said enclosure for controlling the supply of refrigerant to said evaporators, means for preventing the flow of air over one of said evaporators and for preventing the flow of liquid refrigerant to said one evaporator, and means dependent upon the relative humidity of the air within said enclosure for actuating said flow preventing means to remove said one evaporator from said refrigerant circuit and from the path of the air circulating through said duct.

5. A system for conditioning the air within an enclosure including a duct, means for admitting to said duct air from said enclosure, means for admitting to said duct fresh air from outside said enclosure, means for circulating air through said duct and into said enclosure, means including two refrigerant evaporators arranged in said duct in parallel with respect to the path of the air circulating through said duct for cooling air circulating through said duct, means including a compressor and a condenser and having a refrigerant circuit for supplying liquid refrigerant to both said evaporators and for withdrawing gaseous refrigerant from both said evaporators, said evaporators being connected in parallel in said refrigerant circuit, means responsive to the temperature of the air within said enclosure for controlling the starting and stopping of said compressor, means for preventing the flow of air over one of said evaporators and for preventing the flow of liquid refrigerant to said one evaporator, and means dependent upon the temperature of the outdoor air for actuating said flow preventing means to remove said one evaporator from said refrigerant circuit and from the path of the air circulating through said duct.

6. A system for conditioning the air within an enclosure including a duct, means for admitting to said duct air from said enclosure, means for circulating air through said duct and into said enclosure, means including two refrigerant evaporators arranged in said duct in parallel with respect to the path of the air circulating through said duct for cooling air circulating through said duct, means including a compressor and having a refrigerant circuit and a condenser for supplying liquid refrigerant to both said evaporators and for withdrawing gaseous refrigerant from both said evaporators, said evaporators being connected in parallel in said refrigerant circuit, means responsive to the temperature of the air within said enclosure for starting and stopping said compressor, means for preventing the flow of air over one of said evaporators and for preventing the flow of liquid refrigerant to said one evaporator, and means dependent upon the relative humidity of the air within said enclosure for starting and stopping said compressor and for actuating said flow preventing means to remove said one evaporator from said refrigerant circuit and from the path of the air circulating through said duct, said temperature responsive means and said relative humidity dependent means being so arranged as to cause continuous operation of the compressor as long as there is a demand for refrigeration by either of said two last mentioned means.

7. A system for conditioning the air within an enclosure including a duct, means for admitting to said duct air from said enclosure, means for circulating air through said duct and into said enclosure, means including two refrigerant evaporators arranged in said duct in parallel with respect to the path of the air circulating through said duct for cooling air circulating through said duct, means including a compressor and having a refrigerant circuit and a condenser for supplying liquid refrigerant to both said evaporators and for withdrawing gaseous refrigerant from both said evaporators, said evaporators being connected in parallel in said refrigerant circuit, means responsive to the temperature of the air within said enclosure for controlling the starting and stopping of said compressor, means for preventing the flow of air over one of said evaporators and for preventing the flow of liquid refrigerant to said one evaporator, means dependent upon the relative humidity of the air within said enclosure for controlling the starting and stopping of said compressor and for actuating said flow preventing means to remove said one evaporator from said refrigerant circuit and from the path of the air circulating through said duct, said temperature responsive control means and said relative humidity dependent control means being so arranged as to cause continuous operation of the compressor as long as there is a demand for refrigeration by either of said two control means, and means dependent upon a predetermined minimum temperature of the air within said enclosure for preventing the operation of said system.

HAL GIBSON.