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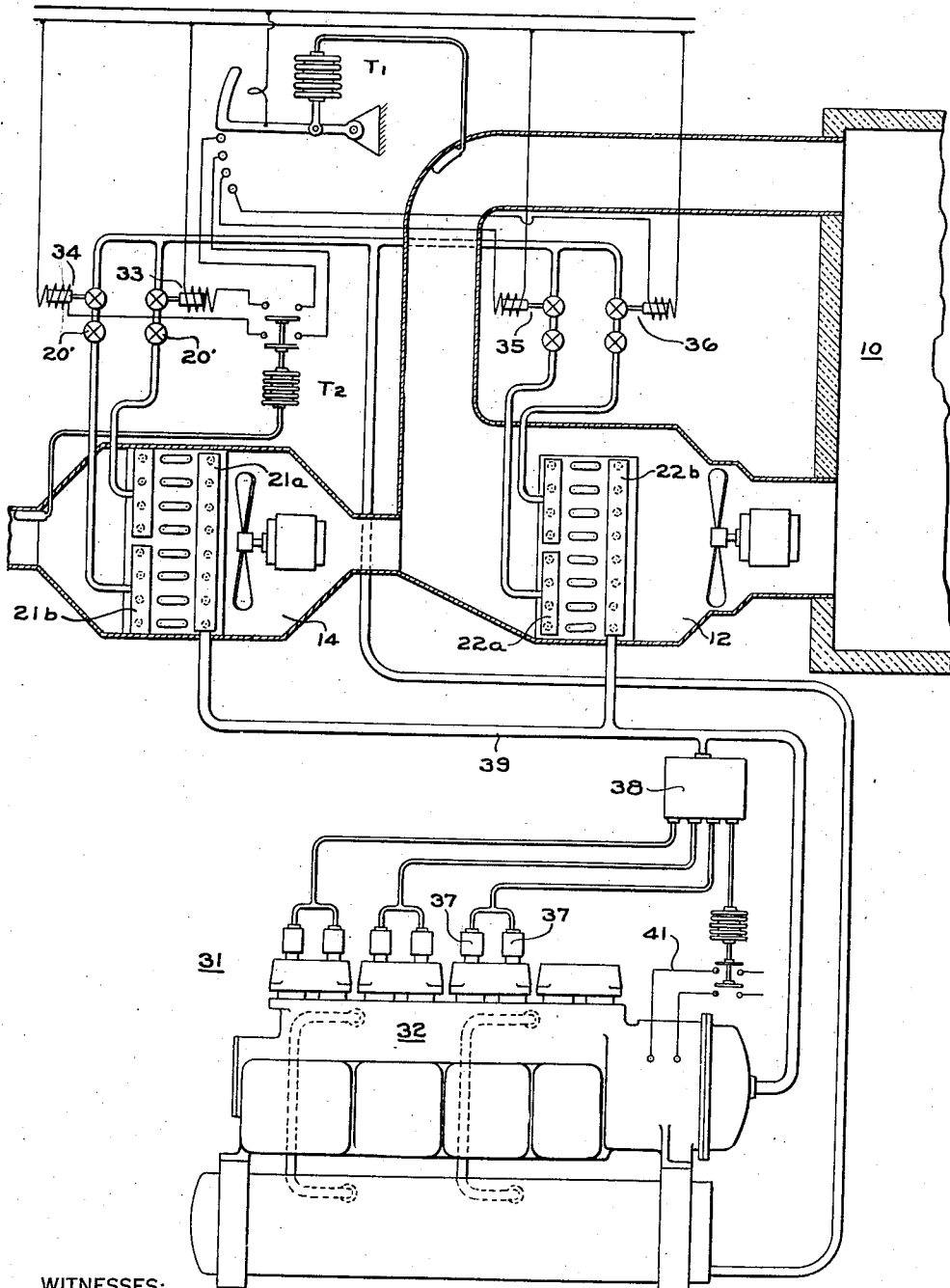
C. M. SANDERS, JR

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AIR CONDITIONING APPARATUS

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2 Sheets-Sheet 2



WITNESSES:

R. J. Eisinger
E. H. Lutz

FIG. 2.

INVENTOR
CHARLES M. SANDERS, JR

BY *W. A. Steiger*
ATTORNEY

UNITED STATES PATENT OFFICE

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AIR CONDITIONING APPARATUS

Charles M. Sanders, Jr., Oak Park, Ill., assignor
to Westinghouse Electric & Manufacturing
Company, East Pittsburgh, Pa., a corporation
of Pennsylvania

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6 Claims. (Cl. 62-6)

My invention relates to air conditioning apparatus, and it has for an object to provide improved apparatus.

A further object is to provide improved air conditioning apparatus adapted for operation at partial load to maintain more readily a desired temperature of the air in the enclosure.

A further object is to provide a simpler and more flexible method of control, providing a better balance between the amount of cooling provided by the apparatus and the cooling load of the air conditioned enclosure.

In accordance with my invention, air withdrawn from the enclosure is mixed with outdoor air. One or more cooling elements are disposed in the path of the outdoor air before mixture, and one or more additional cooling elements are disposed in the path of the mixed air stream for cooling at least a portion of said stream. Another portion of the mixed air stream may be by-passed around the latter cooling element. The mixed air stream is then delivered to the enclosure.

The apparatus is preferably provided with a thermostatic control which is subjected to the temperature of the air in the enclosure and is arranged to initiate operation of the cooling elements in the outdoor air stream successively and then the cooling elements in the withdrawn air successively as the temperature reaches successively higher predetermined values. A further thermostatic control may be provided to terminate operation of the outdoor air cooling elements as the outdoor air temperature drops, leaving the air cooling elements in the mixed air stream to carry the cooling load.

The above and other objects are effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a diagrammatic view of an air conditioning system arranged in accordance with my invention; and,

Fig. 2 is a similar view of a second embodiment.

Referring to the drawings in detail, an enclosure to be air conditioned is indicated at 10. Air is withdrawn from the enclosure through a duct 11 and conveyed to an air conditioning chamber 12. Outdoor air is conveyed through a duct 13, an air conditioning chamber 14 and a duct 15 to the duct 11, in which it is mixed with the return air and flows therewith through the chamber 12 and a duct 16 to the enclosure 10. The flow of

air described is effected in any suitable manner, as by means of fans 14' and 15' arranged in the chambers 14 and 15, respectively.

The present air conditioning system includes two refrigerating systems indicated generally at 17 and 18, each including a motor compressor unit 19 and a condenser 20. It also includes an expansion valve 20' of any suitable type known in the art, for example, a thermostatic expansion valve which operates in response to the superheat of the vaporized refrigerant discharged from the evaporator. The refrigerating system 17 includes an evaporator 21 disposed in the chamber 14 and extending entirely across the outdoor air stream flowing therethrough. The system 18 includes an evaporator 22 disposed in the chamber 12 and extending partially across the mixed air stream. A by-pass 23 may be provided, if desired, between the evaporator 22 and the adjacent wall of the chamber, through which by-pass a portion of the mixed air stream may flow without being cooled.

The evaporator 21 and its refrigerating system 17 are preferably of a capacity to take care of the cooling loads which depend upon the temperature of the outside air, that is, the loads due to transmission or leakage of heat, any infiltration of outdoor air, and admission of fresh air to the enclosure. The evaporator 22 and its refrigerating system 18 are preferably of sufficient capacity to take care of the loads which do not depend on the outside air temperature, for example, sun load, light load, and occupant load.

The control comprises a thermostatic switch T_1 which is responsive to the temperature of the withdrawn air flowing through the duct 11 and is arranged to close its contacts 24 and 25 successively as the temperature of the withdrawn air rises to successively higher predetermined values, which differ but slightly and represent substantially the temperature desired to be maintained in the enclosure 10. A second thermostat T_2 is responsive to the temperature of the outdoor air before it passes over the evaporator coil 21, and is arranged to open contacts 26 as the temperature of the outdoor air decreases below a predetermined value. The latter predetermined value represents the temperature of the outdoor air at which the entire heat load can be taken care of by the evaporator 22. If the evaporators are proportioned as suggested above, the evaporator 21 to take heat loads dependent upon the temperature of the outdoor air and the evaporator 22 to take heat loads not dependent upon outdoor air temperature, then such

predetermined value is the temperature desired to be maintained within the enclosure 10. The thermostats are of any suitable type known in the art and, of course, are adjustable.

The refrigerating system 17 is controlled by a circuit which extends from the line conductor L₁ through the contacts 24 and 26 in series, and the compressor motor of the system 17 to the line conductor L₂. The refrigerating system 18 is controlled by a circuit which extends from the line conductor L₁ through the contacts 25 and the compressor motor of the system 18 to the line conductor L₂. The control has been shown in a simplified manner in order that the inventive thought may be more readily understood, and it is to be understood that the usual expedients and instrumentalities used in the control of apparatus of this nature, including relays, protective devices, are to be used in the usual manner in which such expedients and instrumentalities are commonly used in the art.

Operation

Assuming the contacts 26 of the thermostat T₂ to be closed by reason of a sufficiently high outdoor temperature, the operation of the evaporators is controlled by the thermostat T₁ in response to the temperature of the air in the enclosure 10 to maintain said temperature at substantially the desired value. A demand for cooling is indicated by a rise in temperature in the enclosure. As the temperature reaches the first predetermined value, the contacts 24 close, completing the circuit for the refrigerating system 17. Operation of the latter is effected to supply refrigerant to the evaporator 21, which serves to cool all of the outdoor air passing through the chamber 14. The temperature not yet having reached the second predetermined value, the contacts 25 are open, rendering the refrigerating system 18 of the evaporator 22 inactive. In this case, therefore, the outdoor air is cooled and dehumidified by the evaporator 21, mixed with air withdrawn from the enclosure, and the mixture is delivered without further cooling to the enclosure 10. Upon decrease in temperature below the first predetermined value, the contacts 24 are opened to terminate operation of the refrigerating system 17 and the evaporator 21, whereupon a mixture of uncooled outdoor and return air is delivered to the enclosure.

An increase in the cooling load of the enclosure beyond the capacity of the evaporator 21 is represented by an increase in temperature to the second predetermined value at which both of the contacts 24 and 25 are closed, resulting in operation of both refrigerating systems and both evaporators. The entire outdoor air stream is cooled by the evaporator 21 as before. In the duct 11 it is mixed with the air stream from the enclosure and the mixed air stream then passes through the chamber 12, in which the major portion of the mixture flows over and is cooled and dehumidified by the evaporator 22. The two portions of the mixed air stream passing over the evaporator 22 and through the by-pass 23, respectively, then mix and are delivered to the enclosure 10 through the duct 16.

As the temperature of the air in the enclosure 10 decreases below the second predetermined value, the contacts 25 open to terminate operation of the refrigerating system 18 and the evaporator 22, leaving the refrigerating system 17 and evaporator 21 alone in operation to supply cooling.

If the temperature of the outdoor air drops to the predetermined value at which the contacts 26 of the thermostat T₂ are opened, indicating that the entire cooling load can be carried by the evaporator 22, the refrigerating system 17 and the evaporator 21 are shut down. The cooling load of the enclosure is now carried by the refrigerating system 18 and the evaporator 22 under the control of the contacts 25 of the thermostat T₁. The operation is initiated and terminated upon closing and opening, respectively, of the contacts 25 to maintain the temperature of the enclosure 10 at substantially the second predetermined value.

Figure 2

Provision may also be made for varying the amount of cooling effected in the chamber 14 and in the chamber 12, preferably by varying the effective evaporator cooling surface. For example, as illustrated in Fig. 2, evaporators 21a and 21b are arranged in parallel in the chamber 14, and evaporators 22a and 22b are arranged in parallel in the chamber 12. It is to be understood, however, that any other suitable provision for dividing the evaporator surface or for varying the effective evaporator surface may be provided. All of the evaporators are connected to a common refrigerating system 31, including a variable capacity compressor 32.

In this embodiment, the several evaporators are provided with solenoid valves which control the supply of liquid refrigerant thereto. The solenoid valves for the evaporators 21a, 21b, 22a and 22b are designated 33, 34, 35 and 36, respectively. The thermostat T₁ is arranged to energize the solenoids 33 to 36 in response to successively and slightly higher predetermined values representing substantially the temperature desired to be maintained in the enclosure 10. The thermostat T₂ is arranged to open the circuit of the solenoid 33 as the outdoor temperature decreases to a value such that the entire cooling load can be taken care of without the evaporator 21a. It opens the circuits of solenoids 33 and 34 when the outdoor temperature decreases to a still lower value such that the entire cooling load can be taken care of by the evaporators 22a and 22b.

The operation of the compressor 32 is controlled in accordance with the total load of those evaporators which are in operation. It is provided with several unloader mechanisms 37 which are adapted to render the associated cylinders of the compressor ineffective to compress refrigerant. They are controlled by a suitable control mechanism 38 which is responsive to the pressure in the suction line 39 connecting the outlets of the several evaporators with the inlet of the compressor. As the suction pressure increases, the cylinders are successively loaded and as the suction pressure decreases, the cylinders are successively unloaded, thereby maintaining a substantially constant suction pressure. As the suction pressure reaches a predetermined minimum value, operation of the compressor is terminated by opening the motor circuit 41. The particular mechanism for controlling the capacity of the compressor forms no part of the present invention; the invention contemplating any suitable mechanism whereby compressor capacity may be suitably controlled.

Figure 2—Operation

The operation of the embodiment shown in

Fig. 2 is, in a general way, similar to that of Fig. 1. Assuming the temperature of the outdoor air to be sufficiently high to cause the thermostat T₂ to close the several contacts, the operation of the several evaporators is controlled by the thermostat T₁. As the temperature increases to successively higher values, the several solenoid valves are successively opened in order to render the evaporators 21a, 21b, 22a and 22b effective in the order named. Conversely, upon decrease in temperature, the evaporators are rendered ineffective in the reverse order. The amount of cooling is thus automatically controlled to maintain substantially the desired temperature in the enclosure 10.

If either the evaporator 21a or both the evaporators 21a and 21b are rendered inoperable by the thermostat T₂, then the cooling load is carried by the remaining evaporators under control of the thermostat T₁, as will be fully apparent from the description that has already been given.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited but is susceptible of various other changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. In an air conditioning system for an enclosure, the combination of means for effecting flow of a stream of air from the enclosure and a stream of outdoor air, mixing the two streams and delivering the mixed air stream to the enclosure, first means for cooling the outdoor air stream before mixing, second means for cooling the mixed air stream, said first and second cooling means comprising direct expansion evaporator elements disposed in the respective air streams and compressor elements separately connected to the respective evaporator elements, and means for successively initiating operation of the first and the second air cooling means automatically in response to successively higher predetermined values of a heat load condition of the enclosure.

2. In an air conditioning system for an enclosure, the combination of means for effecting flow of a stream of air from the enclosure and a stream of outdoor air, mixing the two streams and delivering the mixed air stream to the enclosure, first means for cooling the outdoor air stream before mixing, second means for cooling the mixed air stream, means for successively initiating operation of the first and the second air cooling means automatically in response to successively higher predetermined values of a heat load condition of the enclosure, and means responsive to a predetermined minimum temperature of the outdoor air for terminating operation of the first air cooling means independently of the last-mentioned means.

3. In an air conditioning system for an enclosure, the combination of means effecting flow of a stream of air from the enclosure and a stream of outdoor air, mixing the two streams

and delivering the mixed air stream to the enclosure, a plurality of air cooling elements for cooling the outdoor air stream before mixing, a plurality of air cooling elements for cooling the mixed air stream, means responsive to successive increases in a heat load condition of the enclosure for successively initiating operation of the outdoor air cooling elements and then the mixed air cooling elements, and means responsive to successively lower outdoor air temperatures for successively terminating operation of the outdoor air cooling elements independently of the action of the last-mentioned means.

4. In an air conditioning system for an enclosure, the combination of means for effecting flow of a stream of air from the enclosure and a stream of outdoor air, mixing the two streams and delivering the mixed air stream to the enclosure; a refrigerating system including an evaporator disposed in the path of the outdoor air stream before mixture, a second evaporator disposed in the path of the mixed air stream and a variable capacity compressor connected to said evaporators; means for successively initiating flow of refrigerant through the first and the second evaporator automatically in response to successively higher values of a heat load condition of the enclosure; and means responsive to the suction pressure in the refrigerating system for controlling the capacity or output of the compressor.

5. In an air conditioning system for an enclosure, the combination of means for effecting flow of a stream of air from the enclosure and a stream of outdoor air, mixing the two streams and delivering the mixed air stream to the enclosure; a refrigerating system including a plurality of evaporators disposed in the path of the outdoor air stream before mixture, a plurality of evaporators disposed in the path of the mixed air stream, and a variable capacity compressor connected to said evaporators; means responsive to successively higher values of a heat load condition of the enclosure for successively initiating flow of refrigerant through the outdoor air evaporators and then the mixed air evaporators; and means responsive to the suction pressure in the refrigerating system for controlling the capacity or output of the compressor.

6. Refrigerating apparatus comprising a plurality of evaporator elements, individually operable valves for respectively controlling flow of refrigerant thereto, means including a common temperature-responsive element for controlling a plurality of said valves, a multi-cylinder compressor common to said evaporator elements for withdrawing vaporized refrigerant therefrom, means for condensing the compressed refrigerant discharged from the compressor, and means for varying the capacity or output of said compressor in response to suction pressure by unloading one or more cylinders, whereby the compressor output is varied in accordance with evaporator load while substantially constant pressure and temperature of the refrigerant is maintained in the evaporator elements whose valves are open.

CHARLES M. SANDERS, Jr.