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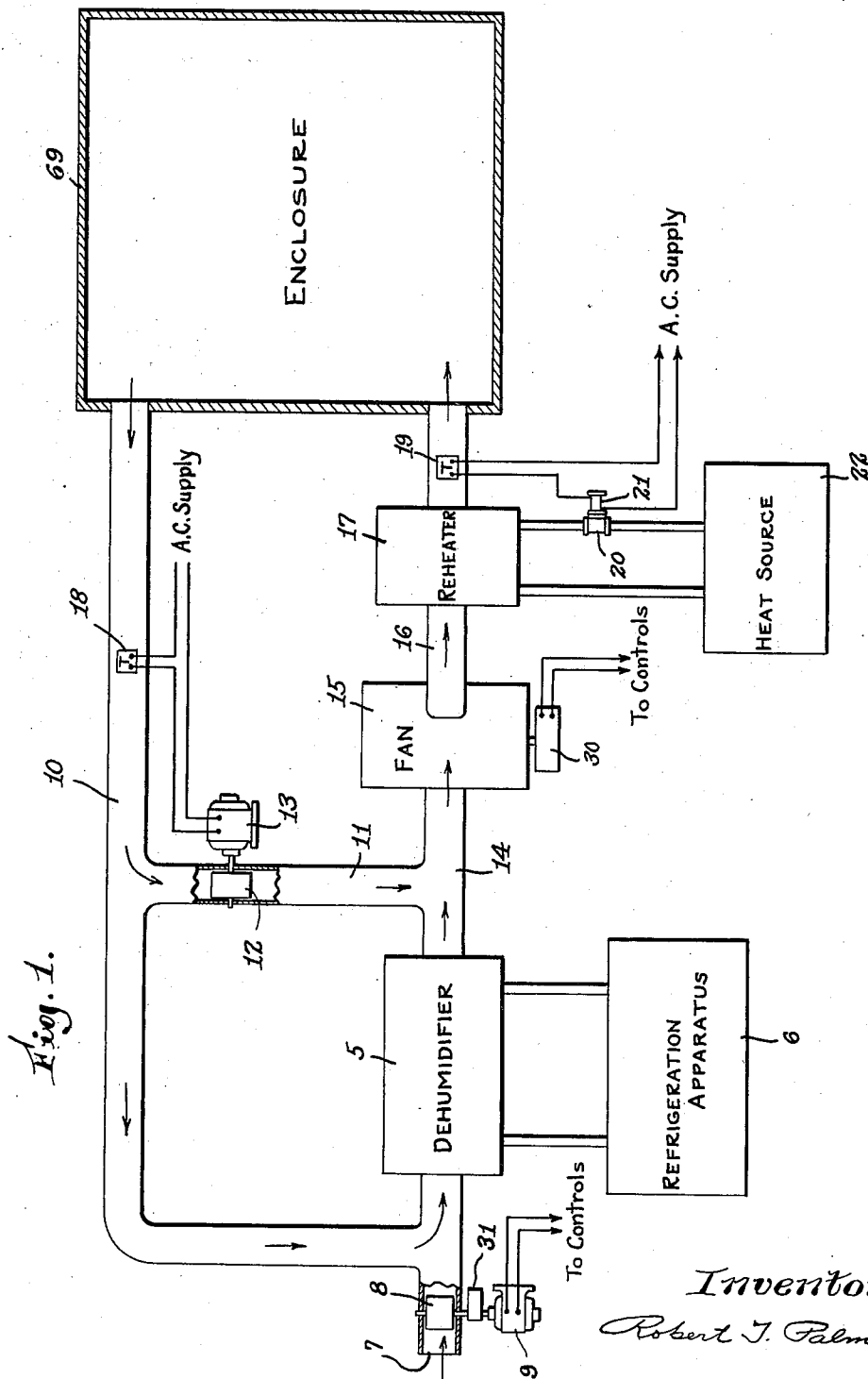
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AIR CONDITIONING SYSTEM

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2 Sheets-Sheet 1



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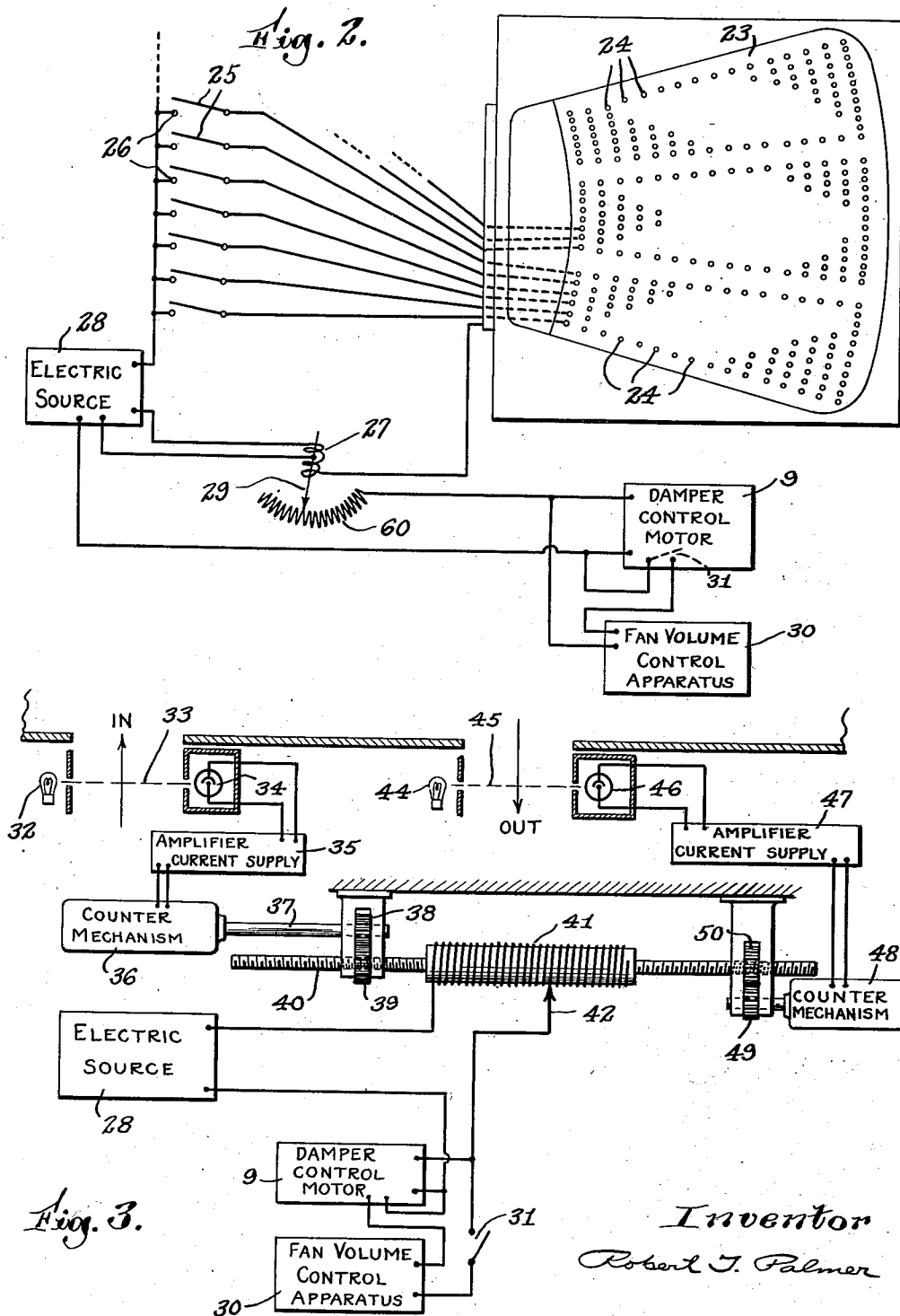
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UNITED STATES PATENT OFFICE

2,091,562

AIR CONDITIONING SYSTEM

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5 Claims. (Cl. 98—33)

This invention relates to the conditioning of air and relates more particularly to methods and apparatus for the cooling and dehumidification of air in summer.

5 In systems such as are installed in motion picture theatres, for example, for the cooling and dehumidification of air in summer, it is customary to chill fresh and recirculated air to a low dew point to remove its undesired moisture content and then to reheat the too cold dehumidified air by mixture with other recirculated air, known as by-pass air. A typical system is disclosed in Patent No. 1,670,656, issued May 22, 1928 to W. L. Fleisher.

15 It is highly desirable to vary the proportion of fresh air to recirculated air passing through the dehumidifier in such a system, in proportion to the number of people in the theatre. As the number of people increases, it is desirable and in fact required by ordinance in many locations, that the volume of fresh air increase in proportion. As the number of people decreases, a saving in refrigeration is effected by decreasing the volume of fresh air and by increasing the volume of recirculated air passing through the dehumidifier since the condition of the recirculated air is much nearer the desired standard than that of the fresh air having a higher temperature.

20 In the past, the volume of fresh air entering the dehumidifier of an air conditioning system has been varied by automatic controls, such as that disclosed by the Reissue Patent No. 16,611, reissued May 3, 1927 to L. L. Lewis. Lewis employs a hygrostat in the recirculated air duct which acts to increase or decrease the volume of fresh air entering the system in proportion to the increase or decrease respectively of the moisture in the recirculated air. The supposition is that as the number of people in the theatre increases, more moisture will be given off and the hygrostat will respond to the number of people in the theatre.

25 According to a feature of this invention, the approximate if not the actual number of people in the auditorium or other enclosure served with conditioned air, is determined at all times by instruments which function to vary the volume of fresh air entering the air conditioning system by actual count of the number of people in the enclosure or by an actual comparison of the number of people entering and leaving the enclosure.

30 In prior systems, it has been the practice to supply a constant volume of conditioned air to the auditorium of a theatre regardless of the number of occupants. Constant speed fans were em-

ployed and the proportions of fresh to recirculated air were varied and the condition of the air was varied as variations in the conditions in the auditorium took place.

35 According to another feature of this invention, the air conditioning system operates as in the past to deliver a constant volume of air to the enclosure until it is occupied by a predetermined number of people and as the number of occupants varies above this predetermined number, the system functions to increase the total air as well as the volume of fresh air delivered to the enclosure in proportion to the increase in the number of occupants above the predetermined number.

40 An object of the invention is to vary the volume of fresh air entering an air conditioning system in accordance with changes in the number of occupants in the enclosure served with conditioned air as indicated by the actual physical presence of the occupants.

45 Another object of the invention is to vary the volume of fresh air entering the dehumidifier of an air cooling system in accordance with changes in the number of occupants in the enclosure served, and to vary the volume of recirculated air entering the dehumidifier in accordance with the condition of the recirculated air.

50 Another object of the invention is to vary the volume of fresh air entering the dehumidifier of an air cooling system in accordance with changes in the number of occupants in the enclosure served, to increase the sensible heat of the dehumidified air with by-pass recirculated air, and to vary the volume of the by-pass air in accordance with the conditions of the air in the enclosure.

55 Another object of the invention is to supply a constant volume of conditioned air to an enclosure up to the time a predetermined number of people occupy the enclosure, and to vary the total volume of air delivered to the enclosure in accordance with changes in the number of occupants above the predetermined number.

Other objects of the invention will be apparent from the following description taken together with the drawings.

The invention will now be described with reference to the drawings of which;

60 Fig. 1 is a diagrammatic view of an embodiment of a complete air conditioning system according to this invention;

65 Fig. 2 is a diagrammatic view illustrating one embodiment of an automatic control for deter-

mining the number of people in the enclosure to be served; and

Fig. 3 is a diagrammatic view of another embodiment of a control for determining the number of people in the enclosure.

The dehumidifier 5 is supplied with refrigerant by the refrigeration apparatus 6, which may comprise the usual compressor, condenser, expansion and evaporator mechanism. The dehumidifier 5 may be of the preferred spray type, in which case the evaporators in the refrigeration apparatus 6 serve to cool water or a brine solution which is circulated to sprays in the dehumidifier 5.

The dehumidifier 5, may, however, contain cooling coils which would serve as evaporator coils for the refrigerant supplied in this case, by the apparatus 6.

Both types of dehumidifiers are well known and are in common use, and so will not be explained in detail here.

The dehumidifier 5 may be controlled, as described in said Lewis patent, to deliver dehumidified air at a constant dew point, regardless of changes in the condition of air entering the dehumidifier.

Fresh outside air enters the system through the duct 7 and the volume of fresh air is controlled by the damper 8 which is adjusted by the damper control motor 9, the circuit for the control of, and the operation of which will be explained in detail later.

Recirculated air from the enclosure 69, to be served, passes through the duct 10 and enters the dehumidifier with the fresh outside air. A portion of recirculated air passes through the duct 11, past the damper 12, the position of which is adjusted by the control motor 13, to enter the duct 14 on the output side of the dehumidifier.

The fan 15, operating normally at a constant output, causes the flow of the fresh, recirculated and by-pass air through the system and discharges the mixed conditioned air through the duct 16, through the reheater 17 and into the enclosure 69.

The motor 13 of the by-pass damper 12 is controlled by the thermostat 18 mounted in the recirculated air duct. This thermostat 18 responds to the condition of air within the enclosure 69 to vary the volume of by-pass air, mixing with the dehumidified air at the output side of the dehumidifier, to increase or decrease the superheat added to the dehumidified air as the enclosure air becomes too cold or too hot respectively.

The reheater 17 supplements the action of the by-pass air when the by-pass air is insufficient to heat sufficiently the dehumidified air. While the thermostat 18 could be made to adjust the reheater 17 when the by-pass damper 12 is fully open, the thermostat 19, at the output side of the reheater 17, is shown to control through the valve 20, operated by the motor 21, the supply of heat from the source 22.

Adjustment of the by-pass damper 12 not only serves to control the volume of by-pass air entering the system through the duct 11 at the output side of the dehumidifier, but also serves to control the volume of recirculated air entering the input side of the dehumidifier with the result that as the volume of by-pass air is decreased or increased, the volume of recirculated air entering the dehumidifier, is increased or decreased respectively.

Since it is desired to adjust the volume of fresh outside air entering the dehumidifier in accordance with the number of occupants of the en-

closure 69, the fan volume control apparatus 30 responds to the number of people, under control of the apparatus which will now be described.

Referring now to Fig. 2, the panel 23 contains the plurality of lights 24 which correspond to seats in the auditorium of a motion picture theatre. The seats are so arranged that when occupied, circuits are closed which cause the lights in the panel 23 to light up, indicating which seats are occupied. The lights 24 are all similar and each draws the same current from the electric supply source. For the purpose of illustration, the plurality of switches 25 indicate switches which are closed, when the theatre seats are occupied, to rest against the contacts 26, thus closing the light circuits.

Since the total current drawn by the lights 24 is directly proportional to the number of lights, the circuits of which are closed, this current may be measured to indicate the number of seats in the theatre which are occupied. The galvanometer winding 27 is connected in series relationship with the electric source 28 and the plurality of lights 24 which are arranged in parallel with each other but in series to the electric source 28 and the galvanometer 27. The pointer 29 on the galvanometer is arranged to contact with the resistance 60, which is connected in circuit with the damper control 9 of Fig. 1 and at times with the fan volume control apparatus 30 of Fig. 1. This galvanometer is so adjusted that when no lights in the circuit are burning, the pointer 29 is at the extreme left hand portion of the resistance 60 and when all of the seats are occupied and all of the lights 24 are burning, the galvanometer pointer will be at the extreme right hand end of the resistance 60. The galvanometer pointer 29 is connected to one side of the supply from the electric source 28 so that the damper control motor 9 is connected to the electric source 28 in series with the resistance 60 and pointer 29.

Both the damper control motor 9 and the fan volume control apparatus 30 are connected to the electric source 28 through the resistance 60, but they are so arranged that the fan volume control apparatus 30 is not adjusted until the damper control motor 9 has adjusted its damper 8 to wide open position. This volume control apparatus 30 and its associated fan 15 are preferably of the type disclosed by the H. F. Hagen Patent No. 1,846,863, issued Feb. 23, 1932, where the fan operates at a constant speed and the volume of air moving through the fan is varied by spin inducing vanes in the inlet of the fan. In the present case, the vanes are adjusted automatically by a motor similar to the damper control motor 9 and which may be of the well known type manufactured by the Direct Control Valve Co. of New York City. Obviously, the speed of the fan motor could also be adjusted.

The electric circuit, comprising the resistance 60, lights 24 and damper control motor 9, is so adjusted that the motor 9 moves its damper 8 proportional to the number of lights 24 which are burning, up to a point corresponding to a predetermined number of occupants within the enclosure 69. This predetermined point may represent the average number of occupants or it may represent the maximum which it is expected will occupy the theatre except during the showing of feature pictures when the number of occupants is expected to greatly exceed the maximum on ordinary occasions. When this predetermined point is reached, the damper control motor will

have adjusted the damper 8 to its wide open position. Beyond that point, no greater volume of outside air could be drawn into the system without adjustment of the volume of total air passing through the fan 15.

When the predetermined point has been reached and the damper 8 is wide open, the switch 31 is closed by the motor 9 when it reaches its extreme position with the damper 8 wide open, connecting the fan volume control apparatus 30 to the electric source through the resistance 60 to the pointer 29. The control apparatus 30 is so arranged, however, that the amount of resistance remaining between the pointer 29 and the right hand end of the resistance 60 is too great to cause the control apparatus 30 to function. As, however, the number of occupants above the predetermined point increase, the amount of the resistance 60 remaining in the circuit decreases, and causes the control apparatus 30 to increase the volume of air passing through the fan thus increasing not only the volume of fresh air drawn in through the dehumidifier but the volume of recirculated air drawn from the enclosure 69.

The damper control motor 9 and the fan control apparatus 30 function together at all times to vary the volume of fresh air drawn into the system, in proportion to the number of people within the enclosure 69. In plenum systems such as this, special exhaust outlets are not necessary, since air escapes from the enclosure being conditioned, through cracks and crevices, in volume equal to that of the fresh air admitted through the fresh air duct. When the fresh air inlet is closed, the system, of course does not act as a plenum system, since due to the handling of recirculated air alone, a pressure higher than atmospheric air could not be built up in the enclosure. When the fresh air damper is wide open, the amount of air handled by the fan is a maximum, and therefore the pressure in the enclosure and consequently the leakage therefrom, is a maximum. From a closed position of the fresh air damper at which no fresh air is admitted to open position at which the maximum amount of fresh air is admitted, there is a variable flow of leakage air which is directly proportional to the air pressure in the enclosure which is in turn directly proportional to the position of the damper in the fresh air duct. It is seen, therefore, that since the position of the fresh air damper is a function of the number of occupants of the enclosure, the fresh air admitted is a function of the number of occupants.

The fan volume control apparatus 30 functions additionally to cause the air conditioning apparatus to perform greater duty during occasional peak loads. The refrigeration apparatus may be designed for average conditions or maximum load, under ordinary conditions, and peak load conditions may be taken care of without requiring that the plant be designed with large apparatus so as to be able to handle peak conditions at all times.

The explanation in connection with the control in Fig. 2 has for the purposes of illustration, been based on the assumption that sufficient seats in the theatre are provided to take care of all the people within the theatre. There could, of course, be a number of people in the theatre who are not seated. This number would be small in proportion to the number of seated occupants and the system may be adjusted to provide for a number of unseated occupants, which experience has shown to be an average.

In the embodiment of the invention illustrated by Fig. 3, the number of people entering the theatre is counted, the number of people leaving the theatre is counted and the counting mechanism is so arranged as to indicate the actual number of people who have entered the theatre and who have not left. The light source 32 throws the light beam 33 across the space in a passageway through which the persons entering the theatre pass in single file, and strikes the photo-sensitive cathode of the photo-electric cell 34. Each person passing through the passageway interrupts the beam 33 causing the photo-electric cell to provide fluctuations in its output circuit which fluctuations are amplified in the amplifier 35, and which operate the counter mechanism 36 which registers the number of fluctuations. The counter mechanism 36 which is similar to the well known telephone message register, is provided with the shaft 37 on which is mounted the gear 38. The gear 39 meshes with the gear 38 and is provided with an internal gear which meshes with the threads in the member 40. As the number of impulses from the photo-electric cell 34 accumulate, the member 40 is moved by operation of the counter mechanism and the gears 38 and 39, from left to right (facing the drawing). The member 40 carries the resistance 41 which is moved back and forth in sliding contact with the pointer 42. As the resistance 41 is moved by the member 40 to its extreme right hand position, the amount of resistance in the circuit with the electric source 28 and the damper control motor 9, is decreased, causing the damper control motor to function as previously described to adjust its damper 8 to increase the volume of fresh outside air entering the duct 7.

Since the number of people entering the theatre would not give the true indication of the number of people in the theatre since the occupants are almost always continuously leaving, another light source 44 is arranged to throw a beam 45 across a passageway through which the occupants of the theatre leave same. This light beam strikes the cathode of the photo-electric cell 46 which is connected with amplifier 47 and which supplies amplified currents to the counter mechanism 48. Each interruption of the light beam 45 by a person leaving the theatre causes the photo-electric cell to send an amplified impulse to the counter mechanism 48 which is so arranged with the gears 49 and 50 to move the member 40 from right to left in accordance with accumulations in the number of people leaving the theatre. This causes increases in the resistance 41 in the control circuit and causes the damper control motor to adjust its damper towards a closed position as the number of people leaving the theatre increases.

When both light beams 43 and 45 are interrupted simultaneously, the counter mechanisms 46 and 48 would oppose each other causing the resistance 41 to remain unchanged at the moment. Its position, with respect to the pointer 42, however, would be determined by the difference between the number of people who have entered the theatre and who have left the theatre, after the system has been placed in operation.

As previously explained with respect to Fig. 2, the resistance 41 and pointer 42 are arranged, as resistance 60 and pointer 29 of Fig. 2 are, so that when a predetermined number of people are in the theatre, the damper control motor adjusts

its damper to a wide open position, placing the volume control apparatus 30 in circuit with the electric source, the resistance 41 and pointer 42 so that further increase in the number of people in the theatre causes the control apparatus 30 to increase the volume of air passing through the fan 15.

Figs. 2 and 3 illustrate two ways in which the number of people in the theatre may be determined. It is obvious that with the arrangement in Fig. 3 that several single file passages may be provided for the entrance and that several single file passages may be provided for the exit of theatre customers. It is also obvious that a turnstile or a treadle or other equivalent mechanisms may be substituted for that shown by Fig. 3.

In the attached claims, the means for determining the approximate number of occupants referred to, is defined as means for determining the actual physical presence of said occupants as by count of the number of seats occupied or as by observation and comparison of the number of persons entering and leaving the enclosure, and disclaimer is made of any means for determining the number of occupants by observation of heat or moisture resulting from their presence.

When the theatre is empty and the system is placed in operation, the damper control motor 9 holds the damper 8 in a closed position, with the result that only recirculated air passes through the dehumidifier 5 and after a period of time, the recirculated air will be in its proper condition.

When a theatre opens and the customers come in, the control mechanism functions to permit a volume of fresh air corresponding to the number of customers, to pass through the dehumidifier, and to be supplied into the auditorium. The volume of fresh air is thus determined by the physical presence of the occupants and not by hygrometers or thermostats, which form of apparatus might or might not indicate the presence of theatre occupants.

Whereas several embodiments of the invention have been described for the purpose of illustration, it should be understood that the invention is not limited to the exact arrangement disclosed, since many departures may be made by those skilled in the art, after having had access to this disclosure.

What is claimed is:

1. Air conditioning apparatus comprising in combination, an enclosure to be supplied with conditioned air, a cooling and dehumidifying unit, means for supplying conditioned air from said unit into said enclosure, means for supplying fresh air into said unit, a fan for moving the air to be conditioned through said unit, means for adjusting the volume of fresh air entering said unit in accordance with changes in the number of occupants in said enclosure, means for automatically adjusting said fan for varying the total volume of air passing through said unit when the volume of fresh air entering said unit has reached a predetermined point, means for supplying recirculated air from said enclosure into said unit, and means for varying the volume of said recirculated air in accordance with variations in the condition of the air within said enclosure.

2. Air conditioning apparatus comprising in combination, an enclosure to be supplied with conditioned air, a cooling and dehumidifying unit, means for supplying conditioned air from said unit into said enclosure, means for supplying fresh air into said unit, a fan for moving the air to be conditioned through said unit, means for adjusting the volume of fresh air entering said unit in accordance with changes in the number of occupants in said enclosure, means for automatically adjusting said fan for varying the total volume of air passing through said unit when the volume of fresh air entering said unit has reached a predetermined point, means for supplying recirculated air from said enclosure into said unit, means for mixing other recirculated air from said enclosure as by-pass air with the conditioned air at the output side of said unit, and means for varying the volume of recirculated air entering said unit and the volume of by-pass air in accordance with changes in the condition of the air within said enclosure.

3. The method of conditioning air and supplying conditioned air into an enclosure occupied at different times by different numbers of occupants which comprises conditioning outside air and air recirculated from the enclosure, supplying the conditioned air into the enclosure, varying the volume of outside air in accordance with changes in the number of occupants of said enclosure up to a predetermined number while holding the volume of air delivered into said enclosure constant, and varying the volume of conditioned air delivered into said enclosure in accordance with changes in the number of occupants above said predetermined number.

4. The method of conditioning air and supplying conditioned air into an enclosure occupied at different times by different numbers of occupants which comprises conditioning outside air, mixing air recirculated from the enclosure with the conditioned air, supplying the mixed air into the enclosure, varying the volume of outside air in accordance with changes in the number of the occupants of said enclosure up to a predetermined number while holding the volume of air delivered into said enclosure constant, and varying the volume of air delivered into said enclosure in accordance with changes in the number of occupants above said predetermined number.

5. The method of conditioning air and supplying conditioned air into an enclosure occupied at different times by different numbers of occupants which comprises conditioning outside air, and air recirculated from the enclosure, mixing air recirculated from the enclosure as by-pass air with the conditioned air, supplying the mixed air into the enclosure, varying the volume of outside air in accordance with changes in the number of the occupants of said enclosure up to a predetermined number while holding the volume of air delivered into said enclosure constant, varying the volume of air delivered into said enclosure in accordance with changes in the number of occupants above said predetermined number, and varying the volume of the by-pass air added to the conditioned air in accordance with changes in the condition of the air within the enclosure.

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