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METHOD AND APPARATUS FOR VENTILATING BUILDINGS

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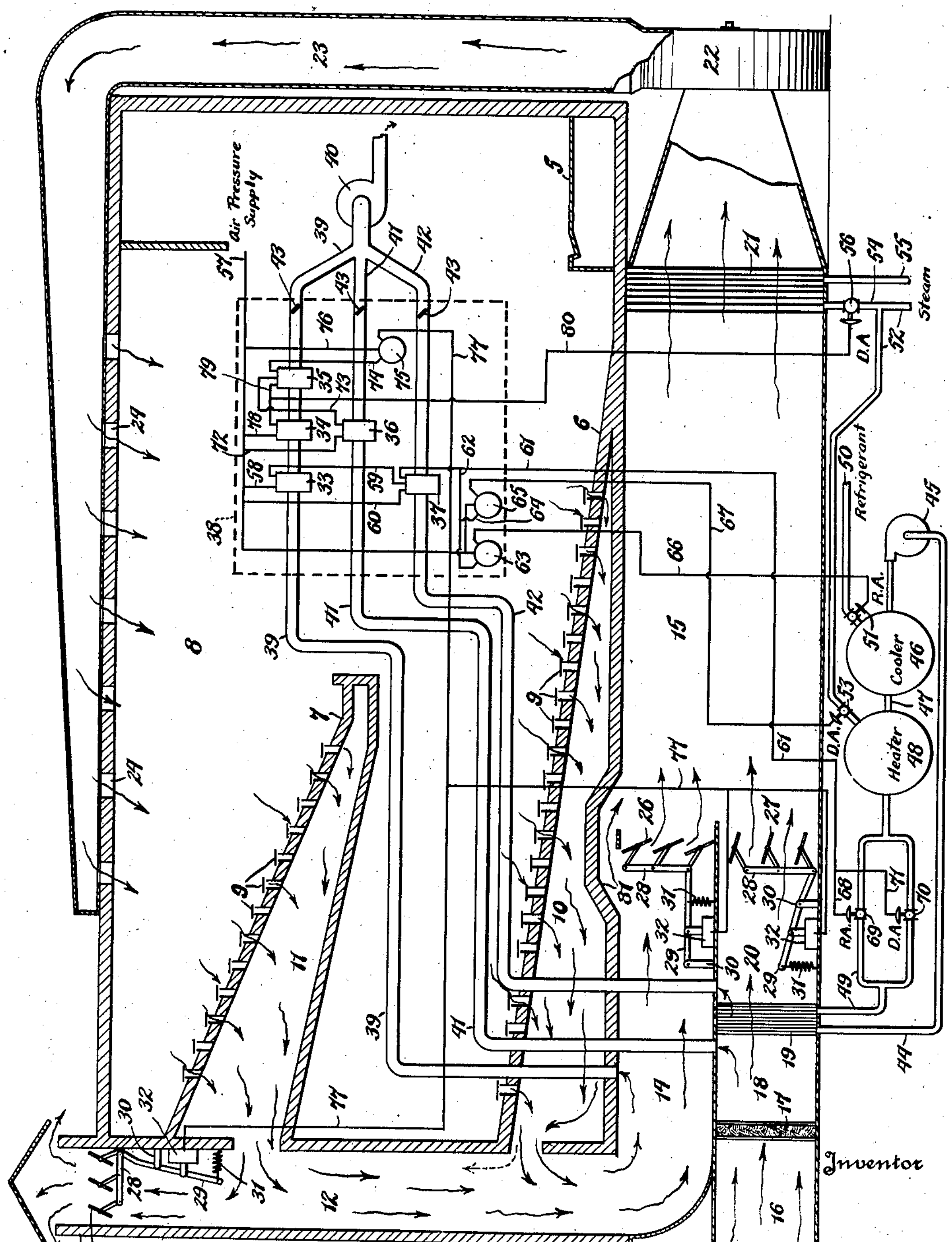

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METHOD AND APPARATUS FOR VENTILATING BUILDINGS

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This invention relates to a method and apparatus for cooling and ventilating buildings and is more particularly intended for cooling, heating and ventilating enclosures where a large number of people congregate such as in theatres or auditoriums although the invention can also be embodied in systems for use in factories or the like or in domestic installations in private dwellings.

In the ventilation of buildings, particularly where a large number of people congregate, such as in a theatre, the comfort and health of the people depend not only on the condition of the air itself, but also on the movement of the air through the auditorium. Thus regardless of the heating or cooling effect it is desirable to have a large volume of air circulated through the auditorium. It is also desirable that the temperature of the air inside the auditorium bear a definite ratio to the temperature of the outside air, within, of course, the range of human comfort. Thus it is desirable in the summer time to maintain a temperature inside of the enclosure approximately ten degrees below the outside temperature. If this ratio is departed from, the people coming in from the outside experience a chill which not only renders them uncomfortable at the time of entering but may continue through their stay. Furthermore a very oppressive feeling occurs on passing to the outside if the differential is too great. The conditions of the air within the enclosure are also subject to constantly fluctuating conditions. In the winter time fresh air must, of course, be provided for ventilation, and must be heated, this being, however, only a part of the air which must be circulated through the enclosure to insure a movement of air sufficient to insure the comfort of the occupants. In summer time fresh air must be also provided for ventilation and this air cooled to maintain the desired ratio between inside and outside temperatures. At the same time it is desirable not to circulate cooled fresh air exclusively through the auditorium because such a large amount of fresh air is not necessary for ventilation and the cooling of the entire volume of air necessary to secure the desired air movement would require an unnecessary amount of refrigeration. At the same time the air conditions in the room are subject to constantly varying conditions; the number of people in the room generating heat, whether few or many, the infiltration of heat in summer, the loss of heat through the walls of the building in winter, the heat generated by the lights, and other variables.

It is one of the objects of this invention to provide a method and apparatus for circulating air through an inclosure in which in both winter and summer a proper amount of fresh air is admitted to the enclosure in accordance with the number of people in the enclosure, a sufficient amount of air is moved through the enclosure to insure the comfort of the occupants and in which the air forced into the room is maintained at such temperature to insure the maintenance of the desired temperature of the room, regardless of the number of occupants or other variable influences and during the summer time bearing a ratio to the fluctuating outside air temperatures.

Another object is to provide such a system in which the larger proportion of the air handled by the system is air withdrawn from the room and returned with the fresh air to the room and in which such recirculated air is not passed through the cooling coils. The recirculated air is, of course, very close to the standard to be maintained and by cooling or heating only the fresh air and tempering it with the recirculated air economies in the amount of refrigerant or heating medium employed can be effected, particularly as compared with systems in which all of the air is dehumidified by passing it through cooling sprays and must be thereafter heated to maintain the proper temperature.

Another object is to avoid the use of dehumidifying sprays and to effect the cooling of the fresh air wholly by means of coils which conduct both a refrigerating and a heating medium to cool or heat the fresh air as conditions may require. The present system proposes the elimination of all sprays although it will be understood that humidifying sprays can be used to humidify the return air and sprays for washing either the return or fresh air without departing from the spirit of the invention.

Another purpose is to provide such a system in which the temperature in the enclosure is maintained almost entirely by the functioning of the amounts of fresh and recirculated air returned to the room.

Another purpose is to provide a heating and cooling system in which the controlling thermostats are all mounted on a central instrument board and in which the room air, fresh air and tempered fresh air is drawn from the corresponding ducts and past the sensitive parts of the instruments. By this means all the control instruments are located on one board and readily accessible for inspection, adjustments, repairs and if pressure gages are desired to observe the precise operation of each of the thermostats, they can also be grouped on the board and conveniently visible. This system also permits a rapid flow of air to be induced past the sensitive parts of the instruments so as to make them function more quickly as compared with a system in which the control instruments are located in the main ducts themselves.

Another object is to provide a thermostat control system which will accurately control the amount of recirculated and fresh air employed, the air exhausted and the cooling and heating means to maintain exactly the conditions desired in the room and the temperature ratio with the outside air with a minimum expenditure of power required to both refrigerate and heat the air.

Another object is to provide a system which is functioned exclusively through thermostats and completely avoids the use of hygrostats or wet bulb thermostats, such hygrostats being more delicate, requiring a supply of moisture and requiring more care in maintenance than thermostats.

Other objects are to provide such a system which is compact, particularly in eliminating large dehumidifying spray chambers, which is relatively inexpensive to install and maintain; which is conveniently accessible for repairs, and adjustments and which will at all times handle a constant volume of air.

In the accompanying drawing:

The figure is a diagrammatic sectional elevation of a building equipped with a ventilating system embodying the present invention and showing diagrammatically the arrangement and action of all of the instrumentalities used to carry out the invention.

In its general organization, this invention comprises means for drawing in fresh air and passing it through a heating and cooling coil, means for mixing it with recirculated air in varying proportions, means for exhausting an amount of air from the enclosure proportionate to the amount of fresh air admitted, means for heating mixed recirculated and fresh air before passing into the enclosure and a plurality of thermostats and relays on an instrument board controlling the proportions of fresh and recirculated air employed and the heating and cooling medium employed in the heater and cooler, said thermostats being responsive to the temperature of fresh air, tempered fresh air and room air conducted to them by means of separate conduits to maintain the temperature of the enclosure at a definite ratio to outside air in summer and at the proper temperature in winter and insuring an adequate supply of fresh air at all times.

The air circulating and tempering system

The enclosure represented is that of a theatre having a stage **5**, an orchestra floor **6**, a balcony **7** and a main auditorium **8**. The floor of the balcony **7** and the orchestra floor **6** are shown as provided with a plurality of mushroom ventilators **9** which permit the air to pass through the floors to a space or chamber **10** under the orchestra floor **6** and a space or chamber **11** under the balcony floor **7**. From these chambers the air is drawn into a vertical duct **12**, the upper end of which connects with a roof vent **13** and the lower end of which connects with a recirculated air duct **14**. The recirculating air duct **14** opens into a mixing chamber **15** into which tempered fresh air is also admitted.

This fresh air is drawn from the outside through an intake duct **16** in the inlet of which a filter **17** is arranged so as to prevent the passage of dust and dirt into the theatre. From this filter the fresh air passes into a filtered air chamber **18** and through a plurality of coils **19** which are adapted to conduct either a heating medium or a refrigerating medium so as to heat or cool the air as conditions may require. From the cooling and heating coils **19**, the fresh air passes into a tempered fresh air chamber **20** and thence into the mixing chamber **15**. From the mixing chamber the mixed tempered fresh air and recirculated air is drawn through the coils of a heater **21** by a fan **22** which forces it up a duct **23**, this duct discharging the air through openings **24** provided in the ceiling of the auditorium. It is, therefore, apparent that fresh air is drawn in and a part of the air recirculated by the fan or blower **22** and a part of the room air instead of being recirculated can escape through the vent.

The control of the relative amounts of tempered fresh air and recirculated air returned to the room and the amount of room air which is allowed to escape is determined by the automatic regulation of louvers **25** in the vent stack, louvers **26** between the recirculated air duct **14** and the mixing chamber **15** and louvers **27** between the tempered fresh air chamber **20** and the mixing chamber **15**. Each of the louvers is shown as pivoting about its longitudinal axis and the arms of the louvers of each set are tied to swing together by a bar **28** which is connected to a lever **29** fulcrumed at **30** and yieldingly held in one extreme position by a spring **31**. The louvers are moved to their opposite positions by an air motor **32** which is connected to the opposite side of the lever **29**. All of the motors **32** for operating the three sets of louvers **25**, **26** and **27** are supplied with the same degree of pressure from a single controlling source, as hereinafter described and it is therefore apparent that all three sets of louvers move in unison. The arrangement of the motors **32** operating the vent louvers **25** and the tempered fresh air louvers **27** is such that they open together and close together and therefore as the tempered fresh air louvers **27** are progressively opened up to admit more fresh air, the vent louvers are also progressively opened up to permit of the exhaust or venting of a proportionate amount of room air through the vent **13** to the atmosphere. It will be noted, however, that the motor **32** operating the recirculated air louvers **26** is between the fulcrum **30** and the bar **28** connected to the louver arms. It is therefore apparent that as the tempered fresh air louvers **27** are progressively opened, the recirculated air louvers **26** are progressively closed and vice versa. By this means, through the uniform application or diminution of air pressure to all of the motors **32**, the tempered fresh air louvers **27** and the recirculated air louvers **26** are operated to vary in reverse order the proportions of recirculated air and tempered fresh air admitted to the mixing chamber **15**.

It will be understood that the above organization is purely an example of a simplified form of apparatus and that other apparatus could be employed such as independent exhaust fans and ducts etc.

The instrument board

The control of the system is shown as effected by five thermostats. Three of these thermostats, a master thermostat **33**, a pilot thermostat **34** and a sub-thermostat **35** are responsive to the temperature of the air in the enclosure. Another, a master thermostat 36 is responsive to the temperature of the outside air and the other thermostat, or sub-thermostat 37 is responsive to the temperature of the tempered fresh air in the tempered fresh air chamber 20. All of these thermostats are mounted on an instrument board 38 indicated by dotted lines. For convenience in understanding the invention the instrument board with its associated instruments and connections has been greatly enlarged in the drawing and placed in the auditorium although it may be located wherever convenient.

To actuate the thermostats 33, 34 and 35 in response to the temperature in the enclosure, the sensitive parts of each of these thermostats is arranged in a small air duct 39 which is connected at one end with the recirculated air duct or chamber 14 and at its other end is connected with the inlet of a small blower or fan 40 which discharges in any suitable place. It is therefore apparent since the temperature of the recirculated air in in the recirculation chamber or duct 14 is the same as the temperature of the air in the enclosure 8 and as a small amount of this recirculated air is drawn through the duct 39 and past the sensitive parts of the thermostats 33, 34 and 35, that these thermostats will be actuated in response to the temperature in the auditorium 8.

In a similar manner the sensitive parts of the master thermostat 36 are arranged in a small air duct 41 which is connected at one end with the filtered fresh air chamber 18 and at its other end to the inlet of the fan or blower 40 so that filtered fresh air is drawn through this duct and the master thermostat 36 is responsive to outside air temperatures.

Similarly the sensitive parts of the sub-thermostat 37 are arranged in a small air duct 42 which is connected at one end with the tempered fresh air chamber 20 and at its other end to the inlet of the fan or blower 40 so that a small amount of tempered fresh air is drawn through this duct and the sub-thermostat 37 is responsive to its temperature.

By this arrangement all of the controlling thermostats can be mounted on a single instrument board where they are conveniently accessible for reading, adjustment or repairs. At the same time their sensitive parts are in a stream of air having a relatively high velocity so that the thermostats respond quickly. The velocity of each stream of air through the three ducts 39, 41 and 42 can be regulated by separate dampers 43 in each duct, and the handles operating these dampers can also be carried by the instrument board 38. It will be understood that any means other than the separate blower 40 could be employed for drawing air through the ducts 39, 41 and 42 and that these streams of air could be induced by the main blower 22.

The heating and cooling media systems

As previously stated, the coils 19 between the filtered fresh air chamber 18 and the tempered fresh air chamber 20 are adapted to conduct both a refrigerating medium and a heating medium depending upon the conditions to be obtained. For this purpose, a suitable non-freezing and high boiling liquid is circulated through these coils. The outlet pipe 44 from these coils is connected to a pump 45 which forces it into a cooler or cooling interchanger 46 and thence a pipe 47 into a heater or heating inter-chamber 48. From the heating interchanger 48 the heating and cooling liquid returns to the inlet of the coils 19 by a branched pipe 49. The cooling medium such as cold brine is admitted to the cooling interchanger 46 through a brine inlet pipe 50 and the flow of brine into this cooling interchanger 46 is controlled by a reverse acting diaphragm valve 51. In a similar manner the heating medium such as steam is admitted to the heating interchanger 48 through a steam inlet pipe 52 and the admission of steam to this heating interchanger 48 is controlled by a direct acting diaphragm valve 53. These diaphragm valves are so set that they do not overlap so as to both cool and heat the cooling and heating medium at the same time, as hereinafter described, which would, of course, be wasteful.

The steam pipe 52 is connected by a branch 54 with the inlet to the heating coils 21, the outlet of the coils being indicated at 55. The admission of steam to the heating coils 21 is controlled by a direct acting diaphragm valve 56.

The control system

The control is effected by air pressure, this pressure being supplied at 15 pounds through an air pressure supply line 57.

All five thermostats 33—37 embodied in the construction shown in the present application are of the direct acting intermediate type, that is with a constant air pressure of say 15 pounds supplied at the inlet of each thermostat, the air pressure on the outlet of the thermostat rises with rising temperature of the air in which the sensitive parts of the thermostat are located. Conversely with falling air temperature, the air pressure on the outlet of each thermostat falls. It follows that when an intermediate desired temperature is to be maintained by the thermostat that an intermediate outlet pressure is also maintained by each thermostat.

The thermostats 33 and 36 are master thermostats. A master thermostat has a comparatively wide range of temperature change and corresponding outlet pressure change, often having a range of temperature change of 20° F. to cause an outlet pressure change of 0 to 15 pounds. Such a master thermostat can be made by adjusting to cover different limited ranges, for example from 75° to 95° F. or from 60° to 80° F. The master thermostats herein used are employed to vary the setting of a sub-thermostat. For example, as the temperature to which the master thermostat is exposed varies, say from 95° to 85° F. the outlet air pressure will vary from 15 to 7.5 pounds, which change in air pressure changes the setting of, say, from 85° to 75°. The constant interval (in the above example 10°) can be changed by adjustment of the sub-thermostat. Thus the master and sub-thermostat in combination accomplish the purpose of maintaining constant differential temperatures between the two media in which the two instruments are located by having the sub-thermostat control the temperature of one media.

The master thermostat 33, the sensitive parts of which are responsive to the temperature of the air in the auditorium 8, is supplied with pressure at 15 pounds from the main pressure supply line 57 by a pipe 58. Its outlet line 59 connects with and controls the setting of the sub-thermostat 37, the sensitive parts of which are responsive to the temperature of the tempered fresh air in the tempered fresh air chamber 20. This sub-thermostat 37 is connected by a line 60 with the main pressure supply line 57 so that it is supplied with pressure at 15 pounds and its outlet line 61 is connected by one branch 62 with a snap relay 63 and by another branch 64 with a snap relay 65. These snap relays are supplied with air at 15 pounds pressure from the main pressure line 57 and the relay 63 has its outlet connected by the line 66 with the reverse acting diaphragm valve 51 controlling the refrigerant flow to the cooling interchanger 46 and the snap relay 65 has its outlet connected by the line 67 with the direct acting diaphragm valve 53 controlling the supply of steam to the heating interchanger 48. Each of the snap relays 63 and 65 employed is one which with its setting will maintain 0 outlet pressure until the inlet pressure rises to a set pressure at which point full 15 pounds air pressure is delivered by the snap relay to its outlet and maintained until its inlet pressure falls below the snap relay setting when 0 pressure is established on its outlet. The two snap relays 63 and 65 are so set that there is an interval between these operations of, say, two pounds pressure so that at no time is steam admitted to the heater interchanger 48 and refrigerant to the cooling interchanger 46, as hereinafter described.

The outlet 61 of the sub-thermostat 37 which actuates the snap relays 63 and 65 and which as explained with the master thermostat 33 controlling its setting is intended to maintain a constant differential between the room temperature and the filtered fresh air in the tempered fresh air chamber 20, also has a branch 68 controlling a reverse acting refrigerant diaphragm valve 69 in one of the branches or divisions of the heating and cooling medium supply line 49. In the other branch of this line 49 is arranged a direct acting diaphragm valve 70 which is also connected to the outlet line 61 of the sub-thermostat 37 by a branch line 71. Whether the heating and cooling medium supply pipe 49 conducts hot or cold liquid to the coils 19 to heat or cool the air in the tempered fresh air chamber 20, depends of course, on the action of the snap relays 63 and 65 and their control of the reverse acting and direct-acting diaphragm valves 51 and 53 which admit, respectively, a cooling medium and steam to the cooling interchanger 46 and the heating interchanger 48. The amount of cooling medium admitted to the coils 19 from the cooling interchanger 46 is, however, determined by the reverse acting diaphragm valve 69 in one branch of the pipe 49 to the coils 19 and the amount of heating medium admitted to the coils 19 from the heating interchanger 48 is determined by the direct acting diaphragm valve 70 in the other branch of the pipe 49 to the coils 19, as hereinafter more fully explained.

The master thermostat 36 has its inlet connected by a line 72 and has its outlet line 73 connected to the sub-thermostat 35 to control the setting of the sub-thermostat 35. Since, as previously explained, the action of a master and sub-thermostat is to maintain a constant temperature differential in the two media in which they are placed, and as the sensitive parts of the master thermostat 36 are responsive to the temperature of filtered fresh air or outside air temperatures and the sensitive parts of the sub-thermostat 35 are responsive to the temperature of the air in the auditorium 8, it is apparent that these two thermostats 36 and 35 are intended to maintain a constant differential between inside and outside temperatures. For this purpose the outlet line 74 of the sub-thermostat 35 is connected to the inlet of an acceleration relay 75, which acceleration relay 75 is supplied with air at 15 pounds pressure from the air pressure supply line 57 by a line 76. The outlet line 77 from this acceleration relay 75 connects with each of the air motors controlling the louvers, these being the motor 32 controlling the louvers 25 in the vent stack 13; the motor 32 controlling the louvers 26 between the recirculation air duct 14 and the mixing chamber 15 and the motor 32 controlling the louvers 27 between the tempered air chamber 20 and the mixing chamber 15. The acceleration relay 75 is designed to vary its outlet pressure in the line 77 more rapidly than the pressure impressed upon its inlet line 74 by the combined action of the master thermostat 36 and the sub-thermostat 35. Such a relay can be adjusted to have equal pressures at its inlet and outlet at any point between 0 and 15 pounds. The acceleration relay 75 employed in this application preferably has a ratio between its inlet and outlet pressures of 1 to 2, respectively. For example, with the acceleration relay 75 set to maintain equal inlet and outlet pressures at 5 pounds, a rise in pressure from 5 to 7 pounds or a two pound rise, on its inlet causes its outlet pressure to rise from 5 to 9 pounds or a 4 pounds rise. Thus the outlet pressure of the acceleration relay 75 rises from 0 to 15 pounds with a rise of from 4 to 11½ on its inlet. The purpose of this acceleration relay 75 is to give a wider range of pressure change on the relay outlet 77 for functioning the motors 32 and at the same time accelerate their action with relation to variations in inlet pressures maintained by the master and sub-thermostats 36 and 35 which control it.

Since, as previously explained, the motors 32 are so arranged that the stack or vent louvers 25 and the fresh air louvers 27 open together and close together to admit and exhaust equal quantities of air to and from the auditorium 8, and since the motors 32 are arranged so that the recirculation air louvers 26 and the fresh air louvers 27 open and close proportionally and in reverse order, it is apparent that the master thermostat 36 and its sub-thermostat 35 through the acceleration relay 75 and the motors 32 maintain a constant differential between inside and outside temperatures by varying the amounts of cold fresh air and relatively warm recirculated air admitted to the auditorium.

It is also apparent that this ratio between inside and outside temperatures, preferably 10° F. lower in the auditorium 8 cannot be maintained at all times, such for example as in winter time. To avoid this the action and feed of air through the sub-thermostat 35 is piloted by the pilot thermostat 34 which is responsive to the temperature in the auditorium.

This pilot thermostat 34 is supplied with air pressure at 15 pounds from the main air pressure supply line 57 by a branch 78 and its outlet 79 forms the sole source of air pressure for the sub-thermostat 35. The pilot thermostat 34 is responsive to the same temperatures as its sub-thermostat 35 and since it controls the entire supply of air pressure to the sub-thermostat 35, when the setting of the master thermostat 36 and the sub-thermostat 35 calls for a temperature below the setting of the pilot thermostat 34 the pilot thermostat 34 causes a falling air pressure to be supplied to the sub-thermostat 35 thus preventing further drop in temperature of the air to which the pilot thermostat 34 and the sub-thermostat 35 are responsive, that is, the temperature of the auditorium. In other words, for example in winter, the action of the master thermostat 36 and its sub-thermostat 35 would be to maintain a temperature of 10° lower in the auditorium 8 than outside by regulation of the amounts of recirculated and cooled fresh air admitted. This condition is not desired, and when such occurs, the pilot thermostat 34 fails to supply sufficient pressure to the sub-thermostat 35 to do this and so takes control of the auditorium air temperature. With such assumed condition of the setting of the master and sub-thermostats 36 and 35 calling for a temperature below that which the pilot thermostat 34 is set to maintain, the valve port control between the inlet and outlet of the sub-thermostat 35 is wide open in the endeavor to maintain high pressure at its outlet because the temperature of the room air is above its setting, this setting being controlled by its master thermostat 36. Therefore with this condition the pilot thermostat 34 takes the control away from the master and sub-thermostats 36 and 35 and is free to control the temperature since its outlet passes directly through the open port of the inoperative sub-thermostat 35. In operation, these three thermostats, the master thermostat 36, the pilot thermostat 34 and the sub-thermostat 35 maintain a constant differential temperature between the master and the sub-thermostat until a desired minimum is reached at which point the pilot thermostat maintains the desired minimum regardless of how much lower temperature the master thermostat 36 and sub-thermostat 35 may tend to maintain.

The line 79 connecting the pilot thermostat 34 with the sub-thermostat 35 is connected by a pressure line 80 with the direct acting diaphragm valve 56 controlling the admission of steam to the heater 21. This results in the heater 21 being under the direct control of the pilot thermostat 34 and since this pilot thermostat is set to maintain a definite minimum room temperature, when it fails to do this through the admission of heated fresh air and recirculated air, it opens the diaphragm valve and admits steam to the heater 21. As all of the air handled by the system goes through this heater 21, the air returned to the auditorium is raised to the temperature to maintain the desired temperature in the auditorium.

The recirculation air by-pass

An open by-pass 81 is provided around the louvers 26 between the recirculation air duct 14 and the mixing chamber 15. The flow of air through this by-pass is fixed whereas that through the recirculated air louvers 26 is variable, as is also the flow through the fresh air louvers 27, said fresh air having an additional resistance opposed to its flow consisting of the filter 17 and the coils 19. When the recirculated air louvers are opening the fresh air louvers 27 are closing and vice versa. The linkage which controls these sets of louvers and the free opening through said louvers and through said filter 17 and coils 19 is so proportioned that there is at all times a constant pressure differential between the pressure in the recirculated air duct 14 and the pressure of the mixing chamber 15 and also a constant pressure differential between the pressure in the intake duct 16 and the pressure in said mixing chamber 15. In other words, as the volume of air passing through the by-pass 81 and through the recirculated air louvers 26 is diminished, the volume of air passing the fresh air louvers 27 is increased (or vice versa) in exact proportion, i. e. the amount of increase caused by a change in position of the one set of louvers is exactly equalled by the amount of decrease caused by the concomitant change in the position of the other set of louvers. This arrangement of relative resistances to the flow of air in these various passages and the open by-pass assures the maintenance at all times and under all operating conditions, that the volume of air delivered to and removed from the auditorium 8 will always remain constant, thus assuring uniform air movement which is essential to human health and comfort, and that the amount of air being constant, the amounts of fresh and recirculated air can be accurately controlled in accordance with the number of people in the enclosure.

Operation

In the following description of the operation the pressures and limits referred to are by way of example only and are not intended to limit the scope of the invention.

Assuming that the fan 22 is operating, fresh air from the outside is drawn through fresh air duct 16, filter 17, filtered air chamber 18, tempering coils 19 which cool or heat the filtered fresh air as the case may be, tempered fresh air chamber 20, past fresh air louvers 27 into the mixing chamber 15. At the same time a part of the air from the auditorium is drawn through the mushroom ventilators 9 in the orchestra floor and balcony into the passages 10 and 11, vertical duct 12, recirculated air duct 14 and through the by-pass 81 and past louvers 26 into the mixing chamber. The mixed tempered fresh air and recirculated air is then drawn through the heater 21, into the fan 22 and is discharged through the duct 23 and openings 24 out into the auditorium 8 at its ceiling. A part of the room air passing into the duct 12 passes upwardly past the vent louvers 25 and vents to the atmosphere.

A supply of refrigerating medium is available in the pipe 50 to supply the cooling interchanger 46 and a supply of steam is available in pipe 52 for the heating interchanger 48 and the heater 21. Air pressure at 15 pounds is also supplied to the pressure supply line 57 and the fan 40 is drawing air from the recirculated air duct 14, through the small duct 39 and past the sensitive parts of the thermostats 33, 34 and 35; from the filtered fresh air chamber 18 through the duct 41 and past the sensitive parts of the thermostat 36; and from the tempered fresh air chamber 20 through the small duct 42 past the sensitive parts of the thermostat 37, these thermostats and their associated relays being mounted on an instrument board 38. Since the air passing through the filtered fresh air chamber 18 is drawn directly from outdoors, it will be assumed that the air drawn through the small duct 41 is the same temperature as outdoors. Likewise since air passing through the recirculation duct 14 is drawn directly from the auditorium 8 it will be assumed that the air drawn through the small duct 39 is at room or auditorium temperature.

At all times, both winter and summer, a constant differential temperature is desired between the air in the auditorium 8 and the air in the tempered fresh air chamber 20, the temperature in this tempered fresh air chamber 20 being always between 15° and 20° F. lower than the temperature in the auditorium 8. This requires that in cold weather the tempering coils act as a heater and in hot weather as a cooler. To obtain these temperatures, the master thermostat 33 which is supplied with air pressure at

15 pounds through its inlet line 58 and is responsive to the temperature of the air in the auditorium 8, controls the setting of the sub-thermostat 37 which is responsive to the temperature of the tempered fresh air in chamber 20. Since both the master thermostat 33 and the sub-thermostat 37 are direct acting and the setting of the sub-thermostat is controlled by the master thermostat, they walk up and down together and maintain a constant differential in the temperature of the air to which they are responsive, say of 15° F. As the temperature rises or falls in the auditorium 8 so as to disturb this constant differential, the setting of the sub-thermostat 37 is raised or lowered an equal amount by the varying air pressure through the line 59 from its master thermostat 33 which is responsive to the temperature in the auditorium 8. If the temperature in the tempered fresh air chamber 20 rises above the differential to be maintained, it rises above the setting of the sub-thermostat 37 and the air pressure on its outlet line 61 rises. The outlet line 61 of the sub-thermostat 37 is directly connected through the lines 62 and 64 with the direct acting snap relays 63 and 65, the outlet lines 66 and 67 of which are connected respectively with the direct acting diaphragm valve 53 which controls the admission of steam to the heater 48 and with the reverse acting diaphragm valve 51 which controls the admission of the cooling medium to the cooling interchanger 46. The outlet line 61 of the sub-thermostat 37 is also connected through the lines 68 and 71 with the reverse acting diaphragm valve 69 which controls the amount of cooling medium admitted to the coils 19 and with the direct acting diaphragm valve 70 which controls the amount of heated medium admitted to these coils. A rising pressure in the outlet line 61 from the sub-thermostat 37, as explained, first opens the snap relay 65 to admit full pressure to its outlet and close the direct acting diaphragm valve 53 to cut off the steam and after an interval of further rise in pressure actuates the snap relay 63 to admit full pressure to the reverse acting diaphragm valve 51 and admit the cooling medium to the cooling interchanger 46. When, therefore, the temperature of the tempered fresh air chamber 20 rises above the constant differential to be maintained between it and the auditorium 8 (the tempered fresh air chamber 20 to be from 15° to 20° lower than the auditorium 8) the temperature in this chamber 20 rises above the setting of the sub-thermostat 37 and raises the air pressure on the outlet line 61. The first effect of this rising temperature is to close the direct acting diaphragm valve 70 and operate the snap relay 65 to admit full pressure to its outlet line 67 and close the direct acting diaphragm valve 53, if it is open. At 6 pounds pressure on the outlet line 61 of the sub-thermostat 37, these direct acting valves 70 and 53 are completely closed and all steam to the heating interchanger 48 is cut off and also the heated liquid from this interchanger is prevented from passing to the coils 19. As the pressure on the sub-thermostat outlet line 61 continues to rise in response to a rising temperature in the tempered fresh air chamber 20 above the differential to be maintained, it reaches 8 pounds at which time the snap relay 63 is opened and full pressure is admitted through supply line 57, snap relay 63, line 66 to the reverse acting diaphragm valve 51 which opens the reverse acting diaphragm valve 51 and admits the cooling medium to the cooling interchanger 46. At the same time this rising pressure in line 61 gradually opens the reverse acting diaphragm valve 69 so as to permit an amount of the cooled liquid from the cooling interchanger 46 to be circulated through the coils 19 by the pump 45. As the pressure in outlet line 61 continues to rise, the pressure on the reverse acting diaphragm valve 69 opens it so as to admit more and more cooled medium from the cooling interchanger 46 to the coils 19 until the desired differential is obtained by the lowering of the temperature in the tempered fresh air chamber 20.

Should, on the other hand, the temperature in the tempered fresh air chamber 20 drop below the ratio desired to be maintained in the auditorium 8 and this chamber, such a condition for example, occurring in winter, the reverse action will take place.

Thus the pressure on the outlet line of sub-thermostat 37 will drop, gradually closing the reverse acting diaphragm valve 69 and cutting off the flow of cooled liquid from the cooler interchanger 46 to the coils 19. When 8 pounds is reached this valve 69 is completely closed and the snap relay 63 is actuated to cut off pressure to the reverse acting diaphragm valve 51 thereby cutting off the flow of cooling medium to the cooling interchanger 46. As the pressure and outlet line 61 continues to drop at 6 pounds it operates the snap relay 65 to cut off pressure to the direct acting diaphragm valve 53 which thereby opens and admits steam to the heating interchanger 48. At the same time the pressure in the outlet line 61 falling below 6 pounds gradually opens the direct acting diaphragm valve 70 to admit the heated liquid from the heating interchanger 48 to the coils 19 which heats the air in the tempered fresh air chamber 20 until the temperature to maintain its desired differential with the air in the auditorium is reached at which point, the sub-thermostat 37 is brought back to its setting (as maintained by the master thermostat 33 which is responsive to the temperature in the auditorium 8) and the fall in pressure in its outlet line 61 is arrested.

It is thus apparent, by having the master thermostat 33 responsive to the temperature of the air in the auditorium and having it control the setting of the sub-thermostat 37 which is responsive to the temperature of the air in the tempered fresh air chamber 20 and further by having this sub-thermostat control the heating and cooling of the air entering the tempered fresh air chamber 20, that a constant differential can be obtained between the temperature of the air in the tempered fresh air chamber 20 and the auditorium 8, both in winter and summer, this differential being preferably a temperature of from 15° to 20° lower in the tempered fresh air chamber 20 than in the auditorium 8.

There remains, therefore, the mixture of a sufficient quantity of the 15° to 20° cooler fresh air from the tempered fresh air chamber 20 with recirculated air to maintain a constant temperature within the auditorium 8 of 10° lower than outside. This is maintained by the master and sub-thermostats 36 and 35 and to prevent the maintenance of this ratio when such a ratio would make the auditorium 8 too cold for human comfort, the pilot thermostat 34 is provided which also controls the heater 21 to insure that the auditorium temperature never drops below a predetermined minimum.

Bearing in mind that the tempered fresh air in the tempered fresh air chamber 20 is always maintained at from 15° to 20° cooler than in the auditorium 8 where people congregate from one to two persons up to capacity, and that the temperature in the recirculation air duct 14 is the same as that in the auditorium 8, it is evident, as long as air is required to be delivered into the auditorium at lower than room temperature to absorb the heat given over by the human bodies etc. that any desired temperature can be maintained by the mixture of proper proportions of recirculated and cooler fresh air in the mixing chamber 15, provided, of course, large enough volumes of the recirculated and fresh air are supplied through the recirculating air duct 14 and the fresh air duct 16.

It is also evident that as the number of occupants in the auditorium increases, an increase in the proportion of cooler fresh air from the tempered fresh air chamber 20 will be required to absorb the heat given off by the increased number of occupants, lights and/or other sources of heat. As the number of occupants in the auditorium 8 increases the temperature of the air delivered into the auditorium 8 must be lower and this lower temperature of the air supplied to the enclosure is obtained exclusively by mixing proportionally less recirculated air from the recirculated air duct 14 with a larger quantity of cooler fresh air from the tempered fresh air chamber 20. Thus, by this system of temperature control and with a proper provision for sufficient quantity of cooler fresh air always at hand, most excellent conditions can be automatically maintained in the auditorium, not only as to temperature but more important still, the conditions as to ventilation will be perfect because the amount of fresh outside air will always increase in proportion to the number of occupants and/or the heat to be absorbed in the auditorium. Furthermore, since the same amount of air delivered into the enclosure is the same at all times, even when nearly all the air is recirculated, and the number of occupants very few, the general air movement in the auditorium is the same, and air movement without objectionable drafts is of great importance to human health and comfort.

The control of temperature in the auditorium is during such conditions (where cooler air is required to absorb heat in the auditorium) is maintained exclusively by the functioning of the fresh, recirculated and exhaust air dampers 27, 26 and 25, respectively. The control of these is effected by the master thermostat 36 which is responsive to the temperature of the outside or fresh air, the sub-thermostat 35 which is responsive to the temperature of the air in the auditorium 8 and which controls the action of the accelerating relay 75 and the pilot thermostat 34 which is responsive to the temperature of the air in the auditorium 8 and controls the supply of air to the sub-thermostat 35 the master thermostat 36 controlling the setting of the sub-thermostat 35.

When the weather outside is warm and the temperature in the recirculation duct 14 is above the setting of the pilot thermostat 34, the air pressure on the outlet line 79 of the pilot thermostat 34 will be high and since this outlet line 79 is connected by the line 80 with the direct acting diaphragm valve 56 controlling the supply of steam to the heater 21, no warming of the air can occur between the mixing chamber 15 and the inlet of the fan 22. Since the air pressure on the outlet line 79 of the pilot thermostat 34 is high and is connected directly with the inlet of the sub-thermostat 35, a supply of air at adequate pressure is supplied to the sub-thermostat 35 and this sub-thermostat 35 is enabled to control the temperature in the auditorium 8 as follows:

When the temperature in the recirculation air duct 14 and auditorium 8 begins to warm up due to additional occupants entering the auditorium 8, this air is drawn through the duct 39 and past the sensitive parts of the sub-thermostat 35 so that the air pressure on its outlet line 74 will begin to increase. The line 74 is connected to the accelerating relay 75 which is supplied with pressure by line 76 and for every pound rise in pressure in line 74, the relay outlet pressure in line 77 rises two pounds. This rising pressure in the relay outlet line 77 is impressed on all three of the diaphragm motors 32. This rising air pressure in the relay outlet line 77 causes the exhaust dampers 25 and fresh air louvers or dampers 27 to be gradually opened by their respective motors 32 and at the same time the recirculation louvers or dampers 26 are proportionately closed by its motor 32. Since the tempered fresh air from the tempered fresh air chamber 20 is always from 15° to 20° cooler than that in the recirculation air duct 14 and the auditorium 8, drawing proportionately more of this cooler fresh air from the chamber 20 and less of the warm recirculated air from the auditorium 8 cools the air in the auditorium 8 and prevents its temperature from rising above the setting of the sub-thermostat 35. This action continues as more people enter the auditorium 8 until the fresh air and exhaust louvers 25 and 27 are wide open and the recirculation louvers 26 are closed, under which condition the full amount of cooled fresh air is supplied and needed to maintain the proper temperature and ventilation in the auditorium 8 when it is occupied by people to its full capacity.

As the number of occupants decreases, the opposite action takes place until the auditorium 8 is unoccupied when barely enough cool fresh air is supplied, with the balance of the air supplied by recirculated air, to keep the auditorium 8 at the desired temperature. Thus at all times the auditorium 8 is maintained at the proper temperature whether empty, partially or fully occupied. Also the amount of fresh air supplied from the outside is always proportional to the number of people or heat to be absorbed in the auditorium 8 thus assuring continuous perfect ventilation regardless of the number of people in the auditorium 8.

As previously stated, the setting of the sub-thermostat 35 is controlled by the master thermostat 36 which is responsive to the temperature of the outside air. As the temperature outside rises, the master thermostat 36 admits higher air pressure to its outlet line 73 and this raises the setting of the sub-thermostat 35. This raising of the setting of the sub-thermostat 35 permits the auditorium 8 to have a higher temperature before the sub-thermostat 35 acts to admit a greater proportion of cooler fresh air to cool the auditorium 8 down and therefore it is apparent that a differential is always obtained between the temperature of the air in the auditorium 8 and the outside temperature. The master thermostat 36 and the sub-thermostat 35 are preferably so adjusted that the temperature of the air in the auditorium is maintained approximately 10° cooler than the outside air temperature.

It is apparent, however, that this temperature differential cannot be maintained when it is so cool outside that 10° lower in the auditorium 8 would be uncomfortable. However, when the temperature of the auditorium 8 falls under these conditions, as soon as it reaches the setting of the pilot thermostat 34, his thermostat begins to function. When the temperature in the auditorium drops below the setting of the pilot thermostat 34, the pressure on its outlet line 79 drops and since the sub-thermostat 35 is wide open in an endeavor to obtain still cooler temperature conditions in the auditorium 8, the pilot thermostat 34 acts directly through the sub-thermostat 35 and takes over the control of the proportionate amounts of fresh air and recirculated air to be admitted, the sub-thermostat 35 under such conditions being wholly inoperative and merely serving as a conduit by which the pilot thermostat 34 controls the amounts of cool fresh air and warm recirculated air to be admitted. Thus, in the winter time for example, instead of permitting the master and sub-thermostat combination 36 and 35 to maintain the auditorium approximately 10° cooler than outside, the pilot thermostat 34 with the temperature of the auditorium having fallen to its setting, diminishes the pressure supplied to the sub-thermostat 35 and since the sub-thermostat 35 is wide open in a vain endeavor to obtain cooler conditions in the auditorium, the pilot thermostat 34 acts through and takes over the control of the dampers or louvers 25, 26 and 27. As the temperature in the auditorium 8 falls, the pilot thermostat 34, so acting, reduces the pressure on its outlet line 79 which through the wide open and inoperative sub-thermostat 35, its outlet line 74 and direct acting accelerating relay 75, reduces the pressure in the relay outlet line 77, gradually closes the fresh air and exhaust air louvers 27 and 25 and proportionally opens the recirculated air louvers 26. Thus a smaller proportion of fresh air (which is still maintained at from 15° to 20° cooler than the auditorium 8 through the action of the master and sub-thermostat combination 33 and 37 and the, now, heater 19) is admitted as the temperature in the auditorium 8 falls and there is consequently less cooling of the air admitted to the auditorium.

After the temperature in the auditorium 8 has fallen below the setting of the sub-thermostat 34, it is necessary for the air admitted to the auditorium to be heated to insure comfortable conditions. Following the action of the pilot thermostat 34 in cutting down the relative amount of cool fresh air supplied, the falling pressure in the pilot thermostat outlet line 79, through the line 80, reduces the pressure on the direct acting diaphragm valve 56 and permits this valve to open and admit steam to the heater 21 which warms up the air admitted to the auditorium. As the temperature in the auditorium 8 continues to drop, the pressure on the pilot thermostat outlet lines 79 and 80 drops further thereby opening up the direct acting diaphragm valve 56 further and further and maintaining the desired minimum temperature in the room. In this way the desired minimum room temperature is maintained while fresh air is still supplied.

The action of the pilot thermostat 34 is such that an excessive amount of fresh air is not admitted while the heater 21 is operating, which condition would require an excessive amount of heat. When the temperature in the auditorium falls to a point where the pilot thermostat 34 begins to function, in reducing the pressure on its outlet line 79, there will be a drop in pressure of about 1 pound between this line, which also forms the inlet for the sub-thermostat 35 and the sub-thermostat outlet line 74, this drop occurring by reason of the friction to the passage of air through the open port of the sub-thermostat 35. The pressure in the outlet line 74 of the sub-thermostat 35 is always 1 pound below the pressure in the outlet line of the pilot thermostat 34, when this pilot thermostat takes control. The dampers or louvers are operated by the outlet line pressure of the accelerating relay 75 and being an accelerating relay the maximum of fresh air and the minimum of recirculated air is supplied to the auditorium when the relay 75 outlet pressure is 12 pounds, with a corresponding pressure of 8½ pounds on the sub-thermostat 35 outlet line 74 and 9½ pounds on the outlet line 79 of the pilot thermostat 34. As the temperature in the auditorium falls, the fresh air and exhaust air dampers 27 and 25 begin to close and the recirculation dampers to open and reach their limit of travel at 3 pounds pressure on the outlet 77 of the relay 75 or at 5 pounds pressure on the outlets 79 and 80 of the pilot thermostat 34. At 6 pounds pressure on the outlets 79 and 80 of the pilot thermostat 34, the steam valve 56 begins to open and prevent the auditorium temperature from falling. This entire change from maximum fresh air and with no steam in the heater 21 to minimum of fresh air and maximum of steam in the heater 21 occurs with a change of approximately 2° drop in temperature in the auditorium 8. The opposite, of course, occurs on rising temperature in the auditorium 8. Within an auditorium the amount of heat generated by the large number of people and the lights is so much in excess of the amount gained or lost through the building walls in winter or summer that outside weather conditions will not materially affect the control. Should the loss through the building walls in extreme winter weather tend to delay or prevent an adequate supply of fresh air for proper ventilation, this condition can be compensated for by changing the adjustment of the master thermostat 33 and sub-thermostat 37 to carry less differential in temperature between the fresh and recirculated air passages.

As previously stated, the free area for the passage of recirculated air through the louvers 26 is such that the friction to the flow of air through them is equal approximately to the resistance or friction to the flow of fresh air through the filter 17, coils 19 and dampers 27, both with equal quantities of air. Also the cross sectional area for the flow of recirculated air through the by-pass 81 is such as to impose a resistance equal to that through each of the recirculation dampers 26, the filter 17, coils 19 and fresh air louvers 27. The friction to the flow of air through the exhaust louvers 25 should be negligible as there is sufficient friction to the flow of air from the auditorium 8 into the recirculation and exhaust duct 12 to maintain the desired positive pressure in the auditorium with relation to the outside air.

By this arrangement the static pressure in the recirculation and exhaust air duct 12 and the mixing chamber 15 will always be constant (though not equal) and the fan 22 will therefore always handle the same volume of air at the same speed. Furthermore, the same total volume of air will always flow through the fresh air and recirculation dampers or louvers 27 and 26. Also the desired minimum of recirculation air can be obtained by making the by-pass 81 of a corresponding size, but for any desired minimum of recirculated air, its area must always be such as to impose a resistance to the flow of air which is at all times equal to that of the inflow of fresh air and the inflow of recirculated air through the louvers 26 to the mixing chamber 15. This arrangement of relative resistances to the flow of air in these various passages, viz. the dampers 27, 26 and 25 and open by-pass 81 assures that at all times and under all operating conditions the following desirable objects be obtained:

(1) The volume of air delivered to and removed from the auditorium will always remain constant thus assuring uniform air movement which is essential to human health and comfort.

(2) By the automatic control of the relative proportions of fresh and recirculated air, the combined amount always being constant, but the proportion between the two being determined by the number of people occupying the auditorium 8; the greater the number of people in the auditorium the larger proportion of fresh air drawn from the outside through the fresh air duct 16.

It will be understood that the invention has been illustrated and described in a diagrammatic form and that the temperatures and pressures stated are by way of example. It will, therefore, be understood that the embodiment of my invention can be varied widely as to form without departing from the spirit of my invention and that additions, such as separate exhaust fans and the like can be added. It will also be appreciated that should humidification be desired, humidifying sprays could be put in the mixing chamber 15, these being controlled by a diaphragm valve which is in turn controlled by a hygrostat responsive to the conditions of humidity in the auditorium 8, and that air washing devices can also be embodied in the system.

From the foregoing description it will be apparent that the present invention provides, a cooling and ventilating system which at all times maintains the desired temperature in an enclosure and supplies especially during the summer time an adequate supply of fresh air in accordance with and proportionate to the number of people in the enclosure. It also provides a continuous circulation of a large volume of air through the auditorium, this being constant at all times and being in an amount desirable for comfort regardless of the number of people in the enclosure. The temperature control is also fully automatic, the temperature within the auditorium is always a definite number of degrees cooler than outside during hot weather, and when the weather becomes cold, the means for automatically obtaining this differential are rendered inoperative and the temperature control taken over by a pilot thermostat which insures a minimum temperature and at the same time a proper amount of fresh air. The control thermostats, relays etc. are also all conveniently located on a central instrument board which can be placed at any convenient place, and the fresh air, tempered fresh air and enclosure air, to the temperatures of which the several thermostats respond, are brought with relatively high velocity past their sensitive parts to insure their prompt response. The system, as described is also comparatively simple in construction, and it will function reliably for a long period of time without getting out of order or requiring adjustment.

I claim as my invention:

1. In an apparatus for ventilating an enclosure, means for admitting fresh air, means for tempering said fresh air, thermostat means responsive to the temperature of said tempered fresh air and the temperature of the air in said enclosure and controlling the admission of the tempering medium to said tempering means to obtain a predetermined differential between the temperature of the tempered fresh air and the air in said enclosure, and thermostat means responsive to the temperature of the air in said enclosure for admitting varying quantities of said tempered fresh air into said enclosure.

2. In an apparatus for ventilating an enclosure, means for admitting fresh air, means for tempering said fresh air, thermostat means responsive to the temperature of said tempered fresh air and the temperature of the air in the enclosure for controlling the admission of the tempering medium to said tempering means to obtain a predetermined differential between the temperature of the tempered fresh air and the air in said enclosure, means for mixing said fresh air with recirculated enclosure air, means for returning said mixed air to said enclosure and thermostat means responsive to the temperature of the air in said enclosure for varying the proportionate amounts of tempered fresh air and recirculated air admitted to said enclosure.

3. In an apparatus for ventilating an enclosure in which people congregate, means for withdrawing air from said enclosure, enclosed cooling coils, means for passing fresh air through said cooling coils, means for passing a cooling medium through the interior of said coils at an entering temperature below the dewpoint of the fresh air and warmed therein to a temperature above said dewpoint, thermostat means responsive to the dry bulb temperature of the air in said enclosure for controlling the velocity of the cooling medium through said cooling coils, means for mixing said cooled fresh air with the air withdrawn from said enclosure and delivering said mixed air to said enclosure and means for varying under all operating conditions the proportions of the cooled fresh air in the mixture in accordance with the changes in the temperature of the air in the enclosure.

4. In an apparatus for ventilating a room, means for withdrawing air from the room, means for admitting fresh air, a cooling coil in the path of said fresh air, means responsive to the dry bulb temperature of the air in said room for regulating the velocity of cooling medium through said coil, means for mixing the cool fresh air with the withdrawn air, means for returning the mixed air to the room and adjusting means responsive to the dry bulb temperature in the room for varying the proportions of cool fresh air and withdrawn air returned to said room to vary the temperature of said enclosure.

5. In an apparatus for ventilating an enclosure, an air chamber, means for tempering the air passing through said chamber, means for admitting the air from said chamber to said enclosure, a thermostat responsive to the temperature of said tempered air, a thermostat responsive to the temperature of the air in said enclosure, one of said thermostats being a sub-thermostat controlling the means for tempering the tempered air and the other being a master-thermostat controlling the setting of said sub-thermostat whereby a constant differential is maintained between

the temperature of the air in said enclosure and said tempered air.

6. In an apparatus for ventilating an enclosure, means for admitting fresh air to said enclosure, means for tempering said admitted air, means for maintaining a constant differential between the temperature of the air in said enclosure and the outside air, comprising a thermostat responsive to the temperature of the outside air and a thermostat responsive to the temperature of the air in said room, one of said thermostats being a sub-thermostat controlling the tempering of said fresh air and the other being a master thermostat controlling the setting of said sub-thermostat and means for preventing the temperature of the room from falling below a predetermined minimum temperature comprising a thermostat responsive to the temperature of the air in said room and rendering inoperative said sub-thermostat and controlling the tempering of the admitted air when the enclosure temperature drops below its setting.

7. In an apparatus for ventilating an enclosure, means for admitting fresh air, means for tempering said admitted fresh air, a pneumatic thermostat responsive to the temperature of the outside air, a pneumatic thermostat responsive to the temperature of the air in said enclosure, one of said thermostats being a sub-thermostat controlling the tempering of said admitted air and the other being a master-thermostat controlling the setting of said sub-thermostat whereby a constant differential is maintained between the temperature of the air in said enclosure and the outside air, and a pneumatic controlling thermostat responsive to the temperature of the air in said enclosure and controlling the outlet pressure of said sub-thermostat, said controlling thermostat acting through the open sub-thermostat to control the tempering of said admitted air when the temperature of the air in said enclosure drops to the setting of said controlling thermostat thereby to maintain a minimum temperature of the air in said enclosure.

8. In an apparatus for ventilating an enclosure, means for admitting fresh air, means for tempering the fresh air, means for mixing said fresh air with recirculated air withdrawn from the enclosure, means for admitting said mixed air to said enclosure, a thermostat responsive to the temperature of the outside air, a thermostat responsive to the temperature of the air in said enclosure, one of said thermostats being a sub-thermostat controlling the mixture of tempered fresh air and recirculated air and the other being a master thermostat controlling the setting of said sub-thermostat whereby said thermostats, in combination, maintain a constant differential between the temperature of the air in the enclosure and the outside air and a pilot thermostat responsive to the temperature of the air in said enclosure and controlling the supply of pressure to said sub-thermostat whereby when the temperature of the air in said enclosure drops to the setting of said master thermostat, said master thermostat acts through said sub-thermostat to control the proportions of fresh and recirculated air in said mixture and thereby maintain a minimum temperature in said room.

9. In an apparatus for ventilating an enclosure, means for admitting fresh air, means for tempering the fresh air, means for mixing the fresh air with recirculated air from said enclosure, means for tempering the mixed air, means for admitting the mixed air to said enclosure, a pneumatic thermostat responsive to the temperature of the outside air, a pneumatic thermostat responsive to the temperature of the air in the enclosure, one of said thermostats being a sub-thermostat controlling the relative amounts of tempered fresh air and recirculated air in said mixture and the other being a master thermostat controlling the setting of said sub-thermostat whereby said thermostats, in combination, maintain a constant differential between the temperature of the air in the enclosure and the outside air and a pilot thermostat responsive to the temperature of the air in said enclosure and controlling the supply of pressure to said sub-thermostat whereby when the temperature of the air in said enclosure drops to the setting of the pilot thermostat, the pilot thermostat acts through said sub-thermostat to control the proportions of fresh and re-circulated air in said mixture and said pilot thermostat also controlling the tempering of the mixed air at enclosure temperatures at or below its setting whereby said pilot thermostat maintains a predetermined minimum temperature in said enclosure.

10. In an apparatus for ventilating an enclosure, means for admitting fresh air, means for tempering the fresh air, means for controlling said tempering means to maintain a constant differential in temperature between the tempered fresh air and the air in the enclosure, means for mixing the fresh air with recirculated air from said enclosure, means for tempering the mixed air, means for admitting the mixed air to said enclosure, a pneumatic thermostat responsive to the temperature of the outside air, a pneumatic thermostat responsive to the temperature of the air in the enclosure, one of said thermostats being a sub-thermostat controlling the relative amounts of tempered fresh air and recirculated air in said mixture and the other being a master thermostat controlling the setting of said sub-thermostat whereby said thermostats, in combination, maintain a constant differential between the temperature of the air in the enclosure and the outside air and a pilot thermostat responsive to the temperature of the air in said enclosure and controlling the supply of pressure to said sub-thermostat whereby when the temperature of the air in said enclosure drops to the setting of the pilot thermostat, the pilot thermostat acts through said sub-thermostat to control the proportions of fresh and recirculated air in said mixture and said pilot thermostat also controlling the tempering of the mixed air at enclosure temperatures at or below its setting whereby said pilot thermostat maintains a predetermined minimum temperature in said enclosure.

11. In an apparatus for ventilating an enclosure, a mixing chamber, means for admitting fresh air to said chamber, means for admitting recirculated air to said chamber, damper means for controlling the amount of fresh air admitted to said chamber, damper means controlling the amount of recirculated air admitted to said chamber, means for opening and closing both of said damper means in reverse order to vary the proportion of fresh and recirculated air admitted to said chamber, means for withdrawing the mixed air from said chamber to said enclosure, a by-pass around said recirculated air damper means, the resistance to the flow of recirculated air through said by-pass being approximately equal to the resistance to the flow of both the fresh and recirculated air into said mix-

ing chamber, whereby a substantially constant volume of air is admitted to said mixing chamber in all positions of said damper means and means for discharging the mixed air from said chamber to said enclosure.

12. In an apparatus for ventilating an enclosure, a mixing chamber, means for admitting fresh air to said chamber, means for admitting recirculated air to said chamber, damper means for controlling the amount of fresh air admitted to said chamber, damper means controlling the amount of recirculated air admitted to said chamber, means for opening and closing both of said damper means in reverse order to vary the proportion of fresh and recirculated air admitted to said chamber, means for withdrawing the mixed air from said chamber to said enclosure, a by-pass around said recirculated air damper means, the free area for the passage of air through the recirculation damper means being such that the friction to the flow of air through the same, when open, is equal approximately to the resistance to the flow of fresh air into said chamber when the fresh air damper means are open and the resistance to the flow of recirculated air through said by-pass being approximately equal to the resistance to the flow of both the fresh and recirculated air into said mixing chamber, whereby a substantially constant volume of air is admitted to said mixing chamber in all positions of said damper means, and means for discharging the mixed air from said chamber to said enclosure.

13. In an apparatus for ventilating an enclosure, a mixing chamber, means for admitting fresh air to said chamber, means for admitting recirculated air to said chamber, damper means for controlling the amount of fresh air admitted to said chamber, damper means controlling the amount of recirculated air admitted to said chamber, means for opening and closing both of said damper means in reverse order to vary the proportion of fresh and recirculated air admitted to said chamber, means for withdrawing the mixed air from said chamber to said enclosure, a by-pass around said recirculated air damper means, the free area for the passage of air through the recirculation damper means being such that the friction to the flow of air through the same, when open, is equal approximately to the resistance to the flow of fresh air into said chamber when the fresh air damper means are open and the resistance to the flow of recirculated air through said by-pass being approximately equal to the resistance to the flow of both the fresh and recirculated air into said mixing chamber, whereby a substantially constant volume of air is admitted to said mixing chamber in all positions of said damper means, means for discharging the mixed air from said chamber to said enclosure and means for exhausting the amount of air from said enclosure substantially equal to the amount of fresh air admitted to said chamber.

14. The method of ventilating an enclosure which includes withdrawing air from said enclosure, cooling fresh air before mixture with the air in the enclosure to obtain a constant differential between its temperature and the temperature of the air in the enclosure, mixing said cooled fresh air with the air withdrawn from the enclosure and delivering the mixed air to the enclosure and varying the proportions of fresh air in the mixture under all conditions of operation in accordance with changes in the dry-bulb temperature in the enclosure.

15. In an apparatus for ventilating an enclosure, means for withdrawing air from said enclosure, means for mixing fresh air with said withdrawn enclosure air, cooling coils in the path of a part of the air handled, means for passing a cooling medium through the interior of said coils at an entering temperature lower than the dewpoint of said part of the air handled, means for returning the cooled mixed air to said enclosure and thermostat means responsive to the dry-bulb temperature of the outside air and the air in said enclosure to vary the volume of flow of said cooling medium through said cooling coils to obtain a predetermined differential between the temperature of the air in the enclosure and the outside fresh air and to effect a proportional adjustment of the relative humidity in the room.

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