METHOD OF AND APPARATUS FOR AIR CONDITIONING

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METHOD OF AND APPARATUS FOR AIR CONDITIONING

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The present invention relates in general to air conditioning and is concerned more particularly with an improved method and apparatus for conditioning the air of rooms in buildings where it is possible to maintain an agreeable and wholesome atmosphere under varying weather conditions and the effects of occupancy.

The present invention further contemplates improvements in the heating and ventilating method and apparatus constituting the subject matter of my United States Letters Patent No. 1,913,681, whereby the same may be utilized to greater advantage over a wider range of conditions and other desirable advantages and features accomplished in general in air conditioning systems.

The above-mentioned patent states: "Under the climatic conditions prevailing over the greater part of the United States and in many other countries, outdoor air may be satisfactorily used for cooling and is the principal medium employed in this invention. In schools and other crowded spaces to which my invention is particularly adaptable, the independent heating effect of occupancy usually tends to create an indoor temperature considerably higher than the outdoor temperature, and artificial cooling may be effected by introducing and diffusing outside air in the space concerned. As will readily be appreciated by those skilled in the art, the outdoor air introduced may be precooled, washed or otherwise treated, if desired, before entering the distributing apparatus illustrated, without affecting the method of this invention."

It is therefore evident that at the time I applied for this patent I foresaw further utility of the method thereof, through the use of precondi tioned air, and as will hereinafter appear, have now devised a method and means for providing precondi tioned air in such a way as to extend the utility of the method and apparatus of my above patent to year-round service under all weather conditions in a much more efficient and practical manner than heretofore employed.

The pronounced advantage of Patent No. 1,913,681 lies in graduation of the outdoor air supply according to the actual duty imposed in maintaining a fixed thermal status of the air in the space served. A saving of more than fifty percent in fuel consumption, over earlier conventional practice, was thus made possible in certain classes of heating and ventilating work such, for example, as in the large and important schoolhouse field where it is now in general use. The potency of this feature in this particular is limited to the heating season, but were this its only advantage, the benefit during this period would, of course, be of great value in year-round service.

However, this feature has other advantages which are effective in summer as well as in winter conditioning service, and which take on an added value in year-round service. One of these is that gradual and two parts of air recirculated room air and cooler fresh air affords a simple, effective and reliable method of regulating the room temperature; and it is one which averts the danger of waste incurred by other methods through adverse functioning of the heating and cooling means in the transitional stage between heating and cooling duty. Another advantage lies in better humidity regulation throughout the year.

As pointed out in my earlier patent, the method thereof provides very little fresh air in cold weather, but increases the supply as the weather moderates. Since the moisture bearing capacity of air is limited by its temperature, it follows that air normally contains much less moisture in cold weather than in mild or warm weather. Hence, in cold weather, when the room air would otherwise tend to be quite dry, the moisture content is allowed to build up under the effects of occupancy, because little fresh air is circulated, whereas in mild weather, when the air naturally contains sufficient moisture, the effect of occupancy is nullified by circulating a comparatively large quantity of fresh air. In this way the room humidity is kept within satisfactory limits throughout the heating season. And, where precooled air is used for summer conditioning, this feature is of special value in guarding against excessive humidity. To illustrate, suppose the apparatus be designed to maintain a room temperature of 80° F. in warm weather, in a room where the circulation rate is 30 cu. ft. per minute per occupant and the duty requires that the air be introduced at 60° F. If all the air introduced were preconditioned to 60° F., the relative humidity of the room would rise to 55%; but, if a mixture of one part recirculated air at 80° F. and two parts preconditioned to 50° F. be used to obtain the required 60° F. mean, the relative humidity would be reduced to 42½%, which is a much better level. Moreover, under this method, the relative humidity will not vary so much under different load conditions and will be more in line with that maintained during the heating season.

While the present invention broadens the utili-
ity of my patented method by providing improved means for supplying precooled air in accordance with the requirements of said method, for summer cooling and year-around service, it also constitutes an improvement in heating and ventilating (winter) service. A common difficulty in thermally conditioning rooms, under the normal range of weather conditions prevailing in the greater part of the country during the late fall, winter, and early spring, is that apparatus of a capacity to meet severe conditions is hard to regulate smoothly in average and mild weather; and failure to do so is liable to result in drafty room conditions. Through the present invention, the work is divided into steps which serve to overcome this difficulty.

Although the present invention is in the main directed to improvements in the method and apparatus of my United States Letters Patent No. 1,913,681, it is to be understood that I do not propose to thus limit its application, since it will be appreciated by those skilled in the art that the invention is susceptible of wide and general use.

Other objects and features of the invention will more fully appear from the following detailed description taken in connection with the accompanying drawings, which illustrate a preferred embodiment thereof, and in which:

Figure 1 is a combined vertical sectional view through a building floor and diagrammatically representing the arrangement of the apparatus of the present invention for carrying out my improved method of conditioning the room thereof; and

Figure 2 is an enlarged vertical sectional view taken through an individual room-conditioning unit of a type adapted for utilization in connection with the present invention.

As shown on the drawings:

As shown in Figure 1, a room 1 is equipped with means consisting, in this instance, of a room-conditioning unit 2, itself adapted, and so controlled by a room thermostat 3 as to carry out the method described and explained in my United States Letters Patent No. 1,913,681. It is to be noted, however, that whereas it has heretofore been customary to locate the room-conditioning unit on an outside wall of the room, and to take the required fresh air supply directly from outdoors through an opening in the wall, it will usually be found expedient, in the present instance, to locate the unit on an inner partition and to connect an immersed branch conduit 4 adapted to supply preconditioned air. But, as will be understood by those skilled in the art, the location of the room-conditioning unit and the arrangement of the preconditioned air conduits will vary with circumstances and with the particular form of apparatus used.

Room-conditioning units of various constructions may be utilized to carry out the method, one suitable construction being shown in Figure 2. In this case, the unit consists of a suitable cabinet 5 adapted to be set on the floor, against a wall of the room served, this cabinet being provided with a fresh air inlet 6, a recirculating air inlet 7 and an air discharge outlet 8. The branch conduit 4 is connected to the fresh air inlet 6 to supply preconditioned air in the volumes required and at a sufficiently low temperature to take care of the maximum cooling duty. The recirculated air inlet 7 and the discharge outlet 8 communicate with the room or space served. It is preferred that these communicate with the room directly, or as freely as possible, and that the outlet 8 be arranged to deliver the air into the room in the form of a substantially vertical jet with sufficient force to carry to the ceiling. The cabinet contains a motor driven fan 9, for drawing air through the inlets and communicating it through the outlet. The cabinet is also equipped with a radiator 10 for heating the air drawn through it, and with a filter 11 for cleaning the air. The arrangement is such that only the air drawn through the recirculating air inlet 7 is heated, but all of the air is filtered. However, it is to be understood that filtration is not essential to the method. Dampers 12 and 13 regulate the flow of air through the inlets 6 and 7, respectively, and are so linked together that one closes as the other opens, as associated air passage. A valve (not shown) controls the flow of steam to the radiator. The thermostat 3 controls the operation of the dampers 12 and 13 together with the radiator valve, in a manner and through mechanism well known in the art, so that on a rising room temperature within a selected range the fresh air damper 12 is held closed (or to a fixed minimum setting), and the recirculated air damper 13 is held open while the damper control valve is gradually throttled through the lower portion of its travel, after which the fresh air damper is gradually opened while the recirculated air damper is correspondingly closed. On a falling room temperature within said range, the operation is reversed. Of course, in either phase of the cycle, the room temperature, and hence the control mechanism, comes to rest whenever equilibrium is established between duty and output. As explained in Patent No. 1,913,681, certain modifications of the above-described cycle of control may be employed, but this will suffice to illustrate the principle of the method.

The effect of the patent method is to maintain an approximately uniform temperature in the room under varying weather conditions and the effects of occupancy. In cold weather, the heat gains due to occupancy, sunshine, etc., are usually more than offset by heat losses through the outer walls, hence, the room temperature tends to fall and will be brought to rest at some point within the lower portion of the control range, where the fresh air supply is reduced to a minimum and the radiator control valve is open to supply enough heat to make up the deficit between the natural gains and losses. On the other hand, when conditions are such that the natural gains exceed the losses, the temperature would tend to rise and must be brought to rest in the upper portion of the control range, where the radiator control valve is shut and the dampers 12 and 13 are adjusted to recirculate less air and admit enough fresh air to neutralize the excess heat gain.

Notwithstanding outdoor temperature is the primary factor in determining the duty on the system, it is not controlling. In many instances occupancy and sunshine impose a substantial cooling duty in comparatively cold weather. Throughout a large portion of the year, circumstances permit of a wide range in cooling duty, and then, in the quantity of fresh air required. Where this air is drawn directly from the atmosphere, the problem 2, no problem is involved in connection with the supply. But, where the supply must be drawn in varying amounts from a limited source such as a separate preconditioning station, a problem is introduced.
In regulating the available supply according to the demand. The present invention is directed to a solution of this problem. In certain instances it is feasible to equip each individual room-conditioning unit with additional pre-conditioning means, thus avoiding the problem cited, but in other cases it is not practicable, and it is rarely as satisfactory as providing the various units of the group with pre-conditioned air from a central station. While, in the ultimate service of conditioning the rooms themselves, the unit is superior and peculiarly adapted to carry out the method of my Patent No. 1,913,681, a central distributing system has many practical advantages in the pre-paration or pre-conditioning of air for room-condi- tioning purposes, particularly where this involves pre-cooling. The mere addition of a cooling coil in the type of room-conditioning unit shown in Figure 2 would not be especially difficult. As a matter of fact, the same radiator could be made to serve either heating or cooling by employ-ing water as a circulating medium and heating or cooling the water as required. However, the adaptation of apparatus of this character to summer service is not so simply accomplished. A study of the regulating mechanism will indicate that it is not suitable for a radiator functioning in a cooling capacity. In order, therefore, to adapt room-conditioning units of the type required to carry out the aforesaid method in summer service, it would be necessary to locate the pre-cooling coil outside the port controlled by the damper 12 and provide additional thermo-static regulation. In addition to greatly increasing the cost, this would materially increase the size of the units, which is itself often objectionable, and would make the units much harder to control and service. Another objection to such an arrangement would be that the piping of the units for double service is complicated, unsightly and costly. Moreover, artificial cooling involves dehumidification, and this brings up a sanitary drainage problem that is not easily disposed of.

The present invention provides an arrange-ment wherein the simple unit system of my earlier patent, with its manifold advantages, is used for conditioning the rooms themselves, while a central plant is employed to properly prepare or precondition the air supplied, as required, to the room-conditioning units. In other words, the amount of fresh air required to maintain an optimum condition in each room, under varying weather and occupancy conditions, is regulated and circulated by the room-conditioning units 2, while the aggregate amount demanded is prepared and distributed as required, by a central pre-conditioning plant. Referring again to Figure 2, each room-conditioning unit 2 is supplied with properly pre-conditioned air, according to its needs, through a branch duct 4 from a trunk duct or distributing chamber 14 into and through which the pre-conditioned air is forced by a fan or blower 15. The fan is, of course, driven by an electric motor or other suitable means and draws its supply of air from a pre-conditioning chamber 16 through a suction conduit or pas-sage 17.

The pre-conditioning chamber 16, which may be in any suitable form and construction is provided with a heating element 18, and/or cooling element 19 which serve to subdivide the chamber into a receiving compartment 20 and a delivery compartment 21. The suction passage 17 to the fan 15 communicates with the delivery compart-
lected control range, the thermostat 27 acts to maintain the dampers 24 and 25 in whatever intermediate position the dampers may be.

A leakstat or similar limiting device 28 responsive to outdoor temperature and set to function at a point representative of the indoor supply source temperature, is utilized to render the thermostat 27 ineffective and allow the outdoor dampers 24 to close while the indoor damper 25 to open whenever the outdoor temperature exceeds that at the indoor supply source. In this way, the refrigeration load will be kept to a minimum.

The air-heating element 18 and the air-cooling element 19 are indicated diagrammatically and may be of various forms well known in the art. For the purpose of explaining the invention, it will be assumed that the heating element 18 consists of the usual steam radiator and that the cooling element 19 is a radiator or coil adapted to the use of a suitable refrigerating agent, such as ammonia, freon, etc. It will also be further assumed that the necessary equipment is provided to render these elements serviceable in their respective capacities, all of which is well understood in the art. It will be understood that both elements are only necessary for year-round service, and that either may be omitted or the two functions combined in one element without affecting the broader phases of the invention. On the other hand, humidifiers, filters, atomizers or other preconditioning devices may be added, if desired.

Valves 29 and 30 or other suitable means are provided to control the respective heating and cooling elements. These valves may be regulated through suitable thermostatic means 31 placed in the delivery compartment 21 or other appropriate point to maintain a limited range of temperature of the preconditioned air. For example, with the pneumatic system of control, an intermediate, direct-acting thermostat 31 may be used to control a direct-acting steam valve 29 and a reverse-acting refrigerant valve 30 so that, at the lower limit of the control range, the steam valve will be wide open while the refrigerant valve will be closed; and so that, as the temperature of the preconditioned air rises above said lower limit, the steam valve will gradually close up to some selected point within the range where it will be fully closed; and so that when the temperature of the preconditioned air exceeds said selected point, either critically or by some arbitrary margin, the refrigerant valve will gradually open until the temperature rise is halted.

A by-pass duct or passage 32 affords communication between the air passages on the suction and delivery sides of the fan.

In the arrangement shown, which is commonly known as a "draw-through" arrangement for the reason that the air is drawn rather than forced through the conditioning chamber, the by-pass is preferably connected between the trunk duct 14 and the receiving compartment 20. As will be understood by those skilled in the art, a so-called "blow-through" arrangement might be substituted, wherein the intake duct 22 would connect with the suction inlet of the fan 15 instead of with the receiving compartment 20, the suction duct 17 in this case being omitted and the fan 15 arranged to discharge into the receiving compartment. With such an arrangement, the trunk duct 14 would merely become an extension of the delivery compartment 21 or it might be omitted, and the branch ducts 4 extended separately from the delivery compartment. In the latter case, the by-pass 32 will connect the intake passage 22 with the trunk duct 14 or delivery compartment 21.

The by-pass 32 is preferably provided with a damper 33 which may be regulated so as to maintain a uniform pressure in the trunk duct 14 through the agency of a static pressure regulator 34. Under a maximum demand for pre-conditioned air to supply the various room-compartments, the damper 33 will close the damper; but, as the demand falls off from the static pressure will tend to rise and cause the regulator to gradually open the damper 33 until the tendency ceases. In this way, a constant pressure of properly pre-conditioned air is made available to meet the varying demands of the room-conditioning units at all times. The pressure regulator 34 and even the damper 33 may be omitted with fair satisfactory results where the distributing system is not too complicated and is well proportioned; but, in such cases, the by-pass 32 should be taken from a point near the far end of the trunk duct 14. The by-pass need not be the full size of the trunk duct, but should be large enough to handle the difference between the maximum and minimum supply of pre-conditioned air required at various times by the room conditioners.

Ordinarily, the maximum supply of pre-conditioned air required to serve the various room conditioners will be considerably less than the aggregate peak demands of same, and should be independently estimated on the basis of the actual maximum demand of the group at any one time. For example, the requirements of the units serving east rooms will be greatest in the morning, whereas those units serving west rooms will be greatest in the afternoon. In a building exposed alike on opposite sides, the load factor may be as little as half the required maximum output of the individual units collectively.

It is evident that with the arrangement described, a uniform temperature of pre-conditioned air is made available in the quantities demanded to maintain optimum conditions in the various rooms the year around. The air-conditioning system operates automatically to this end without further attention than such adjustment of the room thermostats as may be required at different seasons, and to maintain a proper supply of steam in weather when it is necessary. As will be understood in the art, the refrigerating equipment may be arranged to operate automatically in response to the demand. Ordinarily, a temperature of about 55°-58° in the trunk duct 14 will serve this purpose best. The optimum room temperature for occupants customarily clothed and sedentarily engaged will vary from about 70°-72° in winter, to 78°-80° in summer.

It is, of course, to be understood that although I have described in detail a preferred embodiment of my invention, the invention is not to be thus limited, but only as defined by the scope and spirit of the appended claims.

I claim as my invention:

1. Air conditioning apparatus comprising a housing having an outlet for conditioned air and separate intakes for air from an outdoor and an indoor source respectively, a damper for each of said intakes, means normally biasing one of said dampers to closed position and the other to open position, mechanism for operating said dampers in unison so as to close one while opening the other, thermal air-conditioning means

"... and the branch ducts..."
within said housing, means for moving air through said housing from said intakes past said thermal air-conditioning means to said outlet, thermostatic means within said housing ahead of said thermal air-conditioning means for actuating said damper operating mechanism, temperature responsive means in the outdoor intake operable to render said thermostatic means ineffective when the temperature of the air in the outdoor intake exceeds that in the indoor intake, a by-pass from said outlet to said housing ahead of said thermal air-conditioning means, a damper in said by-pass and pressure responsive means in said outlet for controlling said by-pass damper to maintain a substantially uniform air pressure at said outlet irrespective of the demand for conditioned air from said outlet.

2. The method of thermally conditioning air, which comprises moving air along a confined path providing intakes into said path from a source of indoor air and from a source of outdoor air, thermally conditioning the intaken air at a point along said confined path, controlling the selection of the source and of the proportionate volumes of air taken in from said sources in accordance with the relative temperatures of the outside air and of the intaken air at a position ahead of said point of thermal conditioning but beyond the points of intake, advancing said conditioned air under a pressure head for delivery and by-passing any excess of such conditioned air over delivery demand back to said confined path ahead of said point of thermal conditioning so as to maintain said pressure head substantially constant.

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