Oct. 1, 1935. A. F. KARLSON 2,016,091

METHOD AND APPARATUS FOR COOLING AND HUMIDIFYING THE AIR OF AN ENCLOSURE

Filed Dec. 31, 1931 4 Sheets-Sheet 1

Fig. 1.

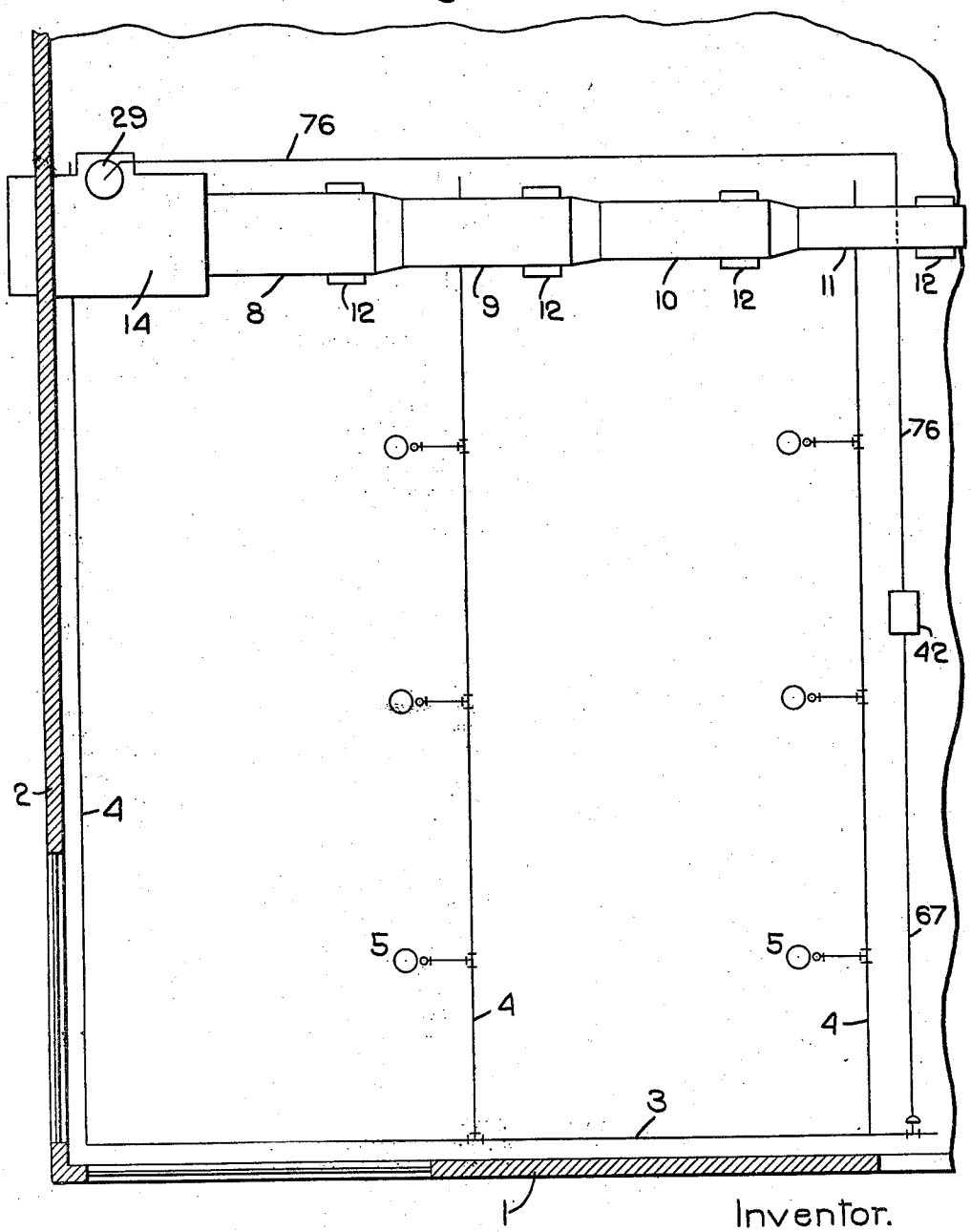

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Fig.2.

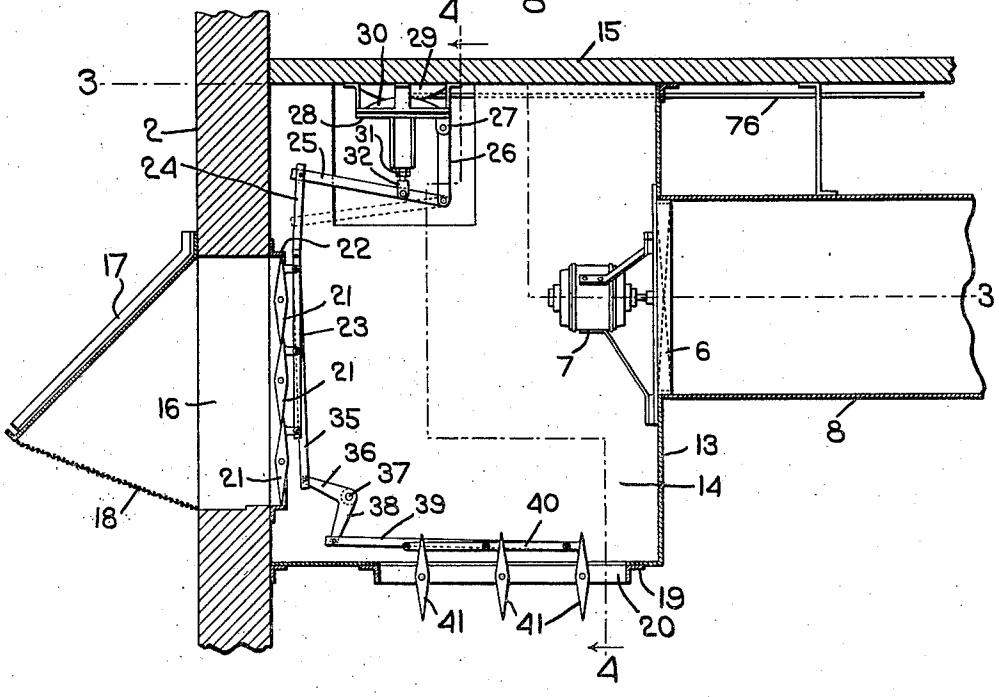
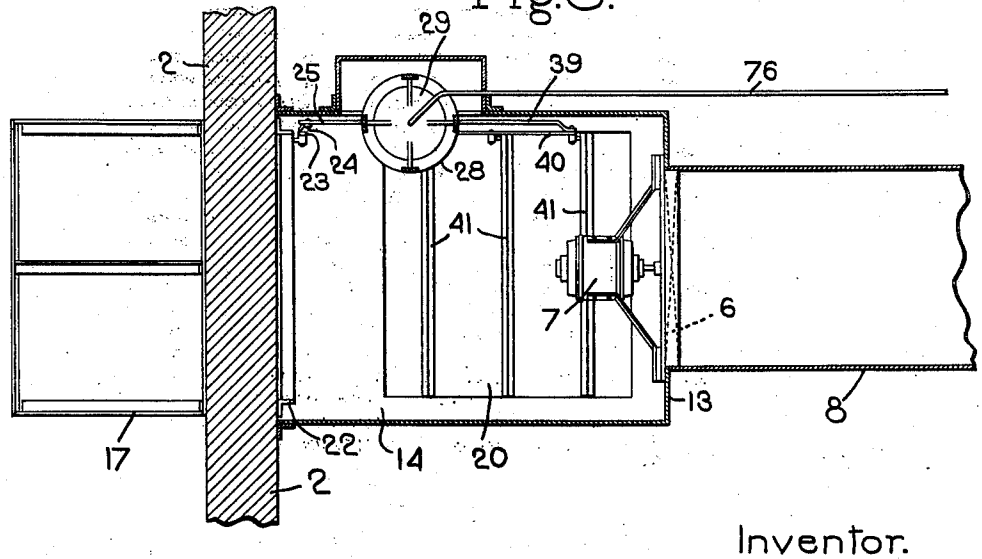


Fig.3.



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METHOD AND APPARATUS FOR COOLING AND HUMIDIFYING THE AIR OF AN ENCLOSURE

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Fig. 4.

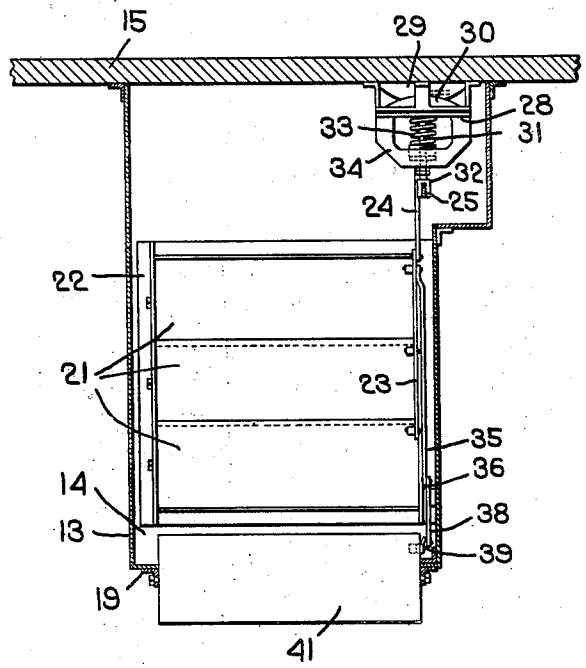
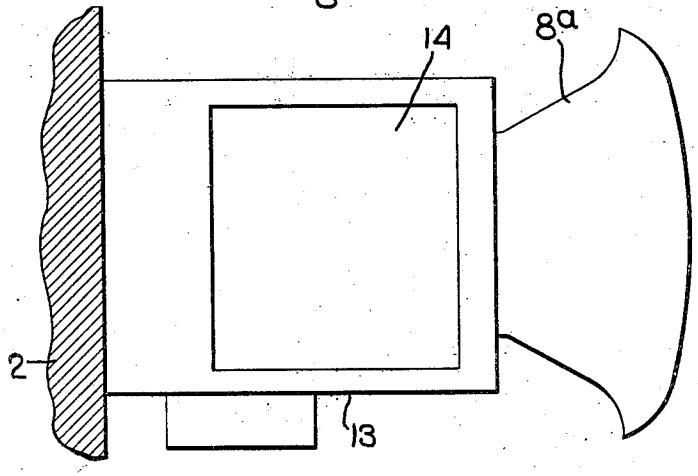


Fig. 5.



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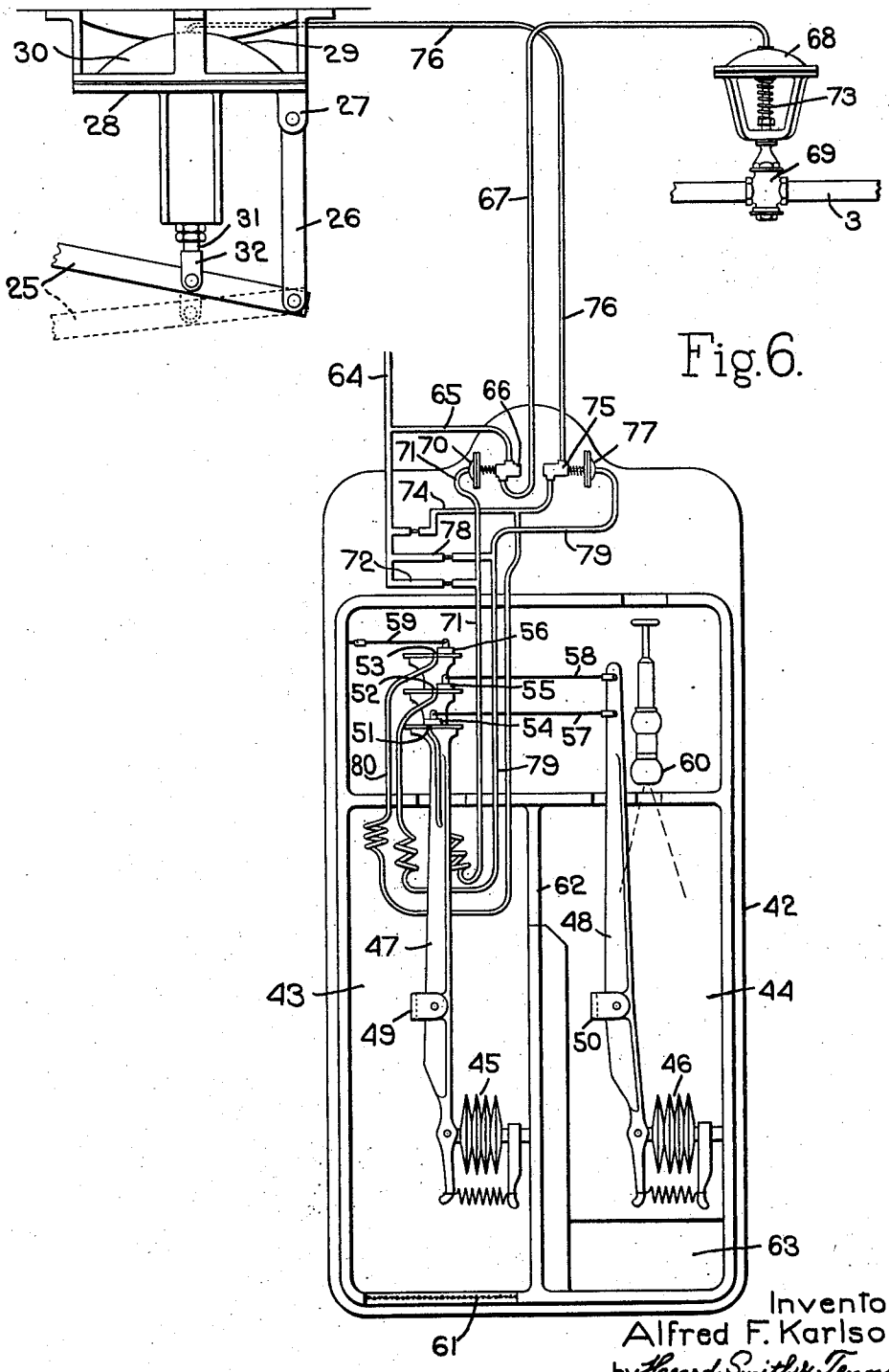

Fig. 6.

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Patented Oct. 1, 1935

2,016,091

UNITED STATES PATENT OFFICE

2,016,091

METHOD AND APPARATUS FOR COOLING AND HUMIDIFYING THE AIR OF AN ENCLOSURE

Alfred F. Karlson, North Leominster, Mass., signor to Parks-Cramer Company, Bost· Mass, a corporation of Massachusetts

Application December 31, 1931, Serial No. 584,025

9 Claims. (Cl. 236—44)

My invention relates to an improved method and apparatus for the humidifying and cooling of the atmosphere of enclosures such as industrial factories by direct humidification and ventilation.

My present invention is an improvement upon the method and apparatus disclosed in my prior Patent No. 1,810,915, of June 23, 1931. The apparatus disclosed in this patent comprises humidifying means for discharging and vaporizing water within the enclosure, separate and independent ventilating means for determining the rate of air exchange for the enclosure, and humidity-regulating means controlling the humidifying means and ventilating means in combination operable to discontinue operation only of the humidifying means in response to excessive humidity and to discontinue or restrict operation only of the ventilating means in response to deficient humidity in such manner as to maintain maximum evaporative cooling of the air in the enclosure at all times while automatically maintaining humidity at the desired standard.

In the construction disclosed in the foregoing patent the operation of the ventilating means under control of the regulating means permits of the entry of external air to the enclosures at rates that vary with the ventilation effective at the moment. In the applied practice of the invention it has been found that in large industrial departments the resulting exchange of air between the exterior and interior frequently is not uniform in all parts of the enclosure and causes sharp local variation in temperature and humidity accompanied by fluctuations in these conditions that are reflected in the actuation of the regulating devices and impair the accuracy of regulation.

It has been further found that in factories where heavy heat liberation requires the absorption of heat by evaporative cooling and also removal of heat by ventilation, even in extremely cold weather, the entry of fresh air to the enclosure, whether through transoms or fans, causes objectionable cold drafts and such extreme local variations in temperature and humidity as are found to be highly objectionable.

It is the object of my present invention to extend and improve upon the method and apparatus disclosed in my prior patent aforesaid for the purpose of equalizing the atmospheric conditions prevailing throughout the enclosure and maintaining them uniform and free from such variations as would otherwise be due to the direct entry and circulation of fresh air and other causes. This object is accomplished by providing a special ventilating system that acts continuously to distribute a constant supply of air uniformly to all parts of the enclosure, including means for admitting fresh air to compose a part of the supply and for adding room air to the fresh air to compose the balance of the supply and thus to temper or raise the temperature of the mixture at times when the fresh air is too cold to be used without dilution.

The arrangement is such that the supply may be composed wholly of fresh air or of room air or of a mixture of such proportions of each as circumstances require. The special damper-means preferably provided for this purpose are operable to determine the exchange of air between the interior and the exterior of the enclosure by varying the admission of fresh air and diluting it with room air in such proportion to the room air that the two ingredients are always complementary components of the constant supply which they compose.

In hot weather when the rate of air exchange required for ventilation is relatively high, the difference in temperature between the room air and the entering fresh air is comparatively small, under which circumstances it is often desirable to use 100% of fresh air for the supply.

In cold weather, on the other hand, when there is a considerable difference in temperature between the room air and the fresh outside air, the volume required for exchange is relatively small and may be effectively tempered by the use of a relatively large component of room air.

By this novel method and means all parts of the enclosure are continuously supplied with air having a common and homogeneous condition of temperature and humidity which air is uniformly humidified and cooled as required by vaporization which, being also uniform throughout the enclosure, produces a final atmospheric condition that is also uniform and homogeneous. Fluctuations in humidity are thereby restricted to those narrow limits that cause actuation of the regulating devices to restore the conditions desired.

The distinguishing characteristics of the present method is the co-ordinated performance of the following functions in accordance with atmospheric conditions in the room, viz.

1. Continuously and uniformly supplying all parts of the enclosure with untreated air of uniform quality in volume sufficient to equalize and maintain uniform the atmospheric conditions throughout the enclosure.

2. Normally supplying moisture continuously for humidification and cooling directly to the air of the room by distribution and vaporization of moisture therein at a rate ample for high humidifying and cooling capacity and alternatively interrupting said vaporization only in accordance with excessive humidity.

3. Normally composing said constant air supply of fresh air only to displace humidified air in like volume by exchange for the purpose of creating a high demand for moisture to replace that lost by escape of humid air in order to maintain a high rate of evaporative cooling and cooling by ventilation.

4. Alternatively reducing the volume of fresh air in said constant air supply and maintaining the constant volume of said supply by the addition of room air to supplement said reduced fresh air in accordance with deficient humidity to conserve moisture or in accordance with deficient temperature to conserve heat.

I am aware that in central station types of humidifying apparatus it is a common practice to condition a supply of air by charging it with moisture from water spray, and subsequently distributing the conditioned air in the enclosure, and that in certain instances the supply of air has been composed of a controlled mixture of fresh air and re-circulated air to which moisture has been supplied before the mixture is delivered into the enclosure.

Apparatus used for this purpose is necessarily complete in itself comprising both the ventilating means and the humidifying means in one apparatus which performs their dual functions and the humidifying capacity of such apparatus is limited in consequence by its ventilating capacity since the current of air is itself the vehicle used for delivering moisture to the air of the room and can absorb and deliver only that amount of moisture required for its saturation together with such limited amounts of fine spray as may remain in suspension and be evaporated after delivery. In view of the relatively large volumes of air handled by such an apparatus and the necessity for moderate velocities at the point of their delivery, the quantity of fine spray which can be thus delivered is relatively small and unimportant.

Such methods in general may be described as indirect humidification; they and the apparatus used for performing them are adapted only for the production of moderate humidity because of the limited carrying capacity of such an air current for accomplishing the delivery of moisture. In contra-distinction to the foregoing, my method may be described as a combination of direct humidification with independent ventilation.

My apparatus comprises two separate physical agencies, namely, a system of direct humidifiers acting to distribute and vaporize moisture in the air of the room itself and an independent ventilating system each of which performs separate functions and each of which is controlled to operate either co-operatively or alternatively as varying conditions of temperature and humidity require.

The supply of air provided in my invention is collected from its separate sources and distributed without being charged with moisture and the volume of fresh air supplied is adjusted solely in accordance with ventilating requirements as determined by deficiencies of temperature or humidity, while the constant supply of mixed air is constantly distributed and, regardless of its proportions, performs the further important function of supplying air of uniform quality simultaneously and uniformly to all parts of the room to insure equalized and homogeneous atmospheric conditions throughout the room.

The humidifier system, on the other hand, is operated independently of ventilation and distributes and vaporizes moisture uniformly in all parts of the room, its uniformly continuous operation being interrupted only exceptionally upon humidity becoming excessive either by reason of excessive natural humidity or by reason of ventilation restricted because of excessive cooling and deficient temperature.

Owing to the independent character and functions of the humidifying means and ventilating means, the apparatus of my invention is applicable to widely varying requirements to meet which the relative capacities of my humidifying and ventilating means may be varied at will without relation to each other and in this advantageous respect my method and apparatus are further distinguished from all of those methods and means found in the prior art in which evaporative and ventilating capacity are characteristically interdependent.

In the preferred embodiment of my present invention, as herein disclosed, I employ a ventilating system that includes air circulating means operable continuously to distribute and circulate within the enclosure a substantially constant supply of air; air proportioning means operable to draw said supply of air in two controllably proportioned components, the one from within the enclosure for recirculation and the other from the exterior thereof for exchange or true ventilation and means operable to mix said components of the air supply prior to distribution. These several agencies are used in combination with independent humidifying means for vaporizing moisture within the enclosure and automatic means operable to control cooperatively the humidifying and ventilating agencies, in such manner as to maintain a predetermined standard or range of humidity throughout the enclosure, together with the controlled admission of sufficient fresh air to effect the maximum cooperative cooling consistent with said standard of humidity, said fresh air being mixed with room air for tempering, and then distributed and circulated throughout the room in substantially constant volume.

The controlling mechanism may be similar in type to the corresponding elements in the apparatus disclosed in my prior patent aforesaid and the entire apparatus is operable to perform the same functions as in my prior invention with improved results.

An illustrative embodiment of the invention is illustrated in the accompanying drawings, in which,

Fig. 1 is a horizontal sectional view through the walls of an enclosure or a section thereof illustrating diagrammatically mechanisms for carrying out the purposes of the invention;

Fig. 2 is a detail vertical sectional view of the means for distributing and circulating the air within the room, showing also means for admitting complementary components of the air supply from the interior and from the exterior of the room; with means for varying the relative value of said components of air;

Fig. 3 is a detail horizontal sectional view of the same on line 3—3 Fig. 2;

Fig. 4 is a detail vertical sectional view on line 4—4 Fig. 2;

Fig. 5 is a detail view illustrating the mixing chamber in elevation and a modified form of distributor;

Fig. 6 is an elevation of a pneumatic regulator of the psychrometric type having wet and dry bulb elements sensitive to and actuated by variations in humidity and temperature of the air of the enclosure, and also showing pneumatic connections therefrom to means for regulating the rate of moisture supply and to mechanism for controlling the air-proportioning means for varying the relative value of the respective components of air supplied to the distributing and circulating means.

The drawings illustrate the application of the invention to an enclosure, such as an industrial factory the air of which is influenced by uncontrollable sources of heat, such as operating machinery. Fig. 1 diagrammatically illustrates such a factory in horizontal section showing the side walls 1 and 2 and apparatus diagrammatically illustrated for vaporizing water within the enclosure comprising a conduit 3 having branches 4 leading to suitable humidifying means, such as spraying devices 5 acting when in operation to discharge and vaporize water within the enclosure. Such means for vaporizing water within the enclosure may be and preferably are similar to that disclosed in my prior Patent No. 1,810,915.

To supplement the functions of ventilating agencies adapted for intermittent use or for natural ventilation through transoms, such as are disclosed in Patent No. 1,810,915, I provide in my present invention a ventilating apparatus comprising one or more fans or sets of fans, adapted for continuous operation, and corresponding delivery ducts provided with a multiplicity of outlets for continuous delivery of the air moved by the fans to all parts of the room, thus establishing continuous agitation and forced movement of air throughout the room.

I also provide air-supply ducts on the intake or suction side of such fans or sets of fans, and provide for each intake duct two separate inlets, one communicating with the interior of the room and one with the exterior of the room.

For each such external or internal inlet I provide a set of damper louvres, mechanically organized for conjoint operation to the end that the one set of louvres shall open and admit more air while the other conjointly closes to admit less air. The air supplied to each set of fans is thus made to consist of two components, one of which, being drawn from the exterior of the enclosure, will displace a like quantity of room air and so effect exchange of air between the interior and exterior of the enclosure in like amount, while the other component, drawn from the interior of the room, is re-circulated within the room.

The mechanism connecting the two sets of damper louvres for conjoint operation constitutes a device that may be either manually or automatically operated to variably proportion the two components of the air supply and thus determine the value of the rate at which air is exchanged between the interior and exterior of the enclosure.

The entry of the two components of outside air and inside air through the proportioning device into a common intake on the suction side of the fans insures a thorough mixing of the outside and inside air prior to its distribution within the room.

The forced introduction of external air to the enclosure results in a plenum of air pressure within the room and a corresponding displacement of room air which will escape to the exterior through such avenues as may be available. It is therefore desirable to provide ventilators or other openings, such as transoms equipped with balanced louvres, in sufficient number and at such locations as will result in desirable movement of air between the duct outlets and such escape outlets, and thus improving the uniformity of air circulation.

Provisions for artificial heating of the air in the enclosure are not contemplated by or essential to my invention. If, however, it be desired to provide for the liberation of artificial heat within the enclosure when needed in connection with my apparatus, indirect radiators may be used for that purpose in connection with the ventilating apparatus, as will be apparent to those skilled in the art.

The humidifying equipment may consist of a multiplicity of any of the various types of direct humidifiers that are adapted to deliver and vaporize water spray within the enclosure. The humidifier units are distributed throughout the enclosure at such intervals and in numbers sufficient to meet the existing demand for moisture and insure its proper distribution.

The purpose and character of and the means employed in my present invention and in my earlier Patent No. 1,810,915, are similar in respect to their common use of the broad principles disclosed of regulating the delivery of moisture and the exchange of air conjointly by automatic regulators responsive to the atmospheric conditions within the room.

It is characteristic however of my present invention that the air circulating and distributing means as a whole functions continuously and without interruption and independently of the admission and exchange of fresh air which nevertheless goes on under automatic regulation in cooperative conjunction with the operation of the humidifiers in response to changes in the humidity or temperature of the room air.

Suitable means are provided for distributing a supply of air within the enclosure and maintaining a continuous substantially uniform circulation of air throughout the enclosure. The particular mechanism illustrated comprises a fan 6 driven by an electric motor 7 and located at the inlet of a duct 8, (see Fig. 2), preferably formed in progressive sections 9, 10, 11, of successively smaller cross sectional area, each of said sections being provided with outlets 12 for distributing the air forced through the duct into the room at desired intervals. The inlet of the duct 8 is located in the wall 13 of a mixing chamber 14, the upper wall 15 of which desirably is formed by the ceiling of the room, and the outer wall 2 of which is an outside wall of the building. The remaining walls of the mixing chamber may be of sheet metal, or any other desirable material, or all of the walls of the mixing chamber may be made of sheet metal with suitable means for communicating with the exterior and interior of the enclosure.

While the distributing duct 8 desirably is formed of sections of successively smaller cross sectional area and provided with lateral outlets, as shown in Fig. 1, other distributing means may be employed, such as a bell-mouthed duct 8—*a* illustrated in Fig. 5, communicating with the outlet of the mixing chamber 14.

The exterior wall 2 of the building is provided with a preferably rectangular ventilator opening 16 through which air is admitted to the mixing chamber 14. Desirably an inclined deflector 17, preferably of sheet metal, is provided to prevent the admission of rain into the ventilating opening and a screen 18, connecting the lower edge of the deflector with the wall of the casing, is provided to prevent the entrance of insects and other foreign matter. One of the interior walls, preferably the lower wall 19 of the mixing chamber, is provided with a preferably rectangular opening 20 of the same area as the ventilating opening 16. Conjointly operable dampers are provided for controlling the value of the components of air admitted to the mixing chamber from the exterior and interior of the enclosure.

In the preferred construction illustrated a series of louvers 21 are pivotally mounted in a suitable casing 22 and are adapted when in the closed position illustrated to prevent the entrance of air from the exterior of the enclosure. These louvers are each pivotally connected to a bar 23, one end of which is connected by a link 24 to one end of an actuating lever 25, the other end of which is pivotally connected to a vertical link 26, the upper end of which is fulcrumed on a boss 27 upon the casing 28 of a pneumatic motor 29.

The pneumatic motor illustrated is of a usual type having an air chamber 30 covered by a diaphragm to which is connected a piston rod 31, the forked end 32 of which is pivotally connected to the lever 25 intermediate of its length (see Figs. 2, 3, and 4). An adjustable balancing spring 33, which is interposed between the diaphragm and an adjustable seat 34 upon a U-shaped frame 34, secured to the base 28 of the motor, serves normally to hold the diaphragm in collapsed position, and the lever 25 in raised position illustrated in Fig. 2. When in this position the louvers 21 are retained in closed position, as illustrated in Fig. 2. The bar 23, which connects the louvers, is pivotally connected to the upper end of a link 35, the lower end of which is connected to one arm 36 of a bell crank which is pivotally mounted upon a suitable stud 37 extending inwardly from one of the side walls of the mixing chamber. The other arm 38 of the bell crank lever is connected to one end of a link 39, the other end of which is pivotally connected to a bar 40 which is pivotally connected to each of a series of louvers 41 which, when in closed position, will prevent the admission of air from the interior of the room through the opening 20. The louvers 41, however, are so arranged as to be in full open position when the louvers 21 for the ventilating opening 16 are in fully closed position. Suitable means, hereinafter to be described, are provided for supplying air under pressure to the pneumatic motor 29. When, therefore, fluid under pressure is admitted to the pneumatic motor 29, its diaphragm will be extended and the piston 31 forced downwardly, thereby swinging the lever 25 downwardly and opening the louvers 21. The downward movement of the bar 23 will thereupon move the link 35 downwardly, thus actuating the bell crank 36 and moving the link 39 endwise (to the right Fig. 2), thereby moving the louvers 41 toward closed position. Such concurrent movement of the louvers 21, which control the effective area of the ventilating opening, and the louvers 41, which control the effective area of the opening leading to the interior of the enclosure, vary the relative value of the components of air supply from the exterior and interior of the enclosure, while maintaining the supply of air drawn by the fan through the mixing chamber substantially constant at all times.

By such construction, therefore, a substantially constant supply of air will be distributed and circulated throughout the enclosure, and, so long as the louvers 21, which control the supply of air from outside of the enclosure, are wholly or partially open, the additional air supplied to the room will create a plenum within the room, the escape of which may be governed either by suitable weighted dampers for ports (not shown) leading through the ceiling, or other wall of the enclosure, or by any other suitable provision for venting.

In the operation of the device, therefore, a continuous circulation of a substantially uniform volume of air throughout the room is continuously maintained, and inasmuch as the air drawn from outside the enclosure is thoroughly mixed with the air admitted to the mixing chamber from within the enclosure and subsequently distributed with substantial uniformity throughout the room, objectionable drafts of cold air are eliminated and substantial uniformity in the condition of humidity of the air throughout the room is maintained.

Any suitable means sensitive to and actuated by variations of the humidity and/or temperature of the air within the enclosure may be employed to control the action of the humidifiers which discharge and vaporize water within the enclosure and to control the air-proportioning means which determines the relative value of the components of the supply of air which is continuously distributed and circulated within the enclosure.

The form of regulating mechanism, which is illustrated herein, is of the multi-stage type generally disclosed in Patent No. 1,284,334, granted November 12, 1918 to William B. Hodge, and which is also shown in my prior Patent No. 1,810,915. Regulators of this type are adapted to maintain constant differential adjustments of any desired value as between two or more actuating stages with respect to any desired value of humidity. Owing to this advantageous characteristic, such multi-stage regulators are especially well suited to the purpose of my invention and are, therefore, preferred although not essential.

The regulator, which is illustrated in Fig. 6, comprises a casing 42 of substantially rectangular form having suitable partitions therein to provide a dry bulb compartment 43, and an adjacent and parallel wet bulb compartment 44. Thermo-sensitive members, which as illustrated are in the form of diaphragm motors 45 and 46, are mounted upon like walls of the compartments 43 and 44, and act upon the lower ends of levers 47 and 48 which are pivotally mounted upon brackets 49 and 50 upon the casing. The upper end of the lever 47 is provided with a plurality of bosses presenting upper flat surfaces constituting valve plates and having ports 51, 52, and 53, respectively. Valves 54, 55, and 56, are mounted upon the respective valve plates to co-operate with the respective ports 51, 52, and 53. The valves 54 and 55 are connected respectively by rods 57 and 58 to the upper end of the lever 48 which is actuated by the wet bulb thermo-sensitive member 46. The upper valve 56, which co-operates with the port 53, is adjustably connected by a rod 59 with the adjacent wall of the casing, and acts to close the port 53 only when the temperature of the enclosure exceeds a predetermined temperature.

A spray head 60, which desirably is located slightly above the wet bulb compartment 44, and which may be of the "Turbo" type disclosed in the patent to Simon No. 1,476,774, granted December 11, 1923, discharges a spray of water into the wet bulb compartment 44, thereby inducing a sample current of air from the enclosure in which the regulator is situated upwardly through a screened opening 61 in the lower end of the dry bulb compartment, thence through an opening 62 in the wall separating the wet and dry bulb compartments 43 and 44, then saturating the sample current of air and discharging it through an outlet 63 at the lower end of the wet bulb compartment.

By virtue of this construction, therefore, the dry bulb thermo-sensitive member 45 is first subjected to the sample of air from the enclosure and the wet bulb thermostat 46 is subjected to the same sample of air after it has been saturated with moisture, so that the thermo-sensitive members 45 and 46 ascertain respectively the dry bulb temperature and psychrometric wet bulb temperature of the air.

Equal variations in wet and dry bulb temperature of the air will cause the levers 47 and 48 to move in unison and substantial parallelism, while variations between the wet and dry bulb temperatures of the air will produce relative movement between the levers 47 and 48 which, acting through the links 57 and 58, will vary the relative positions of the ports 51 and 52 and the valves 54 and 55. The links 57 and 58 desirably are adjustable so that the valves 54 and 55 may be set in any predetermined desirable relation to the position of the ports 51 and 52. Such adjustments may be accomplished by screw threading the ends of the links 57 and 58 and connecting the screw threaded ends to clevises which are pivotally connected to the lever 48.

The relative movements of the valves and their ports are employed pneumatically to control the action of the humidifiers and also the air-proportioning means which determines the relative value of the components of air supplied from the exterior and the interior of the enclosure to the distributing and circulating means. By suitable adjustment, therefore, of the valves relatively to the valve ports, the instrument can be set to determine the limits of the range of humidity within which moisture will be supplied by the humidifiers, and the range of humidity within which air from outside of the enclosure will be admitted to the mixing chamber.

In the particular construction illustrated air under pressure is supplied from a suitable source (not shown) through a pipe 64 and a branch pipe 65 to a relay valve 66 from which a pipe 67 leads to the chamber of a diaphragm motor 68 operable to control a valve 69 in a pipe 3 from which branches 4 lead to the humidifiers (see Fig. 1). The relay valve 66 desirably is of the type disclosed in my prior Patent No. 1,810,915, and illustrated in Fig. 3 thereof and is normally in closed position. The relay valve is actuated to shut off the supply of air from the branch pipe 65 to the pipe 67 by a pneumatic motor 70 to the chamber of which air under pressure is supplied through a pipe 71 from a restricted branch pipe 72 leading from the pipe 64. The opposite end of the pipe 71 communicates with the port 51 which is controlled by the valve 54. When the valve 54 is in closed position shown in Fig. 6, air under pressure, passing from the main supply pipe 64 through the restricted pipe 72, builds up pressure in the pipe 71, thereby actuating the diaphragm motor 70 to open the valve, so that air under pressure will pass from the pipe 64 through the branch 65, thence through the relay valve 66, and pipe 67 to the chamber of the motor 68 for actuating the valve 69 which controls the humidifiers, thus causing a distention of the diaphragm which will depress the valve stem 73 of the valve 69, thereby opening the valve and rendering the humidifiers active. So long as the relative humidity of the air of the enclosure is less than the predetermined standard, the port 51 will remain closed, thereby causing continuous operation of the humidifiers.

If the relative humidity of the air of the enclosure increases, the wet bulb temperature of the air will rise relatively to the dry bulb temperature, thereby causing a separation of the upper ends of the levers 47 and 48, and when the predetermined standard or the upper limit of a predetermined range of humidity is reached, the valve 54 will be withdrawn so as to uncover the port 51, thereby releasing the air pressure in the pipe 71 and from the pneumatically operable motor 70, thereby enabling the valve 66 to assume its normally closed condition and so to release pressure in the pipe 67, thus enabling the spring 73 of the motor 68 to close the valve 69 and discontinue the action of the humidifiers.

The operation of the diaphragm motor 29 for positioning the louvers or dampers of the inlet openings to the mixing chamber is controlled in a similar manner by the relation of the valve 55 and its valve port 52. Air is supplied to the pneumatic damper-actuating motor 29 from the main air supply pipe 64 through a restricted branch pipe 74 through a normally open relay valve 75 to a pipe 76 leading to the chamber of the damper-actuating motor 29. The relay valve 75 desirably is similar to the relay valve 66, but is normally maintained in open position and adapted to be forced toward closed position by air under pressure supplied to its pneumatic motor 77. Air is supplied to the chamber of the motor 77 from the main air supply pipe 64 through a restricted branch pipe 78 which communicates with a pipe 79, one end of which leads to the chamber of the pneumatic motor 77. The other end of the pipe 79 communicates with the port 52 of the valve seat upon the lever 47 which is controlled by the dry bulb member 45 of the regulator.

Inasmuch as the relay valve 75 is normally in open position, air under pressure normally passes from the main supply pipe 64 through the branch 74, thence through the relay valve 75 and pipe 76 to the pneumatic motor 29, thereby extending its diaphragm and forcing the plunger 31 downwardly, thus swinging the lever 25 downwardly and opening the louvers 21 to permit a component of outside air to be drawn into the mixing chamber and at the same time moving the louvers 41 toward closed position, thereby restricting the component of air drawn into the mixing chamber from within the enclosure. When the humidity of the air of the enclosure falls below a predetermined standard or the lower limit of a predetermined range of humidity, the wet bulb temperature of the air will drop relatively to the dry bulb temperature, thereby causing the approach of the upper ends of the levers 47 and 48. This relative movement of the levers 47 and 48 will cause the

valve 55 gradually to close the port 52, thereby building up pressure in the pipe 79 and in the chamber of the diaphragm motor 77, thereby closing the normally open relay valve 75 and shutting off the pressure supply from the pipe 74 and pipe 76 to the damper-actuating motor 29, and releasing the pressure therefrom, so that the spring 33 will swing the lever 25 upwardly, thereby moving the louvers 21 toward closed position and simultaneously the louvers 41 toward open position, thus limiting the supply of fresh air from outside the room and increasing the supply of air drawn from within the enclosure.

The differential setting of the regulator valves 54 and 55 with respect to each other is such that in response to falling humidity port 51 will be closed by valve 54 before port 52 is closed by valve 55, and conversely in response to rising humidity port 52 will be opened before port 51 is opened. The difference in the value of relative humidity corresponding to this differential setting is slight and may be as little as 2% in terms of relative humidity and this differential setting, once established, need seldom be disturbed.

An adjustment (not shown) is provided for modifying the position of the expansible elements 46 and 45 with respect to each other thereby to cause the valves 54 and 55 to function at any desired predetermined value of relative humidity. The organization of the construction as a whole is such that when the desired predetermined value of relative humidity prevails port 51 will be closed by valve 54 and port 52 will be open. Under such conditions the normally closed relay valve 66 and the normally closed humidifier valve 69 will be open and the humidifiers will be in operation, while valve 75 will be in its normally open position and the damper-actuating motor 29 will be operating to hold the fresh air dampers 21 fully open. Under such conditions the apparatus as a whole will be developing the maximum absorption of heat by evaporation and the maximum rejection of heat by exchange of air and this condition will continue only so long as the relative humidity continues at the predetermined standard,—that is to say, within that range of relative humidity whose upper limit is marked by the opening or closing of port 51 by valve 54 and whose lower limit is marked by the opening or closing of port 52 by valve 55. It should be noted that by virtue of this arrangement two separate and distinct actuating stages are provided in a single regulating instrumentality,—a considerable practical advantage over the use of two separate regulating instruments whose differential adjustment might easily be disturbed.

It should be noted that the position of the damper louvers 21 and 41 are dependent upon the reaction of the adjustable balancing spring 33 to the air pressure in the line 76, which pressure, because of the restriction in branch pipes 74 and 78 and because of the small size of the ports in valve 75 is purposely limited to slow changes in value with the object of avoiding the sudden opening or closing of the louvers thereby to accomplish gradual rather than sudden modification of the rate of exchange of air between the interior and exterior of the enclosure in response to progressive changes in the atmospheric conditions that actuate the regulating instrumentality.

The organization of the regulator and the conjoined humidifying and ventilating agencies is such that while humidity continues to prevail at the predetermined standard,—that is, within the range and value corresponding to the narrow interval between the upper and lower actuating stages—humidification and air exchange are both in full operation. If humidity rises to or above the upper stage, actuation discontinues humidification until the standard is restored by a falling humidity, air exchange meanwhile continuing in full operation. Humidity falling below the lower stage results in actuation causing progressive reduction of air exchange until the fall in humidity is checked, after which, as the humidity rises, air exchange is progressively increased, reaching full operation when the humidity is restored to standard, the humidifiers meanwhile continuing in full operation.

This arrangement of regulation is chiefly adaptable for hot weather and in the absence of any other provision manual limitation would be necessary to prevent excessive exchange in cold weather such as might lower the room temperature to an undesirable degree.

It is thus apparent that the present invention is adapted to maintain a substantially uniform condition of relative humidity at all times irrespective of the condition of humidity of the external air or of the temperature of the external air and under normal conditions to provide such interchange of internal and external air as to enhance the comfort and efficiency of the operators whose presence is required within the enclosure.

Having thus described the invention, what is claimed as new, and desired to be secured by Letters Patent, is:

1. The method of conditioning uniformly the atmosphere of an enclosure influenced by heat from uncontrollable sources and continuously cooling said atmosphere at a predetermined maximum rate while maintaining a predetermined standard of humidity that comprises renewing continuously the atmosphere of said enclosure by distributing uniformly therein a supply of air composed of fresh air mixed with air withdrawn from the enclosure, simultaneously supplying the contained atmosphere of the enclosure with moisture by the direct distribution and vaporization of water spray at predetermined and substantially uniformly spaced locations therein and at a predetermined rate, thereby to maintain uniform atmospheric conditions throughout said enclosure at a predetermined maximum rate of evaporative cooling, and regulating the humidity within said enclosure by adjusting the volume of fresh air in said supply in accordance with said predetermined standard of humidity.

2. The method of conditioning uniformly the atmosphere of an enclosure influenced by heat from uncontrollable sources to maintain a predetermined standard of humidity and continuously cooling said atmosphere by evaporation at a predetermined maximum rate when consistent with said predetermined standard of humidity, which comprises renewing continuously the atmosphere of said enclosure by distributing uniformly therein a supply of air composed of fresh air mixed with air withdrawn from the enclosure, normally supplying the contained atmosphere of the enclosure with moisture by the direct distribution and vaporization of water spray at predetermined and substantially uniformly spaced locations therein at a predetermined rate for maximum evaporative cooling,

and regulating the humidity by adjusting the volume of fresh air in said supply in accordance with said predetermined standard, and alternatively interrupting said vaporization only when the humidity exceeds said predetermined standard.

3. The method of conditioning uniformly the atmosphere of an enclosure influenced by heat from uncontrollable sources to a predetermined standard of humidity and to a temperature exceeding a predetermined minimum limit which comprises renewing continuously the atmosphere of said enclosure by distributing uniformly therein a supply of air composed of fresh air mixed with air withdrawn from said enclosure, normally supplying the contained atmosphere of the enclosure with moisture by the direct distribution and vaporization of water spray at predetermined and substantially uniformly spaced locations therein at a predetermined rate for maximum evaporative cooling, and cooperatively regulating the humidity by adjusting the volume of fresh air in said supply in accordance with said predetermined standard of humidity, and alternatively, limiting the volume of fresh air in said supply in accordance with the temperature when falling to said minimum limit and interrupting said vaporization only when the humidity exceeds said predetermined standard.

4. The method of conditioning uniformly the atmosphere of an enclosure influenced by heat from uncontrollable sources to maintain a predetermined standard of humidity and continuously cooling said atmosphere by evaporation at a predetermined rate which comprises drawing fresh air from outside the enclosure for ventilation, mixing therewith air withdrawn from the enclosure for recirculation and continuously renewing the atmosphere of said enclosure by distributing and circulating said mixed air uniformly throughout the enclosure in substantially constant volume, simultaneously supplying the contained atmosphere of the enclosure with moisture by the direct distribution and vaporization of water spray at predetermined and substantially uniformly spaced locations therein at a predetermined rate for maximum evaporative cooling, and regulating the humidity of said atmosphere by adjusting the relative proportions of fresh and withdrawn air in said mixed air in accordance with said predetermined standard.

5. The method of conditioning uniformly the atmosphere of an enclosure influenced by heat from uncontrollable sources to a predetermined standard of humidity and continuously cooling said atmosphere by evaporation at a predetermined maximum rate when consistent with said predetermined standard of humidity which comprises drawing fresh air from outside the enclosure for ventilation, mixing therewith air withdrawn from the enclosure for recirculation, renewing continuously the atmosphere of said enclosure by distributing and circulating said mixed air uniformly throughout the enclosure in substantially constant volume, normally supplying the contained atmosphere of the enclosure with moisture by the direct distribution and vaporization of water spray at predetermined and substantially uniformly spaced locations therein at a predetermined rate for maximum evaporative cooling, and cooperatively regulating the humidity by adjusting the relative proportions of fresh and withdrawn air in said mixed air in accordance with said predetermined standard and alternatively interrupting said vaporization only when the humidity exceeds said predetermined standard.

6. The method of conditioning uniformly the atmosphere of an enclosure influenced by heat from uncontrollable sources to maintain a predetermined standard of humidity and a temperature exceeding a predetermined limit which comprises drawing fresh air from outside the enclosure for ventilation, mixing therewith air withdrawn from the enclosure for recirculation, continuously renewing the atmosphere of said enclosure by distributing and circulating said mixed air uniformly throughout the enclosure in substantially constant volume, normally supplying the contained atmosphere of the enclosure with moisture by the direct distribution and vaporization of water spray at predetermined and substantially uniformly spaced locations therein at a predetermined rate for maximum evaporative cooling, and cooperatively regulating the humidity by adjusting the relative proportions of fresh and withdrawn air in said mixed air in accordance with said predetermined standard of humidity, and alternatively, limiting the proportion of fresh air in said mixed air in accordance with the temperature when falling to said minimum limit and interrupting said vaporization only when the humidity exceeds said predetermined standard.

7. Apparatus for ventilating and humidifying an enclosure influenced by heat from uncontrollable sources comprising continuously-acting ventilating means including an air intake communicating with the interior and exterior of said enclosure, means for drawing interior air for recirculation and external air for ventilation through said intake and for forming a mixed supply thereof, and means for uniformly distributing and circulating said air supply continuously throughout the enclosure to renew the atmosphere contained therein, humidifying means within said enclosure and separate from said ventilating and distributing means comprising a multiplicity of distributed spray-generating units acting normally to distribute and vaporize moisture uniformly throughout the enclosure at a uniform rate in the contained atmosphere thereof, adjustable means for varying the volume of external air admitted to said intake, and automatic regulating means responsive to atmospheric conditions within said enclosure and operatively connected with said adjustable means and with said humidifying means, in combination acting during the normal continuous operation of said humidifying means to regulate the humidity by adjusting the volume of external air admitted to said intake in accordance with a predetermined standard of humidity and operable only upon humidity exceeding said predetermined standard to interrupt the operation of said humidifying means.

8. Apparatus for ventilating and humidifying an enclosure influenced by heat from uncontrollable sources and for controlling the humidity and temperature of the atmosphere therein in accordance with predetermined standards comprising continuously acting ventilating means including an air intake communicating with the interior and exterior of said enclosure, means for drawing interior air for recirculation and external air for ventilation through said intake and for forming a mixed supply thereof, and means for uniformly distributing and circulating said air supply continuously throughout the enclosure to renew the atmosphere contained therein, hu-

midifying means within said enclosure and separate from said ventilating and distributing means comprising a multiplicity of distributed spray-generating units acting normally to distribute and vaporize moisture uniformly throughout the enclosure at a uniform rate in the contained atmosphere thereof, adjustable means for varying the volume of external air admitted to said intake and automatic regulating means responsive to atmospheric conditions within said enclosure and operatively connected with said adjustable means and with said humidifying means, in combination acting during the normal continuous operation of said humidifying means to regulate the humidity by adjusting the volume of external air admitted to said intake and operable to limit the volume of external air admitted to said intake upon temperature falling to a predetermined minimum limit, and operable to interrupt the operation of said humidifying means only when the humidity exceeds said predetermined standard.

9. Apparatus for ventilating and humidifying an enclosure influenced by heat from uncontrollable sources and for regulating the humidity and controlling the temperature of the atmosphere therein in accordance with predetermined standards comprising ventilating means acting continuously to distribute and circulate a substantially constant supply of air throughout the enclosure including adjustable means for furnishing a controllable volume of fresh air from outside the enclosure for said supply thereby to determine the rate of ventilation, means for supplementing the fresh air in said supply with recirculated air drawn from within the enclosure in accordance with the volume of said fresh air to maintain a substantially constant volume of air for said supply, humidifying means within said enclosure and separate from said ventilating and distributing means comprising a multiplicity of distributed spray-generating units acting normally to distribute and vaporize moisture uniformly throughout the enclosure at a uniform rate in the contained atmosphere thereof, and automatic regulating means responsive to atmospheric conditions within said enclosure and operatively connected with said adjustable means and with said humidifying means, in combination acting normally during the continuous operation of said humidifying means to regulate the humidity by adjusting the volume of fresh air in said supply in accordance with a predetermined standard of humidity, and operable to limit the volume of fresh air in said supply upon temperature falling to a predetermined minimum limit, and to interrupt the operation of said humidifying means only when the humidity exceeds said predetermined standard.

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