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METHOD OF HUMIDIFYING AIR AND CONTROLLING THE HUMIDITY AND TEMPERATURE THEREOF.

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1,085,971. Patented Feb. 3, 1914.

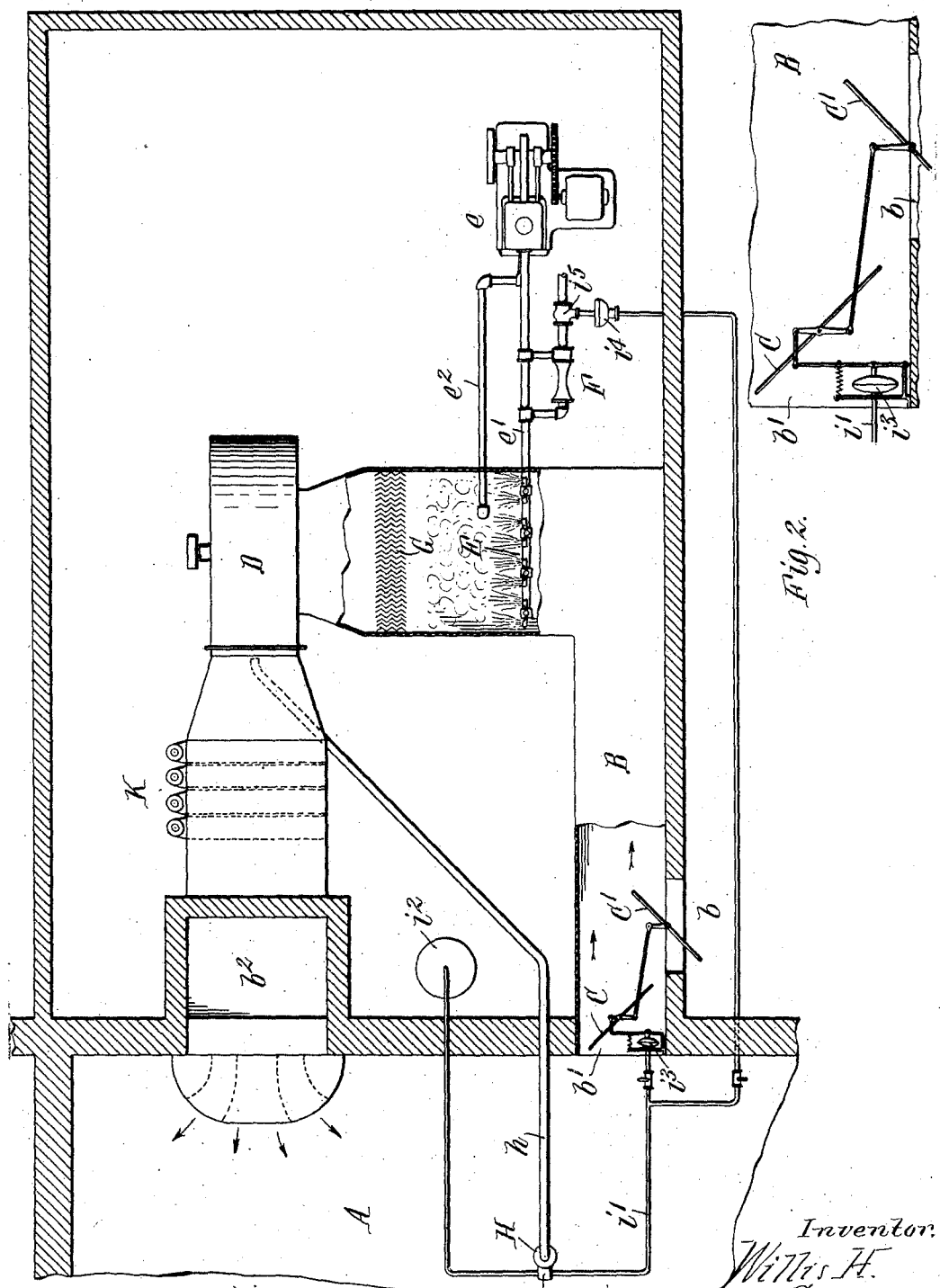

Fig. 1.

Fig. 2.

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UNITED STATES PATENT OFFICE.

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METHOD OF HUMIDIFYING AIR AND CONTROLLING THE HUMIDITY AND TEMPERATURE THEREOF.

1,085,971. Specification of Letters Patent. Patented Feb. 3, 1914.

Application filed May 17, 1907, Serial No. 374,215. Renewed December 1, 1913. Serial No. 804,112.

To all whom it may concern:

Be it known that I, WILLIS H. CARRIER, a citizen of the United States, residing at Buffalo, in the county of Erie and State of New York, have invented a new and useful Improvement in Methods of Humidifying Air and Controlling the Humidity and Temperature Thereof, of which the following is a specification.

This invention relates more particularly to methods or systems for humidifying and for regulating the humidity and temperature of air in textile mills. The invention is nevertheless applicable generally for humidifying and regulating the humidity and temperature of air regardless of the use to which the air is put.

It is essential for various well known reasons to keep the temperature and humidity of the atmosphere in textile mills within prescribed limits, and maintain prescribed conditions of humidity regardless of fluctuations in the temperature in the mill.

Natural ventilation, through windows and ventilators, is prohibited when spinning fine yarns on account of the trouble caused by fluctuating drafts; then, too, when outside air is admitted in large quantities, it being usually much drier than the inside air, it is almost impossible to sufficiently moisten it by humidifying devices in the room, so that while the temperature is reduced the humidity is also decreased. On the other hand, where but a small amount of ventilation is permissible, the high humidity with the increased temperature makes the conditions all the more unbearable and oppressive for the operatives. In many systems ventilation is entirely disregarded and the evaporation of the water sprayed into the room is relied upon to secure the necessary cooling, but cooling in this manner is inadequate on account of the great heat generated by the machinery and, as such cooling can only be secured by moistening the dry air in the room, it is limited by the allowable natural ventilation in the room. The distribution of the humidity is also very uneven, the atmosphere being too dry in the vicinity of inlets for outside air, and too damp in the vicinity of the humidifiers. The drier and cooler entering air tends to remain along the floor and in contact with the yarn, while the warmer and moister air, being lighter, rises and passes out through the ventilators. In such systems the moisture is not fully assimilated by the air and converted into a true vapor, but is simply broken up into fine drops which float about as a sort of mist, dampening things with which it comes in contact. The prior systems, in which a current of air is moistened before it is introduced into the room or building, are not adapted for producing a definite relative humidity, nor for regulating the percentage of humidity for different room temperatures, as may be desirable or necessary.

The primary object of this invention is to produce an efficient and economical method or system for producing definite required percentages of humidification of inclosed air, in which provision is made for cooling the inside air in warm weather and for heating it in cold weather.

Other objects of the invention are to so control the humidifying as to give any required percentages of saturation regardless of the temperature of the inclosed air; also to effect this latter result automatically; and also to utilize the heat of the internal air however generated, for heating the entering air in the moistener to the degree necessary for it to assimilate a required amount of moisture.

These objects are accomplished by supplying the room or building with the necessary volume of outside or fresh air saturated with moisture to the dew point at a temperature which is a predetermined number of degrees below the desired temperature to be maintained in the room, such that, when raised to such desired room temperature, it will have the required relative humidity or percentage of moisture. For example, suppose the room temperature be 80° F. and it be required to maintain this temperature with a relative humidity of seventy-five per cent. This requirement for the room demands approximately 8.3 grains of moisture per cubic foot, which corresponds to a dew point of 71°. The entering air must therefore be saturated at this temperature and, if necessary, the air must be brought to this temperature in the humidifier by heating or cooling it.

I have discovered that for any definite percentage of humidity between 60% and 80% (which include the percentages ordi-

narily required) the difference between the temperature of the room and the corresponding dew point at said humidity is practically constant for all room temperatures between 65° and 95°.

The percentage of humidity of the inside air can be controlled by securing a definite difference between the temperatures of the inside air and saturated entering air, depending upon required percentage of humidity, and this difference is preferably obtained in the manner hereinafter explained. In warm weather the air is saturated by subjecting the same to an atomized spray of water at normal atmospheric temperature, a perfect saturation being effected by supplying the spray water under a constant pressure and volume greatly in excess of the humidifying requirements.

By the proper design of the moistening means and the use of sufficient pressure, the air can be brought uniformly to the point of saturation independent of its initial condition. After saturating the air, the excess or free moisture is eliminated and the moistened air is conveyed through suitable ducts and discharged into the building under a pressure or plenum sufficient to cause an outward leakage at all parts of the building, thereby effectually preventing the inward leakage of outside air. In saturating the air by an atomized spray at atmospheric temperature, it is found that the air is cooled an amount which is exactly proportional to the moisture absorbing capacity of the air, and that the cooling effect of complete saturation is equal to the difference between the wet and dry bulb temperatures of the air entering the moistener, as indicated by the psychrometer, *i. e.* to the wet bulb depression. Hence it follows that the air is cooled to the temperature of the entering air indicated by the wet bulb. For example, suppose that only outside air is being used, the dry bulb temperature of which is 90° and the wet bulb temperature 75°, then the air will absorb twenty-three grains of moisture per pound at the point of adiabatic saturation and will be cooled thereby to a temperature of 75°, a reduction of 15°, owing to the transformation of the sensible heat of the air into the latent heat of the water vapor, so that the temperature of the air supplied to the room will be practically the same as the wet bulb temperature of the outside air used. The spray water, which is circulated and repeatedly used, remains at the wet bulb temperature of 75°.

If the temperature of the outside air is so low that it will not hold sufficient moisture to give the proper percentage of humidity in the room at the desired room temperature, then its temperature must be raised preferably by returning a portion of the warm air from the building or room to the humidifier and there mixing it in proper proportion with the colder outside air to obtain the proper temperature at saturation. For example, suppose the room temperature be 80° F. and it be required to maintain this temperature with a relative humidity of 75 per cent. when the temperature of the outside air is 75° dry bulb and 60° wet bulb. This requirement for the room demands approximately 8.3 grains of moisture per cubic foot, which corresponds to a dew point of 71°, at which temperature the saturated air must leave the humidifier. But if only outside air were used and no heat added thereto, it would, as above stated, leave the humidifier at 60° and would contain only 6.4 grains of moisture per cubic foot, a deficit of 1.8 grains. Therefore, to obtain the proper temperature a mixture of approximately thirty-five per cent. of air returned from the room and sixty-five per cent. outside air is formed. This mixture adiabatically saturated will hold the necessary 8.3 grains of moisture per cubic foot at 71°. The proportion of outside air to air returned from the room will vary anywhere from all outside air with no air return in hot weather, to seventy to eighty per cent. air return with twenty to thirty per cent. of outside air in cold dry weather. The mixture of outside and return air can be secured by hand, with the aid of suitable charts indicating the required proportions of the mixture for the different conditions, but preferably this is accomplished by automatic means controlled by a differential thermostat which is influenced by the temperatures obtaining in the room and in the saturated air in the humidifier. When the temperature of the outside air is so low that the required saturation temperature cannot be obtained by a reasonable proportion of return air from the room, the entering air should be heated the necessary additional amount in some suitable way, preferably by heating the spray water sufficiently to produce the necessary rise in temperature of the air being saturated.

The described fixed relation between the temperatures of the saturated air which is introduced into the room or building, and the air in the room or building must be maintained, and to do this there must be an equilibrium between the cooling and heating effects in the building by whatever means they are caused.

This system is such that the percentage of humidity can be maintained constant regardless of the temperatures inside and outside of the building and regardless of the volume of air supplied.

As the heating of the air after saturation does not alter its moisture contents, it is possible by placing an indirect heater in the duct for the entering air, to heat this air as required to regulate the temperature of the

air in the room or building without in any way affecting the control of the humidity.

An apparatus adapted for carrying out the above described method is illustrated in the accompanying drawing, in which—

Figure 1 is a diagrammatic view, partly in plan and partly in horizontal section, of the apparatus. Fig. 2 is an enlarged section of the dampers controlling the entrance of air to the humidifier.

Like letters of reference refer to like parts in both figures.

A represents a room or building in which the condition of the air is to be controlled.

B represents an air trunk or conduit having inlet openings b b', respectively, for outside air and for return air from the building, and one or more discharge ducts b^2 suitably placed to prevent objectionable drafts in the building. The inlet openings b b' are controlled by suitable dampers C C'.

D represents a fan or blower for conveying air through the trunk and discharging it into the building at the required pressure, and E represents a suitable air moistening device consisting of atomizers or sprayers in the air trunk adapted to fill the adjacent part of the trunk with a very fine mist or spray of water and completely saturate the entire volume of air passing through the trunk. The moistener is supplied with water by a pump e which connects with the sprayers and with the bottom of the air trunk by discharge and suction pipes e' e^2, respectively, whereby the water is circulated and used over and over again. A steam injector or other heater F is provided whereby the water can be heated when necessary. The water is delivered to the moistener in volume and under pressure greatly in excess of the humidifying requirements, whereby the air can be completely saturated at the required temperature. The air leaving the humidifier passes through a suitable eliminator G which removes therefrom the free particles of water, thus leaving in the air only the water vapor which has been properly assimilated. An eliminator consisting of spaced zig-zag baffle plates of the type disclosed in U. S. Letters Patent No. 808,897, granted to me Jan. 2, 1906, is preferably employed.

The temperature of the air entering the humidifier can be regulated to give the required difference of temperature between the saturated air and the air in the building, as explained, by adjusting by hand the dampers C C' to give a proper mixture of the outside and return air, or by regulating the temperature of the spray water, or by a combination of these means, but the regulation is preferably effected automatically by properly proportioning the mixture of outside and return air by means controlled by a differential thermostat H. The thermostat in the apparatus shown is located in the building, one element thereof being influenced by the surrounding air, while the other element is influenced by the temperature of the saturated air in the air trunk which is conveyed to the thermostat through a branch pipe h leading from the air trunk and insulated from the surrounding air. The thermostat could, if preferred, be located elsewhere so long as the saturated air of the humidifier and air of the building are caused to act conjointly upon its elements. The thermostat is arranged to control the inlet dampers C C', or the water heater F, or both, or any other means for regulating the temperature of the air in the humidifier through suitable connections. As shown, the thermostat operates a valve i in a pipe i' to control the flow of compressed air from a reservoir i^2 to diaphragms or other devices i^3 i^4 for operating the air inlet dampers C C' of the air trunk and a valve i^5 in the steam connection to the water heater. The two air inlet dampers are arranged and connected to each other and to the operating device by the links and levers shown, or other means whereby one damper will be closed as the other is opened.

The parts are proportioned and adjusted to maintain the proper relation between the temperature of the saturated air in the humidifier and the air in the building, and the thermostat can be adjusted to give various definite differences between said temperatures to enable the air in the building to be brought to different percentages of saturation for any required temperature. A differential thermostat adapted for thus controlling the temperature of the air in the humidifier is disclosed in a concurrently pending application.

K represents the heater in the discharge end of the air trunk for heating the humidified air for the purpose of controlling the temperature of the air in the building.

While heating the humidified air does not alter its moisture contents, the relative humidity of the air will of course depend upon its temperature.

I claim as my invention:

1. The herein described method of controlling the humidity of air in an inclosure, consisting in introducing into the inclosure air which has been substantially saturated with moisture, and regulating the temperature at which the air is saturated so as to maintain a substantially fixed difference between the temperature existing in the inclosure and the temperature of the saturated air, substantially as set forth.

2. The herein described method of controlling the humidity of air in an inclosure, consisting in introducing into the inclosure air which has been substantially saturated with moisture, and maintaining a subtantially fixed difference between the tempera-

ture in the inclosure and the temperature of the saturated air irrespective of changes in the temperature of the air in the inclosure or of the air entering the humidifier, substantially as set forth.

3. The herein described method of maintaining a substantially fixed percentage of humidity in an inclosure, consisting in introducing into the inclosure air which has been substantially saturated with moisture, and automatically regulating the temperature at which the air is saturated so as to maintain a substantially fixed difference between the temperature existing in the inclosure and the temperature of the saturated air, substantially as set forth.

4. The herein described method of controlling the humidity of air in an inclosure, consisting in introducing therein air which has been substantially saturated with water, and maintaining a predetermined relation between the temperature of the saturated air and the temperature in the inclosure by automatically mixing in different proportions warm moist air from the inclosure with the other air before saturating it, substantially as set forth.

5. The herein described method of controlling the humidity of air in an inclosure, consisting in introducing therein air which has been substantially saturated with water, and maintaining a predetermined relation between the temperature of the saturated air and the temperature in the inclosure by automatically regulating the temperature of the air before saturating it, substantially as set forth.

6. The herein described method of controlling the humidity and temperature of the air in an inclosure, consisting in introducing into the inclosure air saturated with moisture at a temperature which is maintained at a substantially fixed number of degrees below the temperature existing in the inclosure, and increasing the temperature of the air which is introduced after saturation to regulate the temperature in the inclosure, substantially as set forth.

7. The herein described method of controlling the humidity of air in an inclosure, consisting in introducing therein outside air saturated substantially to the dew point with water and regulating the temperature of said dew point by automatically mixing warm moist air from the inclosure with the outside air before saturation in different proportions by means influenced by the differential temperatures of the air in the inclosure and the saturated air, substantially as set forth.

8. The herein described method of controlling the humidity of air in an inclosure, consisting in introducing therein air saturated substantially to the dew point with water and regulating the temperature of said dew point by automatic means influenced by the differential temperatures of the air in the inclosure and the saturated air, substantially as set forth.

9. The herein described method of maintaining a substantially fixed percentage of humidity in air notwithstanding variations in the temperature thereof, consisting in introducing therein air saturated substantially to the dew point with water, and maintaining a substantially constant difference between the temperatures of the saturated air and the other air, substantially as set forth.

10. The herein described method of maintaining a substantially fixed percentage of humidity in air notwithstanding variations in the temperature thereof between 65° F. more or less and 95° F. more or less, consisting in introducing therein air saturated substantially to the dew point with water, and maintaining a substantially constant difference between temperatures of the saturated air and the other air, substantially as set forth.

11. The herein described method of maintaining a substantially fixed percentage of humidity in an inclosure, consisting in introducing into the inclosure air which has been substantially saturated with moisture, and automatically maintaining a substantially fixed difference between the temperature in the inclosure and the temperature of the saturated air, irrespective of changes in the temperature in the inclosure or of the air entering the humidifier, substantially as set forth.

12. The herein described method of maintaining a substantially fixed percentage of humidity in the atmosphere of an inclosure notwithstanding variations in the temperature thereof, consisting in introducing into the inclosure air saturated substantially to the dew point and maintaining a substantially constant difference between the temperatures of the entering saturated air and the air in the inclosure by mixing air from the inclosure in different proportions with said entering air before saturation, substantially as set forth.

13. The herein described method of maintaining a substantially fixed percentage of humidity in an inclosure irrespective of changes in the temperature therein, consisting in introducing into the inclosure air saturated with moisture, and automatically regulating the temperature at which the air is saturated by means influenced by the temperatures of the air in the inclosure and of the saturated air so as to maintain a substantially fixed difference between the temperature existing in the inclosure and the temperature of the saturated air, substantially as set forth.

14. The herein described method of controlling the humidity of air in an inclosure,

consisting in introducing therein air saturated substantially to the dew point with water, and automatically regulating the dew point temperature of the saturated air to maintain a substantially constant difference between said dew point temperature and the temperature of the air in the inclosure, substantially as set forth.

15. The herein described method of controlling the humidity of air in an inclosure, consisting in introducing therein air saturated substantially to the dew point with water, and regulating the dew point temperature of the saturated air to maintain a predetermined temperature difference between said saturated air and the air in the inclosure by automatic means influenced by the differential temperatures of said saturated air and the air in the inclosure, substantially as set forth.

Witness my hand, this 14th day of May, 1907.

WILLIS H. CARRIER.

Witnesses:
CHAS. W. PARKER,
E. C. HARD.