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METHOD OF HUMIDIFYING AIR

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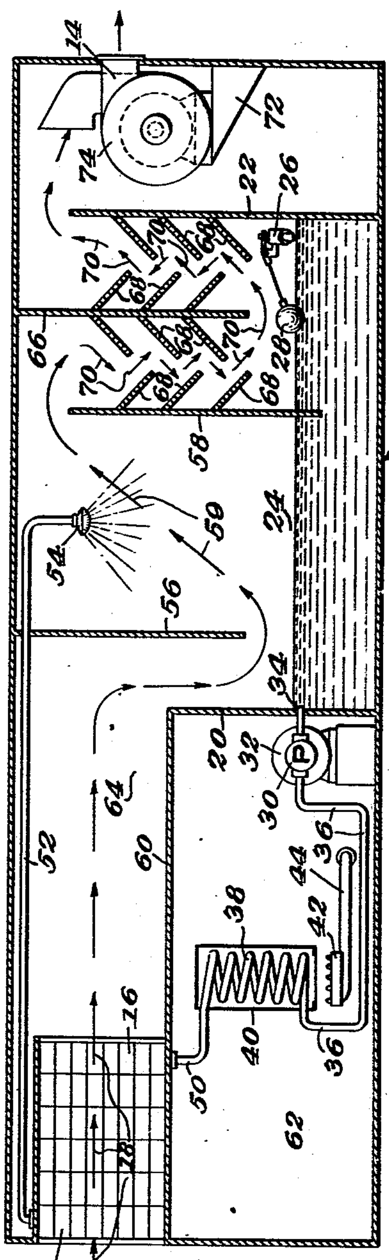

Fig. 1

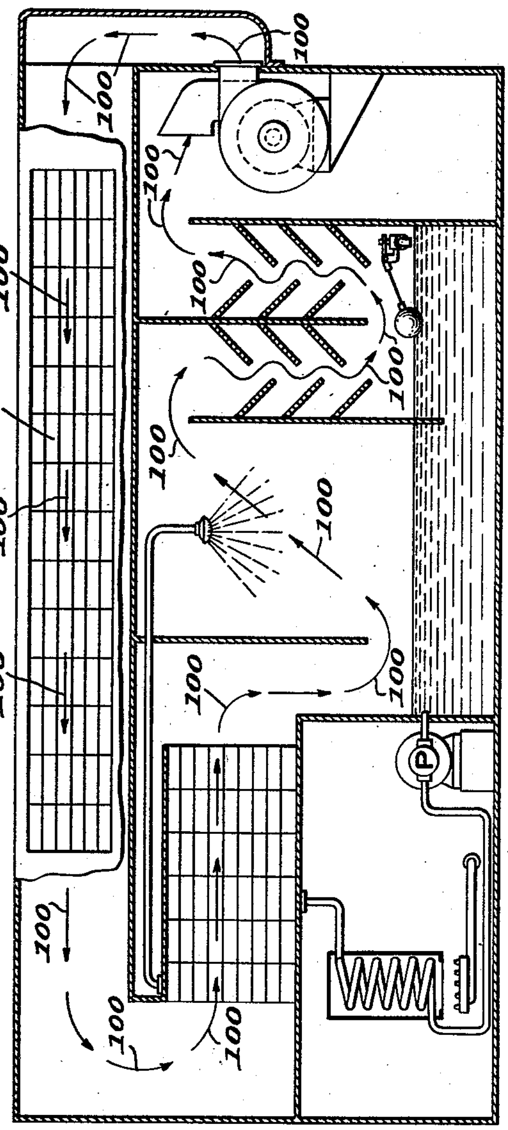

Fig. 2

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METHOD OF HUMIDIFYING AIR

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3 Claims. (Cl. 183—23)

This invention relates to a novel method of humidifying air in a controlled area which relies upon the principle of vapor pressure differential, rather than air in motion, or large numbers of outlets for distribution of moisture.

The present application is a continuation in part of my co-pending application Serial No. 313,387, filed January 11, 1940.

Humidifiers heretofore in use, so far as I am aware, all operate upon the principle of carrying the moisture in suspension or entrained in the air and distributing it by having large numbers of sprays throughout the area to be humidified, or by forcibly circulating the processed air throughout the area by large ducts. Thus steam ejectors, atomizers, operated by compressed air or centrifugal sprayers, central washer systems and devices which draw air through moistened fibers, are all humidifiers which operate on this principle of ejecting fine particles of moisture into the air. My system, on the other hand, seeks to eliminate all the fine particles of moisture carried in suspension in the air, and to rely solely upon vapor pressure differential for distribution of the moisture. By so doing, my method overcomes and eliminates the many disadvantages of these previous systems, makes possible great economies in air humidification, both in cost of installation and operation, and at the same time provides greater efficiency of operation and control.

The distinction between my method and previous methods of humidification is best brought out, because of their superficial similarities, by a comparison of my method with the central washer system in common use. The central washer system circulates the room air through the unit by means of large fans, and water is sprayed into the air while being circulated through the unit, and the moisture is then carried in suspension and distributed about the area to be humidified by means of large ducts, which extend into every portion of the area. The moisture particles, being heavier than air, would otherwise drop to the floor and not circulate if not carried by a rapidly moving current of air. Because of heat losses due to moisture evaporation, the air is occasionally heated up to room temperature before being ejected into the room, to maintain the room temperature. In some instances the water itself may be heated for the same purpose. But in no case is the air or water heated to create a high vapor pressure or to distribute the moisture by vapor pressure differential. Whatever vapor pressure may exist in such a system is wholly insufficient and is not relied on to distribute the moisture. A low vapor pressure differential will not suffice because it will not have sufficient force of distribution and will lose its temperature before proper distribution of moisture can occur, and so cause precipitation. The moisture is distributed by means of fans forcing the air through large ducts which extend to every portion of the area to be humidified and for proper humidification large quantities of air must be continuously circulated. To take a typical installation, where a room area of 50,000 cubic feet is to be maintained at 70° F., and 50 percent relative humidity with 0° F., temperature outside (which carries practically no moisture), the central washer system at the minimum is required to circulate 40 pounds or 280,000 grains of water per hour, or 4,666.6 grains per minute. As 110 grains of water per pound of air is the maximum carrying capacity or saturation point of air at room temperature, 70° F., and the room air entering the unit is already at approximately 50 percent humidity, containing 55 grains of water per pound of air, the capacity of the system to deliver additional and surplus moisture is the difference, or only 55 grains per pound of air. To deliver such 55 grains, 934 pounds of air or 13,076 cubic feet of air per minute are required to be delivered (obtained by dividing 4666.6 grains per minute by 55, and multiplying by 14 cubic feet, the volume of air per pound at 70° F.) As this amount of air entering the unit at 70° F., loses 20° temperature in passing through, which at least halves the moisture-carrying capacity of the air, and if heat is not applied to bring the processed air up to 70° F., 26,000 cubic feet of air per minute (at 50° F.) are required to carry this amount of moisture. If heat is applied to the processed air to offset the heat loss due to vaporization, the 13,076 cubic feet of air per minute will suffice. Without the heat, therefore, the air must be changed once every 2 minutes or 30 times per hour, and if heated, once every 4 minutes or 15 times per hour. To distribute such a vast quantity of air large duct work and fans are required. In winter, the complete changing of air as much as 15 times per hour is very undesirable, because it causes drafts and is injurious to health. To avoid this, systems of much larger capacity are intalled, to permit the air to be changed less frequently. The cost of installation of a unit designed to maintain these conditions, with the large fans, motors, pumps and duct work required, is at least $10,000. The problem of condensation is an additional difficulty, with long and extensive ducts, for if a draft condition occurs anywhere, the moisture will condense and must be drained off. At the same time, with every drop in temperature of 17½° F., the moisture-carrying capacity of the air is cut in half. Draft conditions, therefore, seriously impair the efficiency of the system and require insulation of the ducts to prevent cooling and condensation.

My system, briefly, involves creating a high vapor pressure differential by heating a quantity of water and air, and releasing the vapor at high pressure into the room to be controlled, and relying upon the high vapor pressure differential to carry the water vapor into the far corners of the room by quickly equalizing with the vapor pressure therein. The vapor pressure created by the unit must be high enough to carry the vapor throughout the area to be controlled by itself, without independent carrying means, and to do so before its temperature loss can cause precipitation, and to carry sufficient heat in latent form so as not to materially affect the sensible heat of the controlled area. I seek to avoid entirely the carrying of particles of moisture in suspension, because of the condensation problem they create, their cooling effect on the room temperature and the large volumes of air they require to hold them in suspension. Thus, large fans and duct work for distributing the moisture by circulating large quantities of air are unnecessary and can be eliminated. A unit embodying my method and humidifying the same area and maintaining the same conditions as above need circulate only 250 cubic feet of air or vapor per minute, and such a unit can be installed for $1000, and can be operated for considerably less than a corresponding central washer type. With my high vapor pressure the condensation problem is entirely eliminated because, before a temperature drop occurs, sufficient to cause condensation, the vapor has already equalized and dispersed. The degree of vapor pressure required in any instance is a mere matter of computing the requirements of the particular job, and is determined by the capacity of the unit to deliver processed air, the amount of moisture required to be replaced in any given amount of time, the vapor pressure required to carry it throughout the area before temperature loss occurs which can cause precipitation, and the latent heat of the vapor so as not to upset the temperature of the controlled area. The temperature to which the water and air is heated in any particular instance likewise depends upon the vapor pressure required. The temperature of the water will run between 100° F., and its boiling point, and the temperature of the air will in general correspond, but can be higher. Such computations can be made by any competent humidification engineer, after he understands my method of humidification, and a practical example is given below in the specification.

Before explaining in detail the present invention it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawing, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation, and it is not intended to limit the invention claimed herein beyond the requirements of the prior art.

In the drawing:

Fig. 1 is a longitudinal section through a humidifier capable of performing in accordance with the present, novel method.

Fig. 2 is a longitudinal section through a modified humidifier.

Referring to the drawing and particularly to Fig. 1 thereof, the reference numeral 10 designates a suitably constructed container which is closed except for an air inlet 12 and an air outlet 14. The container is preferably placed in the enclosed space whose air is to be humidified. Suitably mounted in the container at the inlet 12 thereof is a conventional shell and tube-type heat-exchanger 16 through which air must pass and be heated in order to enter the container in the manner indicated by the arrows 18. Also provided in the container 10 by transverse partitions 20, 22 is a reservoir 24 which contains water. Water from any suitable source is admitted to the reservoir 24 through a valve 26, having a conventional air-filled float 28 for controlling the valve so that the water level remains substantially constant. A suitable pump 30, driven by an electric motor 32, has its intake side in permanent communication with the water supply in the reservoir through a conduit 34, while its discharge side communicates through a conduit 36 with the intake end of any suitable heater coil 38 in a shell 40, whose bottom end is open to admit the heat from a gas burner 42 and whose top end communicates with a flue (not shown) for the escape of the products of combustion. The gas burner 42 has a conventional automatic pilot which ignites the burner when gas from any suitable source is admitted through a conduit 44. It is to be understood, of course, that other sources of heat may be used instead of the gas flame, such as steam, oil, electricity and the like. The discharge end of the heater coil 38 communicates through a conduit 50 with the water intake end of the heat exchanger 16 through which water flows counter to and separated from the flowing air therein and in heat-exchange relation with the latter. The water discharge end of the heat exchanger 16 is connected through a conduit 52 with a spray nozzle 54 which is adapted to spray hot water through the flowing heated air in the container and into the reservoir 24. Suitable transverse baffles 56 and 58 in the container cause the heated air to flow counter to the water spray from the nozzle 54 as indicated by the arrows 59. A horizontal partition 60 in the container together with the previously mentioned partition 20 therein form not only a separate chamber 62, in which the motor driven pump 30 and the water heater 38, 40 and 42 are housed, but also an air duct 64 from the inlet 12 to the reservoir 24. Provided on the earlier mentioned baffle 58 and partition 22 and on an intermediate partition 66 are eliminator plates 68 past which the heated and sprayed air flows in the manner indicated by the arrows 70. These eliminator plates remove any moisture in suspension from the air stream. It is to be understood, however, that the eliminator plates may be dispensed with and moisture in suspension may be largely prevented by adjusting the velocity of the water spray. Suitably mounted in the container 10 as on the pedestal 72, for instance, is a motor-driven fan 74 whose discharge end communicates with the outlet 14. The fan 74, when operating, draws air into the container through the inlet 12 and causes it to flow therein in the manner indicated by the arrows 18, 59 and 70 before being expelled through the outlet 14.

Any suitable automatic means (not shown), such as a humidostat may be used to start and control the operation of the motor-driven pump 30, burner 42 and motor-driven fan 74 in accordance with the varying demands for humidity. When the pump 30, burner 42 and fan 74 operate, water from the reservoir 24 is forced through the heater coil 38 and then through the heat exchanger 16 from where it passes to the spray nozzle 54 and thence back to the reservoir. While flowing through the heater coil 38, the water becomes heated and in turn heats the air drawn through the heat exchanger 12 by the fan 74. Thus, both the air flowing through the container and the water sprayed from the nozzle 54 into the flowing air stream are heated.

My invention is based upon the discovery that different vapor pressures in different air masses will almost instantaneously equalize to a common vapor pressure when said air masses come in contact with each other. Actual tests have shown that vapor transfer takes place from a higher to a lower pressure even where the vapor has to travel counter to an air stream such as one having a velocity of 3000 feet per minute, for instance. Vapor will, therefore, flow from a higher to a lower pressure independently of any air motion. Thus, where the vapor pressure is high in one part of a room and lower in the rest of the room, the high vapor pressure will quickly disperse and distribute its moisture evenly, independently of any air motion, to the rest of the room until the vapor pressure throughout the room is uniform. I use this principle to great advantage in the present humidifying method to distribute the moisture evenly throughout the controlled area, independent of other carrying means, and for this purpose I obtain a very high vapor pressure in the air treated in the container. In order to accomplish this, the air in the container must have the high temperature at which such a high vapor pressure is possible. As the vaporization of the considerable moisture added will entail considerable heat losses, considerable heat has to be furnished in excess of that required to bring the air, which is to carry the added moisture, to said high temperature. The spray water as well as the flowing air in the container are accordingly heated to the requisite high temperatures by the water heater 38 and by the heat-exchange between the heated water and the indrawn air in the exchanger 16.

As a practical example of the applied method, if a heated room is sought to be maintained at a temperature of 80° F., and 40 percent relative humidity (.44 inch of mercury vapor pressure) this can be done by heating the spray water in the heater coil 38 to approximately 180° F., while the indrawn air because of heat losses is being heated in the exchanger 16 and by the water spray from the nozzle 54 to an approximate temperature of 150° F. Due to the heat losses on account of the evaporation of the moisture, the temperature of the air at the outlet of the container drops to approximately 104° F., and its relative humidity is around 80 percent, corresponding to a water vapor pressure of 1.4 inches of mercury. Hence the vapor pressure differential at the outlet of the container and in the rest of the room is 1.4 minus .44 or .96 inch of mercury column, with the result that the vapor flows immediately from the higher pressure to the lower pressure. For other conditions, as for humidifying the otherwise conditioned air of a large hall or workshop, for instance, the vapor pressure of the air treated in a small size humidifier may be raised to 3 or 4 inches of mercury column, by increasing the temperature of the air, or the water or both, and the ensuing flow of vapor may suffice to humidify the air in said hall or workshop satisfactorily. The precise temperature of the water (below its boiling point) and of the air, in any instance, is dependent upon the vapor pressure required in that instance, which in turn is dependent upon the volume of the area to be controlled, the temperature and relative humidity desired, and the capacity of the unit. Thus a humidifying unit operating according to my method and having the capacity of circulating 250 cubic feet of air per minute, evaporating 4 gallons of water per hour with a B. t. u. input of 66,000 per hour will maintain the following areas (of normal closed construction and leakage), at the temperatures and relative humidity indicated (when the outside air contains no moisture, as at 0° F.):

Temperature of space

Relative humidity, percent	70°	75°	80°	85°
25	100,000	90,000	72,000	64,000
30	90,000	72,000	64,000	36,000
35	75,000	64,000	36,000	28,000
40	65,000	36,000	28,000	17,000
45	50,000	30,000	20,000	14,000
50	35,000	25,000	15,000	12,000

My method constitutes a radical departure from the accepted mode of humidifying air by the hitherto known conditioners which are more or less general purpose units attempting humidification besides performing other air-conditioning functions such as heating, cleaning the air, etc. These known conditioners rely for the distribution of the added moisture, on large volumes of air currents which carry most of the moisture in suspension and not in a gaseous vapor state. Large volumes of air currents moreover change the temperature of the air in the room to be treated so that the known conditioners are not at all usable where otherwise conditioned air is to be kept at a certain temperature and humidity, as in a variety of industrial plants, for instance. As in the present method air motion takes no part in the distribution of the vapor under high pressure, the transmission of the sensible heat of the treated air in the unit to the air in the room may be curbed to such an extent that the temperature of the room air is not noticeably changed. Thus, a very small volume of air in the unit capable of carrying a large quantity of moisture, as vapor under high pressure, is sufficient to humidify the air in a large space. While the processed air as it is released may have a temperature of 104° F., as in the example given above, it is in the form of latent heat, which is given up as the vapor pressure lowers, and the gas expands. As the pressures equalize, the temperatures also equalize without noticeably or materially affecting the sensible heat of the controlled area. Hence, whatever portion of the sensible heat of the small volume of air in the unit may be transmitted to the large air body outside the unit does not noticeably change the temperature in the controlled area. In fact, with the present method, air circulation may be entirely restricted to the inside of the unit, and the fan 74 may be used for this purpose only, as shown in the modification shown in Fig. 2. With such a system, the sensible heat escaping to the area to be controlled may be reduced to a minimum, and may be further reduced by insulation if desired. The sensible heat circulated by the unit in Fig. 1, however, is so small as not to noticeably or materially affect the sensible heat of the controlled area, and is not a practical problem. It is unnecessary for the processed air of high vapor pressure to be ejected or circulated into the controlled area, although I prefer to do so, as in the unit shown in Fig. 1, because of the greater speed and efficiency of the equalizing reaction. All that is necessary is that contact or exposure be permitted between the high vapor pressure in the unit and the low vapor pressure in the controlled area.

In the modification shown in Fig. 2, the treated air of high vapor pressure is circulated within the unit as indicated by the arrows 100 and is not expelled into the room, but contact or exposure of the high pressure vapor with the low pressure vapor of the controlled area is permitted through a grill 102 in the circulatory passage provided in the unit.

I claim:

1. The method of humidifying air in a controlled area, which comprises heating water and a volume of air causing intimate contact between said heated air volume and water whose temperatures are such that the evaporated water absorbed by said air volume has a vapor pressure of more than an inch of mercury, and then bring said high pressure vapor into contact with said controlled area, whereupon vapor flows from the former to the latter independently of any air motion until equal vapor pressure prevails in the contacting air masses, said high pressure vapor having sufficient heat in latent form as not to noticeably change the temperature of the controlled area.

2. The method of humidifying air in a controlled area, which comprises heating water and a volume of air separately, spraying the heated water into the heated volume of air whose temperatures are such that the evaporated water absorbed by said air volume has a vapor pressure several times higher than that of said controlled area, impinging the water-sprayed air against a surface to remove moisture in suspension from said air, and then bringing said high pressure vapor into contact with said controlled area whereupon vapor flows from the former to the latter independently of any air motion until equal vapor pressure prevails in the contacting air masses, said high pressure vapor having sufficient heat in latent form as not to noticeably change the temperature of the controlled area.

3. The method of humidifying air in a controlled area, which comprises circulating air apart from said controlled area, heating water, heating the circulating air at a certain station, causing at another station of said air circulation intimate contact between said heated water and air whose temperatures are such that the evaporated water absorbed by said heated air has a vapor pressure several times higher than that of said controlled area, and then providing at a third station of said air circulation such communication between said heated air and said controlled area that the former continues in its circulatory path while vapor flows from said heated air to said controlled area independently of any air motion until equal vapor pressure prevails, said high pressure vapor having sufficient heat in latent form as not to noticeably change the temperature of the controlled area.

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