March 7, 1939. W. H. COOK 2,149,990

HUMIDITY CONTROL FOR REFRIGERATED SPACES

Filed Nov. 22, 1937 2 Sheets-Sheet 1

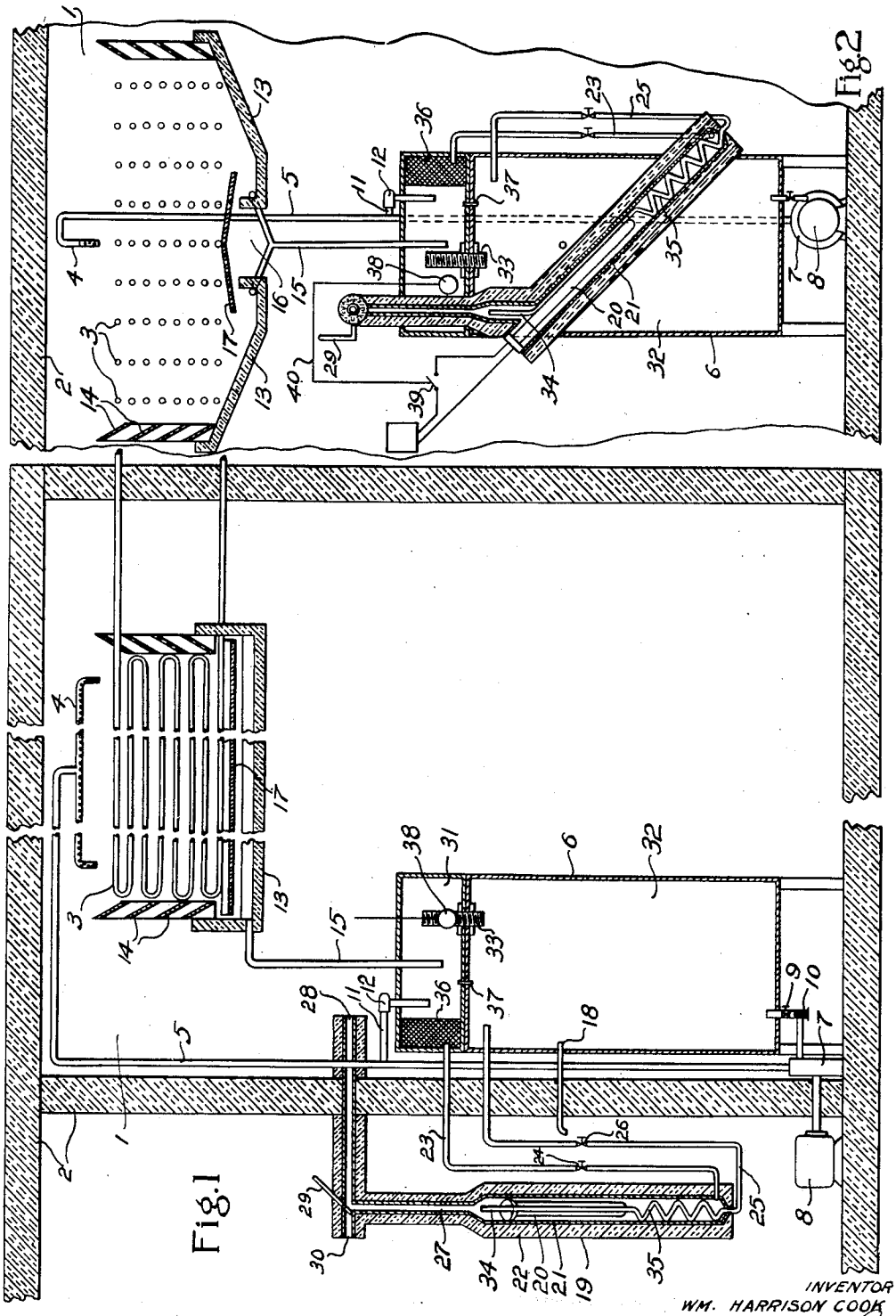

Fig. 1

Fig. 2

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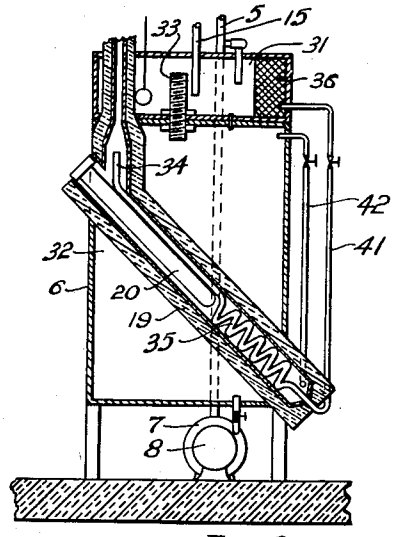

Fig.3

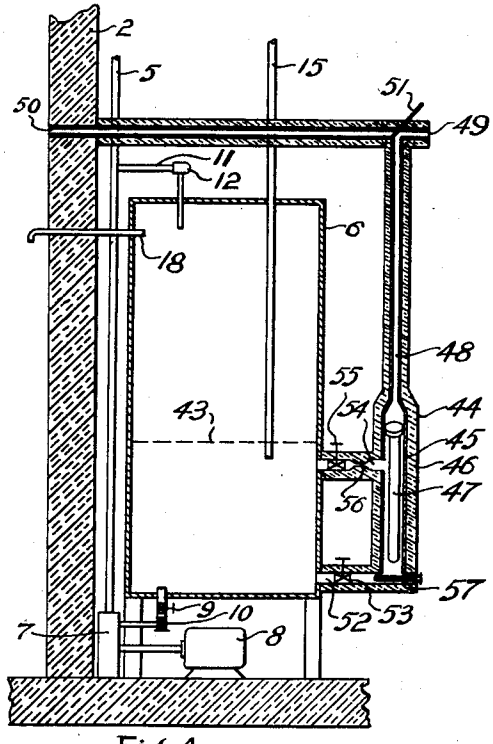

Fig.4

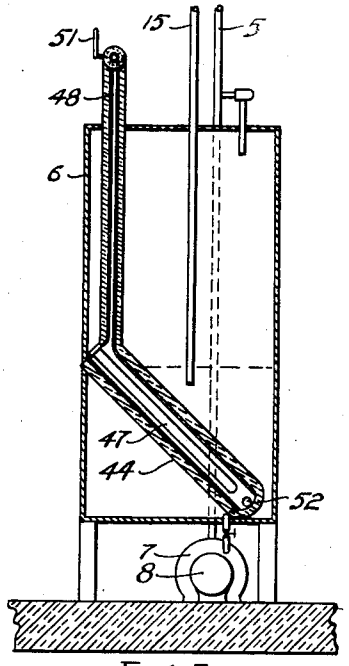

Fig.5

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HUMIDITY CONTROL FOR REFRIGERATED SPACES

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12 Claims. (Cl. 62—103)

This invention relates to a method and means for maintaining and controlling humidities of the atmosphere in refrigerated storage compartments.

An object of the invention is to provide a method and means for maintaining and controlling the humidity in refrigerated spaces with the minimum addition of heat to the refrigeration load.

A further object is to increase the efficiency of heat transfer from surfaces of the cooling elements to the atmosphere in refrigerated spaces by maintaining these surfaces free from ice by means of liquid flowing over them. The prevention of ice formation on the cooling surfaces also avoids the addition of the latent heat of fusion of such ice to the refrigeration load.

Broadly the invention consists in spraying a suitable liquid over the cooling elements to prevent moisture freezing thereon and to collect condensed moisture, collecting this liquid for recirculation, and causing a portion of the liquid to be boiled in an insulated heater to provide water vapor which is discharged into the refrigerated space when high humidities are desired, or which is exhausted externally of the refrigerated space when lower humidities are desired.

The invention will be described with reference to the accompanying drawings, which are more or less diagrammatic and in which,

Figure 1 is a sectional view of an apparatus embodying the invention as applied to a cold storage space,

Figure 2 is an end sectional view of the apparatus, the intervening wall of the storage space being omitted,

Figure 3 is a partial end sectional view of a modified form of apparatus,

Figure 4 is a side sectional view of another form of heater arrangement and

Figure 5 is an end sectional view of the arrangement shown in Figure 4.

In the drawings, 1 is the refrigerated space having insulated walls 2, and 3 the cooling coils, containing a refrigerant, preferably positioned in the upper portion of the space.

Means for preventing ice formation on the cooling coils as a result of freezing of condensed moisture thereon comprise a spray pipe 4 located above the coils in a position to spray the same, a pipe 5 for supplying spraying liquid thereto, a tank 6 containing a suitable liquid, and a pump 7 with motor 8 for circulating the liquid through the pipe. A valve 9 and a screen 10 for the liquid may be provided adjacent the inlet of pipe 5. A pressure release for the liquid in pipe 5 consists of a pipe 11 leading into the tank provided with a relief valve 12.

The liquid employed must be capable of dissolving ice at the temperature of the cooling surfaces of the refrigeration coils, and also of yielding only an aqueous vapor when heated. Brines, for instance, calcium chloride, are suitable, as are also solutions of ethylene glycol. Obviously the liquid used will have a lower vapor pressure than that of ice at the temperature of the refrigerating surfaces and the vapor pressure, which varies with concentration of the liquid, makes dehumidification possible when the aqueous vapor is exhausted externally.

Means for collecting the sprayed liquid and returning it to the tank comprise drip pans 13, insulated on the under side where necessary and located below the coils, louvers 14 at the side of the coils for directing the liquid into the pans and a return pipe 15 leading from the pans to the tank. A space 16 is provided between the pans to ensure necessary air circulation around the coils, baffles 17 being provided above the space to direct the sprayed liquid into the pans. A tank overflow pipe 18 may be provided.

Means for maintaining a suitable humidity in the refrigerated space comprises a heater 19 preferably positioned outside the space, as shown in Figure 1, and having an electrical heating element 20 within a casing 21 surrounded with insulation 22. Liquid is supplied to the heater by means of a pipe 23 having a valve 24, a return pipe 25 having a valve 26 being provided for the liquid. Water vapor formed in the heater rises through an insulated channel 27 for escape through an outlet 28 to the refrigerated space when a higher humidity is required therein or, by means of a flap valve 29, through an outlet 30 to the exterior of the space when a lower humidity is required. In large refrigerated spaces, it may be necessary to provide a distributing fan for the vapor at the outlet 28.

A circulation of the liquid through the heater and back to the tank must be provided to prevent accumulation of the non-aqueous portion in the heater. Since the concentration of the liquid with respect to the non-aqueous phase must be changed to accord with the temperature of the cooling surfaces, the rate of circulation should be varied accordingly. For instance a highly concentrated solution necessitates a greater volume of liquid in circulation through the heater than with dilute solutions if accumulations of the non-aqueous portion therein are to be avoided. Ac-

cording to the invention the circulation between the heater and the tank is preferably restricted to the minimum needful for the operation so that the minimum amount of sensible heat is added to the tank. It is obvious that the sensible heat added to the tank is added directly to the refrigerating load, which is preferably kept as low as possible.

The restriction and control of the circulation are accomplished by a particular arrangement of the tank and heater without placing undue restrictions in the pipe line. The tank 6 is divided into an upper or auxiliary compartment 31 and a lower or main compartment 32. As shown, the inlet pipe 23 for the heater leads from the auxiliary compartment, and the return pipe 25, which communicates with a standpipe 34 through a heat exchanger 35 in the heater, empties into the main compartment. The return pipe 15 from the drip pans empties into the auxiliary compartment and the level of liquid therein is controlled by means of an adjustable standpipe 33 leading from the auxiliary to the main compartment. The heater is so positioned adjacent the tank that it will be fed by gravity with liquid from the auxiliary compartment 31, the inlet pipe 23 communicating with the bottom of the heater casing 21. It will be observed that the inlet of standpipe 34 is below the inlet to pipe 23 in the compartment 31 and at substantially the same level as the outlet of pipe 25. A head of liquid is thus provided to control the flow of the portion of liquid to be circulated through the heater. The rate of flow through the heater is determined by the difference in level between the standpipe 34 and the level in the auxiliary compartment 31, which latter level is regulatable by the adjustable standpipe 33.

In order to conveniently accommodate the heater adjacent the tank, it may be inclined somewhat as shown in Figure 2.

The stand pipe 34 in the heater communicates with return pipe 25 through the heat exchanger 35. When the apparatus is in operation liquid flows down through the heat exchanger, where as much as possible of the heat is removed, then upward through a vertical portion of pipe 25, to prevent air locks, and finally discharges into the main compartment of the tank 32, at a level substantially the same as that of the heater standpipe 34. Valves 24, in the supply pipe 23, and 26, in return pipe 25, are provided for servicing or for controlling the flow temporarily in an emergency. The liquid entering the supply pipe 23 from the auxiliary compartment 31 is preferably screened as at 36 to prevent choking of the lines and undesirable accumulations of insoluble material in the heater.

Means are provided for automatically disconnecting the heater from its heating circuit when for any reason the circulation of liquid in the spraying system, is stopped, as for instance, through failure of the pump. As illustrated, this means comprises a small unrestricted opening 37 leading from the auxiliary compartment to the main compartment of the tank through which the liquid in the auxiliary compartment may drain and a float 38 connected to actuate a switch 39 in the heating circuit 40 when the liquid level approaches the bottom of the auxiliary compartment, as shown diagrammatically in Figure 2.

Figure 3 illustrates an alternative arrangement of the inlet and outlet pipes of the heater. As shown, the liquid is delivered firstly to the heat exchanger 35 by an inlet pipe 41 and then to the heater through standpipe 34, the return flow taking place through a standpipe 42 communicating with the base of the heater. In this arrangement the restriction of the rate of flow through the heater is controlled as previously described by adjusting the standpipe 33 to give the desired level in the auxiliary compartment 31. In this arrangement the outlet level of the heater standpipe 34 must be below the liquid level in the heater as fixed by the outlet level of the return standpipe 42, and this latter level is below that fixed by adjustable standpipe 33.

Figures 4 and 5 illustrate another embodiment of the heater arrangement, the spraying system being the same as that previously described. As shown, the tank 6 comprises but a single compartment, a minimum level of liquid as indicated at 43 being maintained therein. A heater 44, closely similar to heater 19, comprises a casing 45 with an insulated covering 46, a heating element 47, a water vapor channel 48, vapor outlet 49 to refrigerated space and vapor outlet 50 to exterior of the space controlled by a valve 51. The heater 44 may be mounted adjacent the tank within the refrigerated space and a liquid inlet 52, with valve 53, communicates with the bottom thereof. The heater is so positioned, as shown, that the liquid level therein will be maintained, by gravity, at substantially the same liquid level as the tank. This heater is also inclined with respect to the tank for convenience of arrangement. A return pipe 54 with a valve 55 for the liquid is provided just slightly below the level of liquid in the tank and heater. The return pipe 54 is provided with a restricted passage 56 of such a size that the circulation of liquid through the heater is adequate for preventing troublesome concentration of the non-aqueous part of the liquid in the heater, and is preferably restricted so that a minimum amount of sensible heat is added to the tank. The valve 55 may also be used for controlling the circulation.

The liquid inlet 52 may be provided with a screen 57.

While the heater is shown outside the refrigerated space in the embodiment of Figure 1 and within the space in the embodiment of Figure 4, it will be readily understood that the position of the heater is entirely dependent upon the particular installation being made. If placed within the space, the necessity of heavy insulation therefor is more important.

Many modifications of the spraying system to meet individual requirements may be made.

The tank 6 is of sufficient size to receive all the liquid in the circulation system when the apparatus is not in use.

The embodiment shown in Figures 1 and 2 is of particular utility where high humidities are required at low temperature, i. e., of the order of 0° F. or lower. Under these conditions, the circulating medium must be quite concentrated to prevent the formation of ice, and this requires the circulation of a relatively large volume of the medium in relation to the amount of water evaporated. There being no restricted passages in the latter embodiment, choking of the lines by crystallization of the non-aqueous portion of the liquid is avoided, even when a concentrated brine solution is employed. The embodiment shown in Figures 1 and 2 also requires less liquid to maintain the minimum levels necessary in operation. This is important if expensive liquid such as ethylene glycol is used.

The humidity in the refrigerated space may be

controlled either manually or automatically by controlling the heat input to the heater. Most of the present commercial devices used for the automatic control of relative humidity are slow in response and comparatively insensitive at temperatures much below the freezing point. Under these conditions successful manual or automatic control can only be obtained if the humidity conditions are not subject to sudden fluctuations.

With the above described apparatus and with a given heat input, high humidities may be maintained in a closed space below the freezing point with constancy with practically no adjustment of the apparatus. Fluctuations in the outside temperature and other changes affecting the amount of heat to be eliminated from the space cause slight, but generally insignificant, fluctuations in the relative humidity. Where the space is not closed but subject to periodic opening of doors and the like, a loss or gain in the total moisture content will occur, with consequent slight changes in the concentration of the aqueous medium in the tank. The concentration of the liquid medium may be adjusted periodically, for instance, by exhausting water vapor formed by the heater outside the refrigerated space or by adding water or the non-aqueous phase as required.

It will be observed that the heat required for humidification is reduced to a minimum by arranging to have the highest possible proportion of the heat supplied as latent heat in the form of water vapor, instead of as sensible heat.

As previously stated, the described method of and means for humidity control in refrigerated spaces, is capable of maintaining and controlling humidities in the vicinity of saturation, which is the condition usually required in refrigerated spaces held at temperatures below the freezing point of water. It is well known that most perishable food stuffs require the surrounding refrigerated atmosphere to be kept at a relative humidity of 95% or higher in order to avoid desiccation with consequent deterioration in quality and value. These high relative humidities cannot be obtained by the mere addition of water vapor to refrigerated spaces, owing to the dehydrative effect of the refrigerating surfaces, which become coated with ice, thus leading to a second effect previously mentioned, namely, a decreased efficiency of heat transfer.

In actual trials of the apparatus described, it has been found that the humidity was raised to over 95% and maintained at these values with the air temperature at 14° F., with the mean temperature of the refrigerating surfaces at −1° F. The heat transfer efficiency of these surfaces was relatively 50% greater with than without the humidity control described. The relative humidity in the space without the present control never exceeded 80%, a condition which caused severe desiccation of the stored perishable food commodities.

The method and means described are applicable wherever distribution of brine or other suitable liquids over cooling refrigerating surfaces and collection of the same can be arranged.

It may be noted that the invention is applicable for increasing or decreasing the relative humidity in storage or like spaces at temperatures well above and well below the freezing point.

It will be understood that the means for carrying out the invention may vary widely without departing from the scope thereof. Moreover, such means will necessarily be altered to meet varying conditions of installation.

I claim:

1. A method of controlling the humidity in a closed space having cooling elements which comprises applying an aqueous spray to the surfaces of the cooling elements to prevent moisture freezing thereon and to collect condensed moisture, recovering the aqueous spray with its accumulated moisture, continuously vaporizing water in a portion of the recovered spray and delivering the water vapor within or without the space as required.

2. A method of controlling the humidity in a closed space having cooling elements which comprises applying an aqueous spray to the surfaces of the cooling elements to prevent moisture freezing thereon and to collect condensed moisture, recovering the aqueous spray with its accumulated moisture, continuously circulating a portion of the recovered spray through a heater to vaporize a portion of the water therein and delivering the vapor within or without the space as required.

3. Humidity control for refrigerated spaces having cooling elements with a refrigerant circulating therethrough comprising means for spraying an aqueous liquid upon the surfaces of the cooling elements, said liquid having a freezing point below the temperature of said surfaces, means for recovering the sprayed liquid, a constant level tank adapted to receive the liquid, a heater disposed adjacent thereto and having a liquid inlet communicating therewith, said heater being adapted to boil the liquid therein to form water vapor, a standpipe in the heater adapted to withdraw liquid from the heater, said standpipe having an inlet at a level below that of the constant level tank, and means for delivering the vapor within or without said space.

4. Humidity control for refrigerated spaces having cooling elements with a refrigerant circulating therethrough comprising means for spraying an aqueous liquid upon the surfaces of the cooling elements, said liquid having a freezing point below the temperature of said surfaces, means for recovering the sprayed liquid, a constant level tank adapted to receive the liquid, a main tank adapted to receive the overflow from said constant level tank, means for adjusting the level in said constant level tank, a heater disposed adjacent the constant level tank and having a liquid inlet communicating therewith whereby liquid is supplied to the heater by gravity, said heater being adapted to boil the liquid therein to form water vapor, a standpipe in the heater having an opening below the liquid level in said constant level tank and adapted to return liquid to said main tank to maintain a circulation of liquid through the heater, and means for delivering the vapor within or without said space.

5. Humidity control for refrigerated spaces having cooling elements with a refrigerant circulating therethrough comprising means for spraying an aqueous liquid upon the surfaces of the cooling elements, said liquid having a freezing point below the temperature of said surfaces, means for recovering the sprayed liquid, a tank adapted to receive the recovered liquid, a heater disposed adjacent the tank and having a liquid inlet leading from the tank to the lower portion thereof, said heater being adapted to vaporize a portion of the moisture in said liquid, a liquid outlet leading from the upper portion of the

heater to the tank, said outlet having a restricted orifice to control passage of liquid through the outlet, and means for delivering the vapor by the heater within or without the space.

6. Humidity control for closed spaces having cooling elements with a refrigerant circulating therethrough which comprises means for supplying an aqueous fluid having a freezing point below the temperature of the cooling element surfaces, means for spraying said fluid upon said surfaces, means for recovering said sprayed fluid, means for continuously and regulatably fractionally dividing said recovered fluid, a heater adapted and arranged to vaporize a portion of the water of one of such fractional divisions, means for delivering the water vapor within or without said space and means for returning the concentrated fluid to said fluid supply.

7. A method of maintaining the humidity in a closed space having cooling elements adapted to provide a temperature of 32° F. or lower in said space which comprises applying an aqueous spray to the surfaces of the cooling elements to prevent moisture freezing thereon and to collect condensed moisture, said aqueous spray having a freezing point below the temperature of said surfaces, recovering the aqueous spray with its accumulated moisture, continuously vaporizing a part of the recovered spray and delivering the water vapor to the space.

8. A method of maintaining the humidity in a closed space having cooling elements adapted to provide a temperature of 32° F. or lower in said space which comprises supplying an aqueous liquid for continuous application in the form of a spray to the surfaces of the cooling elements to prevent moisture freezing thereon and to collect condensed moisture, said aqueous liquid having a freezing point below the temperature of said surfaces, recovering the sprayed liquid with its accumulated moisture, continuously circulating a portion of the recovered spray through a heater to vaporize a portion of the water therein, and delivering the water vapor to the space.

9. A method of controlling the humidity in a closed space having cooling elements which comprises supplying an aqueous liquid and continuously applying the same in the form of a spray to the surfaces of the cooling elements to prevent moisture freezing thereon and to collect condensed moisture, said aqueous liquid having a freezing point below the temperature of said surfaces, recovering the sprayed liquid with its accumulated moisture, continuously and regulatably fractionally dividing said recovered liquid, vaporizing a portion of the water of one of such fractional divisions, delivering the water vapor formed within or without the space as required and returning the concentrated liquid to the aqueous liquid supply.

10. Humidity control for refrigerated spaces having cooling elements with a refrigerant circulating therethrough comprising means for spraying an aqueous liquid upon the surfaces of the cooling elements, said liquid having a freezing point below the temperature of said surfaces, means for recovering the sprayed liquid, a constant level tank adapted to receive the recovered liquid, a heater having a liquid inlet communicating with the constant level tank, said heater being adapted to receive therefrom a portion of the liquid therein and to vaporize water from said liquid, a liquid outlet leading from the heater, means for controlling the flow of liquid through said heater, and means for delivering the vapor formed by the heater within or without said space.

11. Humidity control for closed spaces having cooling elements with a refrigerant circulating therethrough which comprises means for spraying an aqueous liquid upon the surfaces of the cooling elements, said liquid having a freezing point below the temperature of said surfaces, means for recovering the sprayed liquid, a constant level tank adapted to receive the recovered liquid, a main reservoir tank communicating with said constant level tank and adapted to receive the overflow liquid therefrom, a heater having a liquid inlet communicating with the constant level tank, said heater being adapted to receive from the constant level tank a portion of the liquid therein and to vaporize water from said liquid, a liquid outlet leading from the heater to the reservoir tank, means for controlling the flow of liquid through said heater, and means for delivering the vapor formed by the heater within or without said space.

12. Humidity control for refrigerated spaces having cooling elements with a refrigerant circulating therethrough comprising means for spraying an aqueous liquid upon the surfaces of the cooling elements to prevent moisture freezing thereon and to collect condensed moisture, said liquid having a freezing point below the temperature of said surfaces, means for recovering the sprayed liquid, a heater having inlet means providing a constant supply of said recovered liquid thereto, said heater being adapted to vaporize a portion of the water in the liquid supplied thereto, said heater having liquid outlet means adapted to maintain a continuous circulation of liquid through the heater, means for controlling the rate of flow of liquid through the heater, and means for delivering the vapor within or without said space.

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