

June 20, 1967

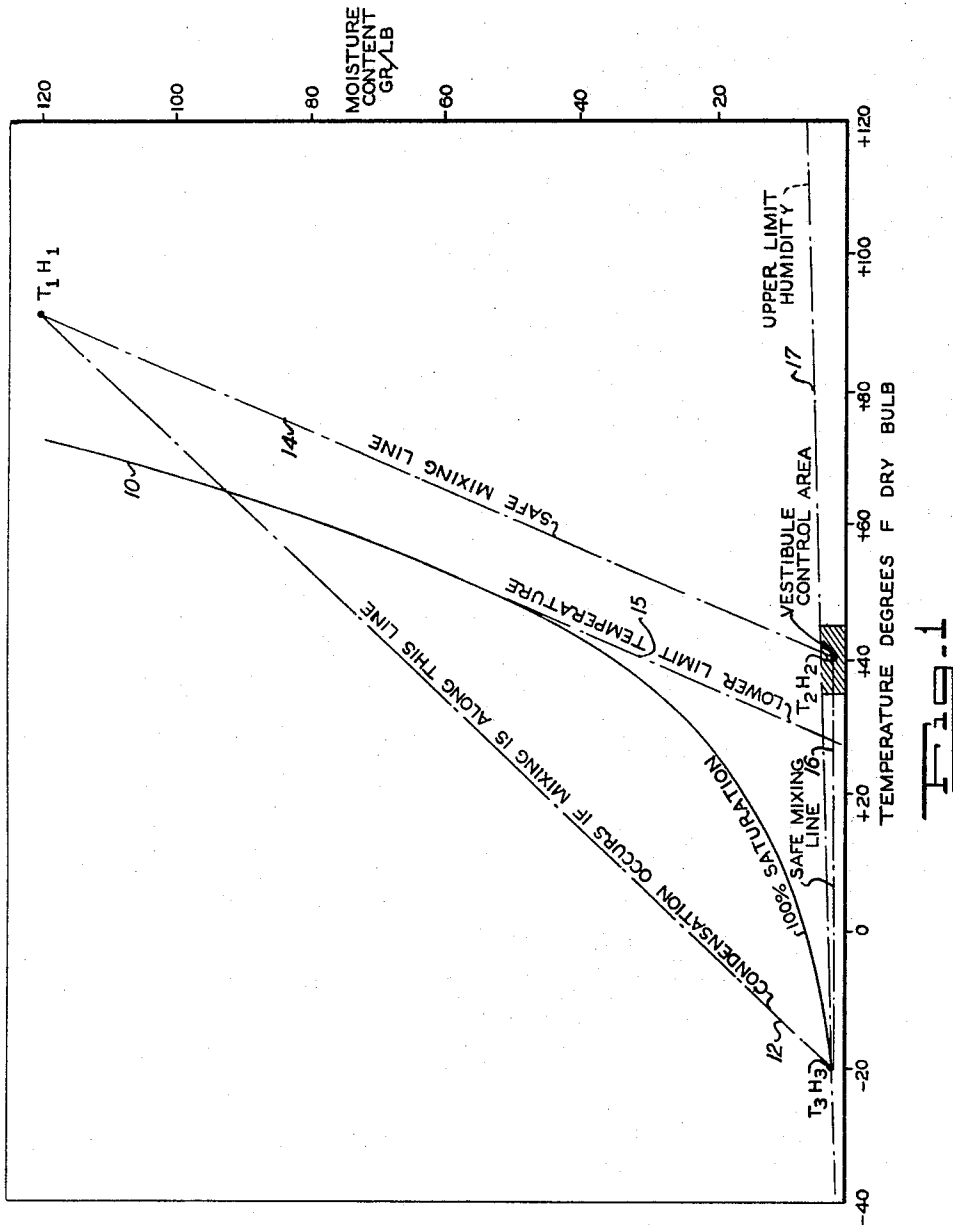
G. C. F. ASKER ET AL

3,326,012

FOG CONTROL

Filed Nov. 9, 1965

2 Sheets-Sheet 1



INVENTOR

GUNNAR C. F. ASKER
ERLING BERNER

BY *Sal B. Wiese*
ATTORNEY

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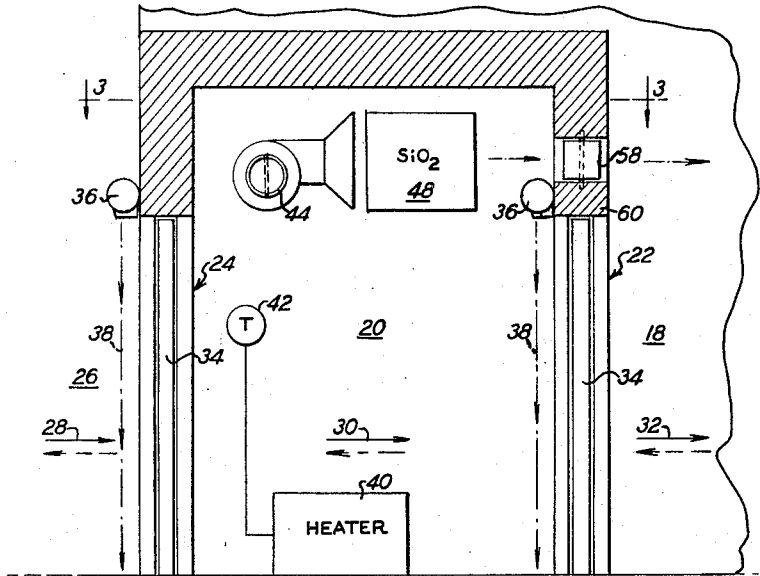


Fig. 1

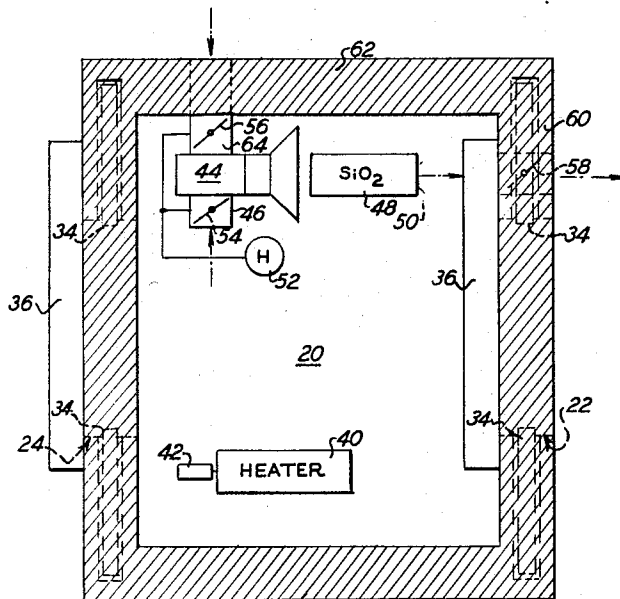


Fig. 2

INVENTOR

GUNNAR C. F. ASKER
ERLING BERNER

BY

Sol B. Wieg
ATTORNEY

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3,326,012

FOG CONTROL

Gunnar C. F. Asker, Princeton, N.J. (18 Industrial Drive, Trenton, N.J.), and Erling Berner, New Castle, Pa., (2890 Covey Crest Circle, Allison Park, Pa. 15101)
Filed Nov. 9, 1965, Ser. No. 506,949
6 Claims. (Cl. 62—78)

ABSTRACT OF THE DISCLOSURE

Method and apparatus for maintaining a vestibule associated with a frozen storage chamber fog-free by maintaining the doorways protected by an air screen and drying and heating the vestibule air to maintain a moisture content below 25% relative humidity and temperature in the range of 30° to 45° F.

This invention relates to the art of preventing fog, moisture or frost from precipitating in an antechamber or vestibule associated with a refrigerated chamber or room whose doorway or opening may be at least temporarily protected by an air curtain in large passage and removal of refrigerated products from a refrigerated, such as a frozen food, storage chamber.

More particularly, the invention is directed to controlling the humidity and temperature condition within a vestibule communicating through an air curtain protected doorway with a refrigerated chamber and through another air curtain protected doorway with the outside air against fogging, deposition of moisture or icing during frequent passage through these doorways loading or unloading of commodities into and out of the refrigerated space.

The invention further relates to the combination of a refrigerated chamber, a vestibule and several doorways, one providing communication between ambient air and a vestibule, and another communicating between the same vestibule and a refrigerated chamber, both openings of which may be protected by air curtains during substantial depositing and withdrawal of commodities from the refrigerated chamber whereby to cause fog and moisture deposition conditions in the vestibule, and dehumidifying means associated with said vestibule for producing and maintaining a non-fogging, non-icing critical condition therein during normal refrigerated commodity movement through said openings.

The invention further relates to a desiccant dehumidifier system associated for operation between a refrigerated zone and a non-refrigerated zone separated by an air curtain, having desiccant means communicating with the non-refrigerated zone for reducing and maintaining the moisture content in a critical range by circulating critically warmed air of said vestibule through said desiccant means and regenerating said desiccant means by comparatively dry air withdrawn from the refrigerated zone circulated over said desiccant to remove moisture and returned for disposal into said refrigerated zone.

Large refrigerated storage spaces wherein temperatures below freezing are conventionally maintained usually have large doorways for loading and unloading of a commodity to be refrigerated and usually frozen, or removed from the frozen storage space, sometimes large enough to accommodate passage of large conveyors or trucks through said opening. If the entrance to such refrigerated storage is protected by a vestibule with double openings, one allowing the vestibule to communicate with ambient air and the other allowing the vestibule to communicate with the frozen chamber, it becomes practical in the absence of high wind velocities to protect the openings, particularly during loading and unloading periods, with air curtains.

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However, during such large movement to supply or withdraw commodities from refrigerated storage with large attendant air interchange either warm moisture laden air passing from the outside into the vestibule or cold dry refrigerated air passing out of the refrigerated chamber into the vestibule, the moisture-temperature condition in the vestibule may exceed saturation at the exchange temperature, whereby moisture will deposit both as fog and as deposited moisture, ice or possibly frost on the walls, floor and appurtenances. Even the problem of greatly reduced visibility by the continuous fog developed may be serious.

It is found, however, according to this invention, that by raising the temperature of the vestibule so that the air therein is in the critical range of 35 to 45° F., and the relative humidity is maintained by control of the moisture therein to the range of 15 to 25%, the vestibule will remain fog, cloud, ice and frost-free tending to deposit no moisture on the walls. This condition is maintained despite only light or normal air screen protection of the openings and usual or large commodity traffic through said vestibule, loading and unloading the refrigerated commodity to and from the refrigerated storage space.

The principle of the invention and certain practical mechanical features useful in following such principle are described with respect to the drawings wherein

FIG. 1 is a psychometric chart plotting temperature against relative humidity and illustrating critical moisture and fogging conditions;

FIG. 2 is a schematic elevational view in section through the vestibule and part of a cold storage chamber; and

FIG. 3 is a sectional view on the lines 3—3 of FIG. 2.

Referring first to FIG. 1, the 100% relative humidity line 10 illustrates a saturated 100% relative humidity condition of the air as it varies with temperature. Consider a point T_1H_1 selected at random, to be a typical temperature-humidity condition of the ambient air which might prevail outside of the system; for example a relative humidity of 75 prevailing at a temperature of 78° F. having an actual moisture content of 120 grains per pound of air. Consider further a condition within a refrigerated chamber indicated by a point T_3H_3 having, for example, a temperature of -20° F. and a moisture content of about 5 grains per pound. If this ambient air at T_1H_1 were mixed with the refrigerated air at T_3H_3 , a condition would develop illustrated by the line 12 interconnecting the points T_1H_1 with T_3H_3 . Since the line 12 intersects the saturated 100% relative humidity condition of curve 10, the mixed gases to the left of and within the hollow of curve 10 would fog, deposit moisture, and below 32° F. would deposit ice.

If the refrigerated chamber opening is protected by a vestibule and the temperature of the vestibule is maintained at an intermediate point T_2 , which is to the right of minimum temperature limit line 15 drawn from the saturation point of the curve 10 at 60° F. down to 27° F. at zero moisture content; and the humidity of the vestibule is maintained at a point H_2 , a point lower than an upper humidity limit line 17 drawn between -40° F. saturated and 20% relative humidity at 40° F., then condensation cannot occur at any such point T_2H_2 maintained in the vestibule. Consequently, the vestibule will always remain ice and fog-free. Thus at any point of the vestibule T_2H_2 , the air temperature-humidity condition will be on line 14 interconnecting T_2H_2 and T_1H_1 when air of the vestibule is mixed with outside ambient air at the condition T_1H_1 . Alternately, the vestibule air condition will be on line 16 interconnecting T_2H_2 with T_3H_3 when the vestibule air is mixed with air in the refrigerated chamber at the T_3H_3 condition. Particularly it will be noted that neither line 14 (to the right of lower limit line 15) nor line 16 (below

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the maximum humidity line 17) can intersect the saturation curve 10.

As a practical matter, in preferred practice for selection of a practical T_2H_2 condition, the relative humidity of the vestibule is maintained below about 25%, such as between 15 and 25%, and the temperature of the vestibule air is heated to the range of about 35 to 45° F. which is above any ice depositing condition.

Referring to FIGS. 2 and 3, a refrigerated chamber 18 is maintained at any desirable temperature condition below freezing; that is, below 32° F. and often even below -10° F. A vestibule 20 is provided surrounding the doorway 22 providing communication between the vestibule 20 and refrigerated chamber 18. On an opposite side of the vestibule 20, a doorway 24 is provided which allows communication between the ambient outside air 26 and the vestibule 20. The paired arrows 28, 30 and 32 represent the loading and unloading directions for passing commodities to be refrigerated from the outside, through the vestibule and thence into the refrigerated chamber; and ultimately withdrawing the cold commodity in the reverse direction of these arrows, each time passing through the opposite doorways 24 and 22 in either direction. The doorways 24 and 22 may have sliding or other type of door closures 34, sliding to closed and open position in both doorways 24 and 22. When the refrigerated chamber is not being loaded and unloaded, the door closures 34 will be in closed position and when the commodity is being loaded or unloaded they will be slid to open position.

A pair of air screen devices 36 are mounted above each doorway opening 22 and 24. These air screen units, by known construction, expel a curtain of air 38 protectively down across each of the openings 24 and 22, each serving alone to isolate the air within the vestibule 20 from ordinary low (or only small) air current conditions prevailing outside of the system, while allowing easy loading or unloading passage of commodities through the doorways. A heater 40, controlled by a thermostat 42, maintains a preset temperature condition in the vestibule 20 in the range stated.

A blower 44 is connected to one inlet duct 46 to draw air from within the vestibule, blow the same over a surface-operative desiccant 48, the dried air being disposed of in divergent streams shown by arrows 50 within the chamber 20. The relative humidity of the air within the vestibule is thus maintained by adsorption of moisture on the desiccant, usually composed of silica gel, the relative humidity thus being reduced to the critical condition below 25%.

The actual humidity within the chamber 20 may be sensed by a humidistat 52 which maintains a damper 54 open for vestibule air entry to the blower 44, and when the vestibule humidity has reached the desired operating range, at least below 25%, the several dampers are reversed in control of the flow of gases. The damper 54 in duct 46 is then closed and dampers 56 and 58 are opened, thus providing communication to and from the refrigerated chamber by way of openings in the chamber walls 60 and 62 for transfer of dry refrigerated air from chamber 18 for regeneration of the desiccant body 48. Thus, in the regeneration cycle of flow dry air is drawn from refrigeration chamber opening 62 and duct 64, the damper 56 being open to the inlet of fan 44, and the cold dry air is blown over the desiccant 48, the cold dry air serving to remove adsorbed surface moisture from the desiccant 48. Simultaneously, the damper 58 in wall opening 60 will be opened to allow return passage of the cold scavenging air back into the refrigeration chamber 18 by way of the opening in wall 60. Thus the desiccant 48 becomes regenerated by cold air drawn from one portion of the refrigeration chamber 18, circulated by fan 44 over the desiccant and returned by way of wall 60, dampers 56 and 58 being opened for regulating that circulation.

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The system could operate semi-permanently with the doors 34 open and openings 24 and 22 protected for relatively long periods of time by air screens 36, but it is preferred to use the air screens only sufficient to allow loading and unloading of the refrigeration chamber 18. Thereafter, the doors 34 are closed and the vestibule chamber is maintained in standby condition by the moderate temperature and humidity control described either by permanent operation or by intermittent operation started a short time before and terminated a short time after the doors 34 have been opened. For purposes of maintaining the humidity in vestibule 20 at the desired condition, both air curtains 36 may draw their supply of air from within the chamber 20 whereby the curtain of air has the humidity of the vestibule.

Alternately, the air curtains 36 may be formed of a laminate of air, a portion of which is drawn from one side of the opening and another from the other, each layer of the laminate reflecting the temperature-humidity condition of only one side of the opening being protected by the laminate of air. That type of construction is described in somewhat greater detail in my copending application, Ser. No. 286,083, filed June 6, 1963.

While I prefer a surface-type dehumidifier comprising granular beads of desiccant confined between thin air permeable screens so that the adsorption is largely by surface contact, other types of desiccant dehumidifier systems can be substituted for bed 48. The present system, it will be recognized, is unique in that the bed adsorbs moisture from within the vestibule at ambient conditions of temperature and pressure therein i.e. atmospheric pressure at a temperature in the range substantially somewhat above a normal refrigeration temperature. The bed is regenerated without heat, rather using cold dry air produced only by refrigeration. For this purpose a surface-adsorption type of drier 48 is used having desiccant silica gel (SiO_2) disposed in their screens so that adsorption and regeneration is effected by mere surface contact with the flowing gases.

Moreover, the system includes the feature that the waste cold scavenging gas used to reduce moisture of the bed may be returned to the large refrigerated space 18 wherein condensed moisture and ice is not critical. In this manner a desiccant-type dehumidifier is operated to pass ambient warm air thereover for drying the same and is regenerated only by passing cold dry air thereover to remove moisture. Since that cold dry air is obtained from a low temperature refrigerated chamber, it stays cold and dry by depositing whatever excessive moisture it may contain in the refrigerated chamber so that a constant low temperature supply of the cold dry refrigerated air is available.

Certain modifications will occur to those skilled in the art and, accordingly, it is intended that the description herein be regarded as illustrative and not limiting except as defined in the claims appended hereto.

We claim:

1. The method of preventing fog, clouding and moisture condensation conditions in a vestibule adjoining an opening in a refrigerated chamber during loading and unloading thereof with consequent intermixture of air on opposite sides of said opening, comprising applying a protective air curtain across said opening to reduce air current flow between the chambers through said opening, and maintaining the vestibule air at a relative humidity below about 25% and at a temperature in the range of 35 to 45° F.

2. The method of preventing fog, clouding and moisture condensation conditions in a vestibule having an opening communicating with outside ambient air and a second opening communicating with a refrigerated chamber maintained at sub-freezing temperature during loading and unloading of commodity into and out of said refrigerated chamber with consequent intermixture of vestibule air with air on each side of said openings, comprising apply-

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ing a protective air curtain across each of said openings to reduce air current flow through said openings, and maintaining the vestibule air at a relative humidity below about 25% and at a temperature in the range of 35 to 45° F.

3. In combination with a refrigerated chamber having means for maintaining said chamber at sub-freezing temperatures, a vestibule, an opening providing communication between said vestibule and said refrigerated chamber and a second opening in said vestibule providing communication between said vestibule and ambient air outside of said chamber for loading and unloading of commodity into and out of said refrigerated chamber by passage through said openings, means for passing an air screen protectively over each of said openings, inhibiting low pressure air currents therethrough, thermostatically controlled heater means for controlling the temperature of the air in said vestibule to a raised temperature in the range of 35 to 45° F., a desiccant body, means for circulating air in said vestibule over said desiccant body to reduce the relative humidity of the air in said vestibule to below about 25%, duct means interconnecting said desiccant body and said refrigerated chamber for withdrawing cold refrigerated air from said refrigerated chamber and passing it in contact with said duct means providing communication between said desiccant body for regeneration thereof and return duct means conveying scavenging air withdrawn from contact with said desiccant body and returning the same to said refrigerated chamber.

4. The combination of a chamber enclosing a refrigerated space and a vestibule, an open doorway allowing air passage and commodity transfer between said chamber and vestibule, means for maintaining the space in said refrigerated chamber at a temperature below 32° F., a desiccant body and means for circulating ambient air from within said vestibule into contact with said desiccant body and returning to said vestibule at a rate to re-

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duce and maintain the relative humidity of the air in said vestibule below about 25%, means for controlling the temperature of the air in said vestibule in the range between 30 and 45° F., and means for regenerating said desiccant body by passing extraneous scavenging air thereover, and means for extraneously disposing of the regeneration air after passing over said desiccant body.

5. Apparatus as defined in claim 4 wherein the vestibule has an open doorway in one side thereof allowing communication of the vestibule with outside air and another open doorway providing communication between the vestibule and said refrigerated chamber, each of said open doorways being protected against excessive intermixture of air through said openings by an air screen mounted over each of said doorways.

6. The device as defined in claim 4 wherein the source of regeneration air is a refrigerated chamber having leading and return duct means providing communication between said refrigerated chamber and said desiccant body and means for circulating the dry air through said duct means from said chamber, over said desiccant body for regeneration thereof and returning the spent regeneration gas to said refrigerated chamber.

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ROBERT A. O'LEARY, *Primary Examiner*.

MEYER PERLIN, *Examiner*.

W. E. WAYNER, *Assistant Examiner*.