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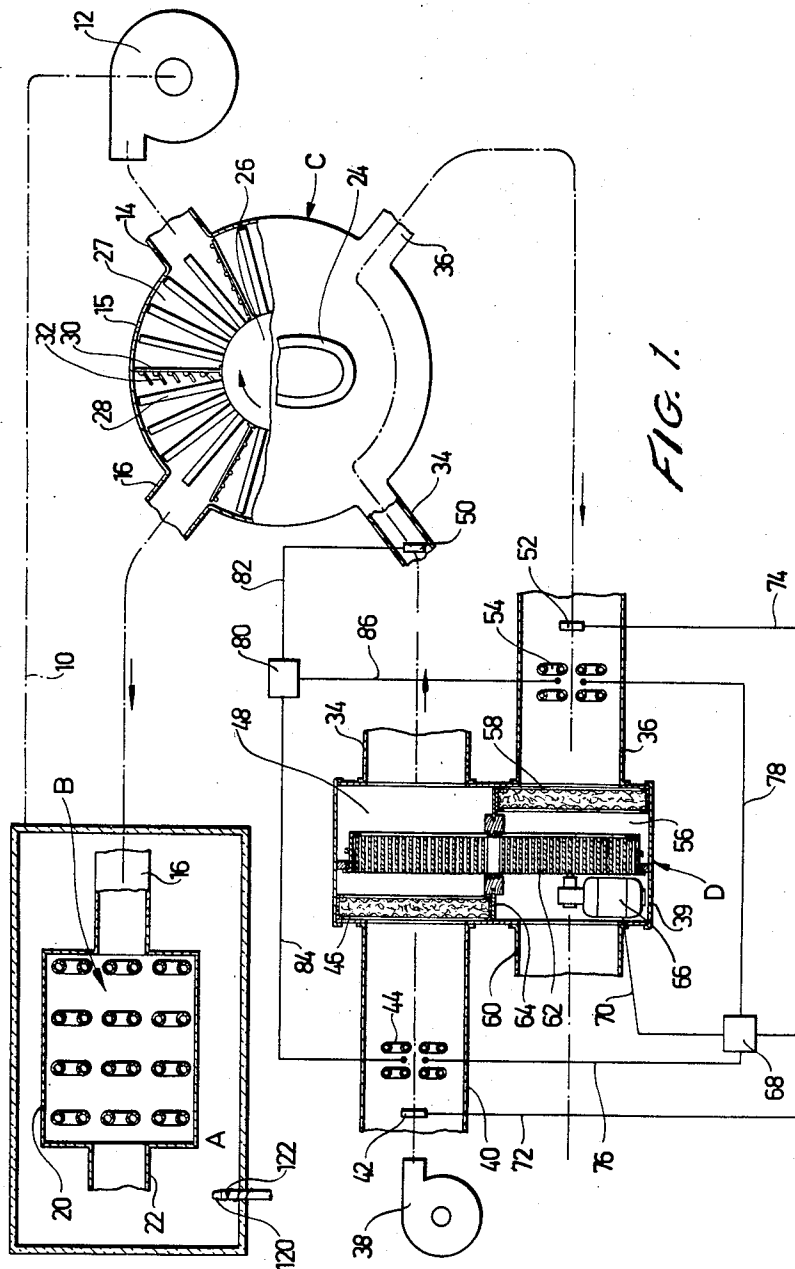
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2,946,201

METHOD FOR AVOIDING FROST DEPOSITS ON COOLING MEMBERS

Filed April 21, 1955

2 Sheets-Sheet 1



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Fig. 2

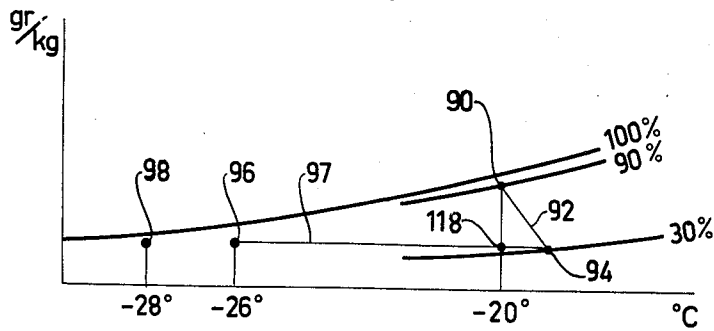
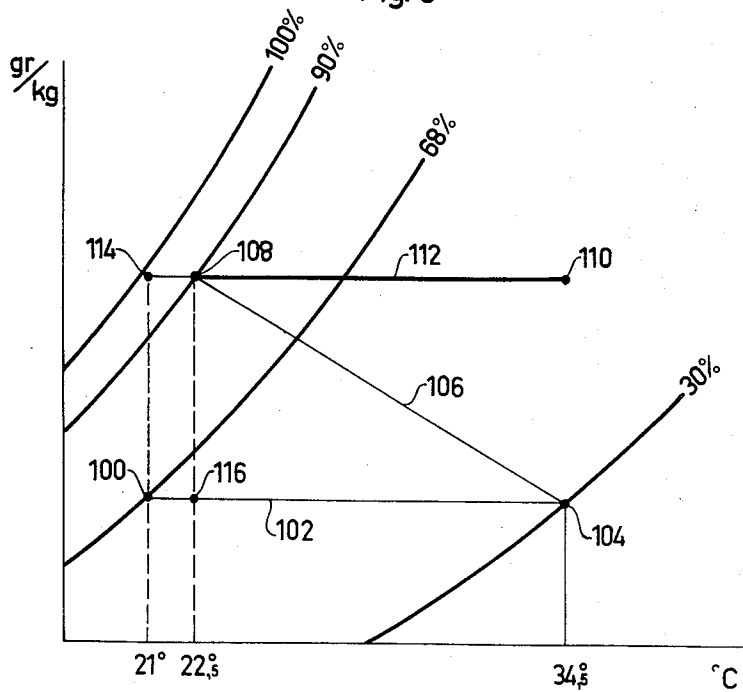


Fig. 3



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METHOD FOR AVOIDING FROST DEPOSITS ON COOLING MEMBERS

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1 Claim. (Cl. 62—94)

My present invention relates to a method of and means for avoiding frost deposit on cooling members.

More particularly my invention relates to a method of and means for avoiding frost deposit on cooling members intended to keep the temperature in a cold-storage room on a predetermined low level and thus to constitute the cold-generating part of a refrigerating machine.

The cooling member is located either within the cold-storage room proper or outside said room, the heat transfer in both cases being effected by contact of the air of the cold-storage room with the surfaces of the cooling member. The relative moisture content in the cold-storage room is generally high for which reason the air usually attains the dew-point when meeting the cooling member which results in a frost deposit on said member. The cover of ice produced thereby on the cooling member reduces the heat transfer between said member and the air for which reason a larger temperature drop than otherwise required must exist in order to keep the air of the cold-storage room on the desired low temperature level. As a consequence the consumption of power of the refrigerating machine is increased. The cooling member may be defrosted at predetermined intervals but then its operation must be interrupted. Another remedy proposed is the spraying over the cooling member of a liquid preventing the precipitated moisture from passing over into the state of ice.

One main object of my present invention is to open a quite new way of meeting the difficulties inherent in the problem frost deposit indicated above. According to one feature of my invention the cooling member is brought into contact with air from the cold-storage room from which air so much of the moisture content has been removed in advance as to reduce said content below the saturation value at the temperature of said member, said removal being effected at a temperature surpassing said first mentioned temperature. According to another substantial feature of my invention the removal of the moisture is effected by absorption by means of a preferably solid medium. In this connection I prefer to cause the air current streaming towards the cooling member in a moisture transferrer to transfer part of its moisture content to an auxiliary air current having a higher temperature but a lower relative moisture content than the air current from the cold-storage room. This auxiliary air current which thus has for its object to regenerate the moisture transferrer may be taken from the ambient atmosphere.

The process embodying my invention can be performed with a minimum of loss of heat, in particular with regard to refrigerating calories generated by the refrigerating machine. It is well known that refrigerating calories are more expensive to produce than heat calories.

Further objects and advantages of my invention will be apparent from the following description considered

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in connection with the accompanying drawings which form part of this specification and of which:

Fig. 1 is a more or less diagrammatic and partly sectional view of an aggregate embodying my invention.

Figs. 2 and 3 each show a psychrometric chart.

Referring to Fig. 1, A denotes a cold-storage room, B a cooling coil, C a moisture transferrer and D a heat transferrer which units are represented on mutually varying scales, the cold-storage room A being represented on a highly reduced scale and the heat exchanger D on a scale enlarged relatively to that on which the other two parts B and C are represented.

The interior of the cold-storage room A is connected by a conduit indicated by 10 with the suction side of a blower 12, the pressure side of which through a conduit 14 is connected to the casing 15 of the moisture transferrer C at a radially exterior portion thereof. Also connected to said radially exterior portion of the casing 15 but peripherally displaced relative the conduit 14 is a further conduit 16 which leads to the casing 20 enclosing the cooling coil B. Said casing 20 has a discharge socket 22 through which air is introduced into the cold-storage room upon having traversed the room enclosed by casing 20 and which may open into a system of distributing channels. The cooling coil B forms part of the refrigerating machine which may be of conventional construction, the other parts of said machine are not represented in the figure since they do not form part of my invention.

The moisture transferrer C contains a rotor driven by a motor 24. Said rotor comprises a hub 26 which together with the casing 15 forms an annular space 27 inside which members 28 carried by said hub are disposed to rotate. Said members spaced from one another carry bodies made of some hygroscopic composition of matter. Each such body is preferably of cellular structure and has a plurality of peripherally perforating fine passageways adapted to be traversed by air. Groups of members 28 are separated from one another by means of partitions 30 provided with damper systems 32 constructed so as in predetermined parts of the circumference of the moisture transferrer allowing passage of air therethrough but in other parts to prevent air from such penetration or only permitting a feeble stream of the air. Additionally to the conduits 14 and 16 two tubes 34 and 36 are connected to the radially exterior portion of the casing 15 of the transferrer C. The partitions 30 are formed so as to allow the air to flow freely within the sector located between the conduits 14 and 16 and also within the sector located between the tubes 34 and 36, but in the sectors formed between said two pairs of conduits or tubes, respectively, air at the utmost can stream in very small quantities.

Moisture transferers of the aforesaid type are more fully described in my co-pending application Serial No. 485,632, filed February 2, 1955, to which application reference is made with respect to the constructive and operative properties of said type of transferers. For my present invention it is essential that said transferers transfer moisture from the one air current to the other without simultaneously transferring heat but to a very insignificant degree. The air currents advance the annular space 27 in a peripheral direction as do the members 28, but opposite to the direction of movement of said members. The rotational speed of the rotor is low and its efficiency is high.

A blower 38 is at its pressure side connected through a conduit 40 to the casing of the heat exchanger D. Disposed inside the conduit 40 behind one another in the direction of the air flow are a heat sensitive bulb 42 and a heater 44. The air streaming through the conduit 40 may be cleaned in a filter 46 before entering

a chamber 48. The tube 34 preferably houses a humidistat 50 and opens into said chamber 48. The tube 36 also extends to the heat exchanger D and houses a heat sensitive bulb 52 and a heater 54. The tube 36 opens into a chamber 56 of the heat exchanger which chamber may be provided with a filter 58. A discharge tube 60 is provided on the opposite side of the chamber 56.

A rotor 62 extends into both chambers 48 and 56 which are separated from one another by a partition 64. Said rotor 62 contains a heat transfer body preferably made of filamentous or laminary material having fine interspaces in the manner described in my co-pending applications Serial Nos. 387,656 and 442,686, filed October 23, 1953, and July 12, 1954, respectively, both now abandoned, which are referred to for a more specified description of their construction and operation. The rotor when moving between the chambers 48 and 56 transfers heat from the one air current to the other while said currents traverse said chambers. Said rotor can be made so as to operate with a very high efficiency attaining up to 90% and even more as is stated in my said copending applications.

The rotor is driven by a motor 66. A relay 68 is connected to the motor through a line 70 and to the bulbs 42 and 52 through the lines 72, 74, respectively. Due to impulses from said bulbs the relay 68 is caused to put the motor into or out of operation as will be described with more detail hereinafter. Said relay is further connected through lines 76, 78 to coupling members for the heaters 44 and 54, respectively, which coupling members may be switches if said heaters are electric heating coils. A relay 80 is connected through a line 82 with a humidistat 50 and through lines 84, 86 with the coupling members of the two heaters.

In the diagrams shown in Figs. 2 and 3 the ordinate represents the absolute moisture content in the air given in a suitable unit such as grams of water (H_2O) per kilogram of air. The abscissa indicates the temperature in centigrade. The diagrams further show curves for various percentage figures of relative moisture in the air as well as lines corresponding to constant enthalpy. Fig. 2 shows changes in the state of the air of the cold-storage room and Fig. 3 changes in the state of the auxiliary air, the scale used in Fig. 2 being substantially larger than that used in Fig. 3 due to the feature that it contains the low temperature portion of the psychrometric chart.

The air inside the cold-storage room is assumed to have the state according to point 90 of Fig. 2, its relative moisture content being 90% and its temperature -20° . The cold-storage air having said state is introduced into the moisture transferrer C and is therein subjected to a change of state indicated by the enthalpy line 92. The air is dried to point 94 where its relative moisture content is 30%. Thereupon the air is conducted to the cooling coil B and is cooled down to -26° corresponding to point 96. There must exist a certain final temperature difference between the surfaces of cooling coil and the air, which difference in the present example is 2° . As the absolute moisture content of the air is not changed between the points 94 and 96, a line 97 interconnecting said points will be parallel to the abscissa. A prolongation of said line intersects the temperature line -28° in point 98. It is evident that the point 98 must be located below the line representing the relative moisture content of 100% if it shall be insured that no ice will precipitate on the surfaces of the cooling coil. The condition for attaining this object is that air from the cold-storage room has been liberated from moisture in the moisture transferrer to an extent sufficient to prevent the line starting from point 94 and extending in parallel to the abscissa from intersecting the saturation curve at the temperature of the cooling coil.

Referring to Fig. 3, the current of auxiliary air is constituted by ambient atmospheric air having a temperature of $+21^{\circ}$ and a relative moisture content of 68%,

as is represented by point 100. In a manner to be explained more detailed hereinafter heat is supplied to said air so as to reduce its relative moisture content to 30%. This change of state is performed with an absolute moisture content remaining constant as indicated by line 102 extending to point 104 located on the line representing 30%. In the moisture transferrer C the auxiliary air takes up moisture from the air of the cold-storage room and changes its state following the enthalpy line 106 to point 108 where said auxiliary air has a relative moisture content of 90% and a temperature of 22.5° C.

In this example the relative moisture content of the air of the cold-storage room has thus been reduced from 90% to 30% and that of the external air has been increased in a corresponding degree. This result presupposes a theoretical efficiency amounting to 100% of the moisture transferrer. In reality, there must be supplied so much more heat as to prolongate the line 102 to the right, seen in the plane of the figure, to a point indicating a lower relative moisture content than 30%. On the other hand, the final state of the auxiliary air when leaving the moisture transferrer in reality corresponds to a lower moisture content than 90%. For the purpose of elucidating the basic idea of my invention these corrective figures may be disregarded. The efficiency of a moisture exchanger of the construction indicated above may be so high as 90% or more for which reason the deviations from the theoretical chart will not become large.

The quantity of the external air regenerating the moisture transferrer C is in relation to the quantity of circulating air of the cold-storage room in a proportion generally corresponding to the quota between the saturation pressures inside the cold-storage room and outdoor said room. When having a temperature of -20° C. inside the cold-storage room and an outdoor temperature of $+21^{\circ}$ C. the ratio of the quantities of air is 1:20 to 25. With regard to quantity, the external air constitutes a small fraction only of the air from the cold-storage room traversing the moisture transferrer C. The conduits traversed by the auxiliary air may thus be given a much smaller dimension than the conduits for the air of the cold-storage room. In the same manner the blower 38 only needs to have a fraction of the capacity of the blower 12.

As will be seen from Fig. 3, the point 108 which in the illustrating example represents the final state of the auxiliary air behind the moisture transferrer C is located at a slightly higher temperature than the point 100 representing the starting state of the external air. The heat transferrer D has for its purpose to recover this quantity of heat. Said recovery is effected by the heater 54 heating the air streaming towards the heat transferrer D to point 110 along line 112 parallel to the abscissa. Thereafter a heat transfer is performed in the rotor 62, the same air current being cooled along said line 112 down to point 114 which change of state thus now, too, is effected without changing the absolute moisture content of said air current. The heat delivered by said air current is thus taken up by the incoming external air which in this way reaches the state corresponding to the point 104. In this way heating expenses have been saved in correspondence to the distance between the point 100 and point 116 located straightly below the point 108. In this case, too, a theoretical efficiency of 100% has been presupposed. In reality the air current outgoing through the discharge opening 60 holds a slightly higher temperature than is indicated by the point 114.

To make the explanation complete it may be pointed out that the moisture transferrer C if besides of its moisture transfer even conveying a smaller quantity of heat from the auxiliary air current to the cold-storage room air current will displace the point 94 slightly to the right of Fig. 2 along a prolongation of the line 97. The same holds true with regard to the point 104 of Fig. 3. This will result in that slightly more heat is required than

corresponds to the theoretical consumption of heat when assuming an efficiency of 100% and pure moisture transfer. The conditions become analogous with regard to the heat transferer D assuming that this transferer simultaneously though to a small degree transfers moisture also between the two exchanging air currents.

The consumption of heat from the point 116 to the point 104 is equal to the enthalpy of the quantity of water expelled, which means the quantity of water multiplied with the steam generating heat. As will be evident from Fig. 2, the consumed quantity of cold from the starting state 90 to the final state 96 includes the steam generating heat for the removed quantity of moisture and is equal to the distance between the point 96 and the line 92. However, this quantity of cold is only slightly larger than the quantity lost by production of ice on the surfaces of the cooling coil in the processes hitherto known. The heat supplied is a cheap form of calories when compared with the cold calories which must be supplied in said known processes to an increased extent as a consequence of the frost deposit on the cooling coil or member.

It is often desirable to keep the moisture content inside the cold-storage room as high as possible, for example when preserving food in order to avoid deterioration of quality or loss in measure weight due to evaporation of water. According to my invention a high moisture content can be maintained without any danger of deposit of frost, since the cold-storage room air present inside the cold-storage room does not come into direct contact with the cooling coil B. To this effect a water sprayer 120 may be provided, if desired combined with a heating coil 122.

The intensity of the current of air from the cold-storage room passing past the cooling coil B is controlled with due regard to unavoidable leakage of heat into the cold-storage room. In this connection the blower 12 may be controlled by a thermostat in a manner well known in the art.

In the example described above the starting temperature of the incoming external air has been assumed to be lower than temperature of said external air behind the heat transferer C. Upon actuation by the two bulbs 42 and 52 the relay 68 has started the motor 66 and switched in the heater 54 while switching out the heater 44. At the same time the humidistat 50 control through the relay 80 that the heat supply to the incoming current of external air is so large as to keep the relative moisture of said air when entering the moisture transferer C just below 30%. If the condition now should become reversed so as to cause the temperature of the air surrounding the bulb 52 to be lower than that of the air surrounding the bulb 42 no necessity exists for supply of heat to the heater 54. On the contrary, such supply would imply a direct loss. Therefore, the relay 68 now receives such actuation by the bulbs 42 and 52 as to

stop the motor 66, to switch out the heater 54 and to switch in the heater 44.

The humidistat 50 controls that the heat generator switched in for the time being delivers the heat quantity necessary for ensuring that the external air when entering the moisture transferer C always has the required relative moisture content. If the external air should have said moisture content without any heating operation the humidistat 50 will stop both heaters.

To make clear the preceding explanation it may be added that external air is to be understood to comprise both air from the ambient atmosphere and air drawn from an enclosure where suitable conditions of temperature and moisture are existent, for example the room in which the condenser of the refrigerating machine is located. The moisture transferer or/and the heat transferer may be of a construction having stationary transfer bodies. As will be understood from my co-pending application Serial No. 485,632 the moisture transferer C may have transfer bodies travelling along another path than the circular one while moving freely in relation to one another, if desired.

While one more or less specific embodiment of my invention has been described it is to be understood that this is for the purpose of illustration only and that my invention is not to be limited thereby, but its scope is to be determined by the appended claim.

What I claim is:

The method of preventing frost formation on cooling surfaces for a cold storage chamber in which the air has a temperature below the freezing point of water and a high relative humidity, the dew point temperature of the air being higher than the temperature of said surfaces forming part of a refrigerating system, the last-mentioned temperature being lower than said first-mentioned temperature, which comprises circulating a stream of air from the storage chamber and drying it by sorbtion in a regenerative moisture exchanger and consequent release of latent heat to thereby reduce its relative humidity to a point representing a dew point below the temperature of the cooling surfaces, and then cooling the stream anhydrously by heat exchange with said cooling surfaces while preventing access of the humid chamber air thereto, passing the so cooled and dried air back to the cooling chamber thereby circulating a quantity of air for each unit of time sufficient to maintain the predetermined temperature and substantially the high humidity in the chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

2,200,243	Newton et al. -----	May 14, 1940
2,257,478	Newton -----	Sept. 30, 1941
2,286,920	Miller -----	June 16, 1942
2,452,685	Rudoy -----	Nov. 2, 1948
2,700,537	Pennington -----	Jan. 25, 1955