April 14, 1953 M. W. BEARDSLEY 2,634,591

VACUUM COOLING SYSTEM EMPLOYING CHAMBER SURFACE CONDENSATION

Filed Sept. 15, 1950

Fig.1

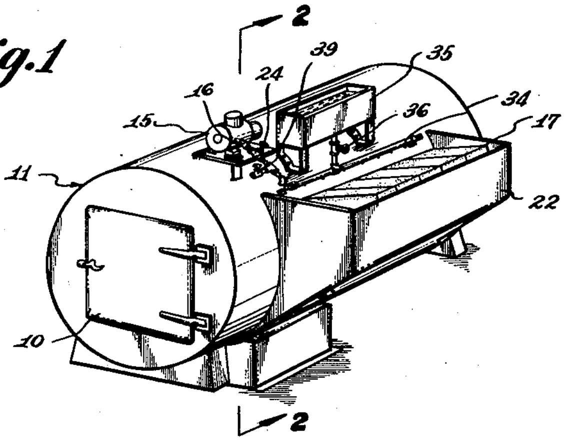


Fig.2

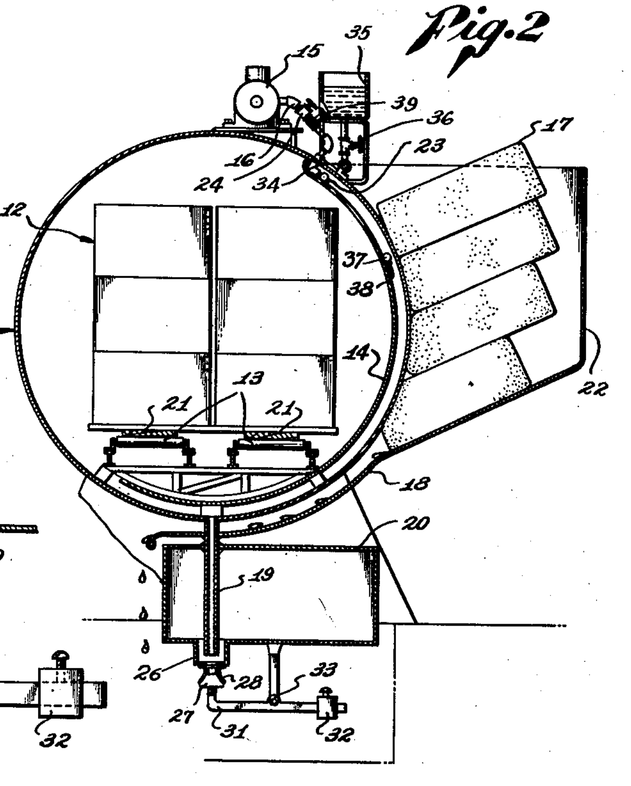
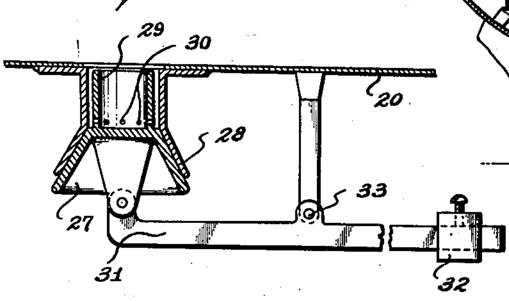


Fig.3



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2,634,591

VACUUM COOLING SYSTEM EMPLOYING CHAMBER SURFACE CONDENSATION

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Application September 15, 1950, Serial No. 184,915

18 Claims. (Cl. 62—168)

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My invention relates generally to the cooling and refrigeration of produce and more particularly to the precooling of such material as lettuce and sweet corn, prior to its shipment. A method and apparatus for this general purpose I disclosed in my copending application, Serial No. 146,784, filed February 28, 1950, and entitled Method and Means for Cooling Produce by the Use of Reduced Pressure. This is a continuation-in-part of said copending application, Serial No. 146,784.

A customary practice in cooling produce such as lettuce, prior to and during the shipment thereof is to interlayer the produce with crushed ice while it is being packed into shipping crates, and also to cover the closed crates with ice in the refrigerator cars in which they are shipped. The disadvantages of this conventional procedure are that the interlayered crushed ice tends to bruise tender vegetables such as lettuce; the water produced by the melting crushed ice causes undesirable and unsightly deterioration of the produce during shipment thereof, and is generally a nuisance; and the crushed ice in spite of considerable care in distributing the same does not maintain a uniform temperature throughout the body of the package as is desired. Still further, the operation of packing the crushed ice into crates or other containers with the produce is a costly and time-consuming phase of the shipping procedure.

The above-identified copending application discloses a method and apparatus for precooling produce by means of a vacuum causing the evaporation of the surface moisture from the produce. This process is classed generally as "vacuum cooling." The present invention concerns further improvements in the method and apparatus for vacuum cooling.

In connection with the present invention it should be noted that the use of vacuum cooling does not entirely dispense with the necessity of ice refrigeration and that ice is still used in the bunkers of refrigtrator cars to maintain the lowered temperature of the produce in spite of the fact that it may have been precooled by the vacuum cooling method. Thus, it is necessary to have ice available at or near the shipping point of produce of the class above-described, even though it may be precooled by the vacuum cooling process.

Vacuum cooling is currently practiced by employing steam-jet pumps to remove the air and water vapor from a closed chamber containing the produce. While steam-jet pumps have proven

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to be the most practical design for pumping a large volume flow of vapor from the vacuum cooling chamber, the overall system with its steam generating boiler and associated equipment is very heavy, bulky and relatively expensive. For these reasons the vacuum cooling plant incorporating steam-jet pumping equipment must necessarily be a large and permanent type installation.

Permanent installations are not, however, a complete answer to the problem of cooling produce prior to shipment. In many instances, it is desirable for precooling equipment to be of a portable nature so that it can be moved from one growing area to another to correspond with the harvest season. As an example, lettuce is harvested in the Salinas, California, area in the summertime, and in the Imperial Valley, California, in the winter. Equipment which can be moved from one of these areas to the other is highly desirable. In this manner, the equipment can be in use throughout the entire year rather than idle for several months during which no produce is harvested in the area where the plant is permanently located.

Vacuum precooling equipment which is sufficiently light and portable may be moved out to the field where the crop is actually being harvested. If precooling is performed in the field, considerable handling and intermediate trucking can be eliminated, so that the overall costs of packing and shipping are greatly reduced. Additionally, field precooling makes it possible for long distance transport trucks to be loaded directly at the field, resulting in a minimum of delay and expense and providing fresher vegetables at the destination.

In the process described in my above-identified copending application, a certain weight of ice is placed inside a treatment chamber with the produce. The weight of ice is determined by the weight and temperature of the material being cooled, but to assure complete precooling a somewhat larger quantity of ice usually is placed in the chamber to effect rapid completion of the cooling cycle. Because of this a small amount of ice is always left over after the process has been completed. Being of odd shape and unknown weight, the residual ice is usually discarded and a new measured quantity is employed with the next batch of material to be precooled.

This situation is of course undesirable. Furthermore, the weighing and loading of ice has also been found to be a time-consuming operation. The present invention concerns improvements by which this undesirable waste of ice is eliminated, the overall process is facilitated, and the equipment made portable.

Bearing in mind the general purpose of vacuum cooling, the fact that ice is usually available in any major produce growing area, and the fact that a vacuum cooling plant employing steam-jet pumping equipment is large, heavy and permanent, it is a major object of the present invention to provide precooling apparatus employing ice as a heat absorbing medium in order that vacuum precooling of comestibles may be accomplished with a portable apparatus.

Another object of the invention is to reduce the cost and power requirement of the plant used in vacuum precooling.

Yet another object of the invention is to increase the speed and facility with which comestibles may be precooled by the vacuum method.

A further object of the invention is to make use of ice in the process of vacuum cooling, without placing such ice in contact with the produce being cooled.

An additional object is to provide apparatus for materially increasing the efficiency of ice refrigeration from the standpoint of theoretical heat absorbing capacity of ice.

A still further object is to provide precooling apparatus especially adapted to handle crated produce.

Yet another object is to provide sufficient means for removing water from an ice refrigeration chamber without wetting the produce therein.

Still another object of the invention is to reduce to a minimum the amount of handling of ice required in a vacuum precooling system using ice.

An additional object of the invention is to provide apparatus which enables mechanical refrigeration equipment to be used in connection with vacuum precooling equipment.

The foregoing and additional objects and advantages will be apparent from a consideration of the following detailed description thereof, such consideration being given likewise to the attached drawings, in which:

Figure 1 is a perspective view of a light precooling plant embodying the present invention;

Figure 2 is an enlarged elevational section taken on the line 2—2 in Figure 1; and

Figure 3 is an enlarged portion of Figure 2 illustrating an automatic condensate tank drain valve mechanism.

For purposes of simplicity, in the drawings, the apparatus shown in Figure 1 has been shown for resting on the ground, although it will be realized that it could be permanently attached to the body of a vehicle such as a truck trailer.

Before proceeding with a detailed description of the apparatus embodying the present invention, the principles of operation will be described briefly as follows. The first principle made use of in the present invention is that evaporating moisture absorbs heat (heat of evaporation) from the surrounding media. Thus, if the surface moisture on, let us say, a head of lettuce is caused to evaporate by reducing the surrounding vapor pressure, the heat of evaporation necessary to cause such evaporation will be absorbed from the lettuce itself, thus cooling the same. This principle is also employed in the apparatus described in the above-identified copending application.

The second principle employed in the present invention is that vapor brought into contact with the surface colder than the dew point of such vapor at its then pressure will cause the vapor to condense with the result that a corresponding amount of heat is released by the vapor and absorbed by the cold surface. This condensation, also, of course, results in a reduction of the pressure if it is accomplished in a closed chamber.

The two principles just set forth are employed in the present apparatus by placing the material to be cooled in a hermetically sealed enclosure having a portion of its wall surface refrigerated, and by then removing substantially all of the air from the enclosure. It will be seen that, as the air is removed and the pressure reduced within the enclosure, a point will be reached at which the surface moisture present in the comestible being cooled will evaporate, thus absorbing heat from the solid body. The vapor thus formed, which comes in contact with the refrigerated portion of the inner wall surface will condense thereon, releasing its latent heat of vaporization to this cooler wall surface. The released heat is then conducted through the chamber wall to ice or other refrigerating material outside the chamber which is used to refrigerate the aforesaid wall portion.

Accordingly, when the air has been substantially removed from the enclosure, evacuation thereof may theoretically be terminated, and the process of heat transfer from the comestible to the refrigerated wall surface will continue until the mass of material being cooled reaches the temperature of the refrigerated wall surface.

As will be pointed out in more detail hereinafter, it is important to the operation of such a system that as much as possible of the air be removed from the chamber so as to substantially fill the same with vapor at the time the pumping of air is stopped, otherwise the aforesaid heat transfer operation will terminate short of the desired reduced temperature of the produce, due to the partial vapor pressure of the water vapor, plus that of the remaining air in the chamber being such as to prevent further condensation of moisture on the refrigerated wall surface.

If air is present in the chamber, it soon collects in a blanket over the refrigerated wall surface and prevents or greatly inhibits further condensation thereof. The formation of such a blanket is due to the fact that condensation on the refrigerated wall surface removes the water vapor from the air-vapor mixture, leaving relatively pure air in a layer adjacent the surface. Thus, I have found it advantageous in most cases to continue the evacuation pumping during the entire cooling cycle in order to remove the above-mentioned blanket of air as it forms and to draw the water vapor into intimate heat transfer contact with the refrigerated wall surface.

In the simple form of the device illustrated in Figures 1 and 2, a single chamber 11 is charged with crated produce 12, or other material to be processed, and ice 17 is applied to the exterior of the chamber wall. The chamber 11 is then sealed and substantially evacuated of air, and the heat transfer process is allowed to continue until the desired precooling temperature of the produce is reached.

An important feature of the present process is the fact that if pure water ice is used as the wall refrigerant, the produce will not be cooled to a point less than the freezing point of water, i. e., the temperature of the ice applied to the portions of the chamber wall, and consequently there is no danger of damaging the produce by freezing the same or portions thereof. I have found by experience, however, that in order to accelerate the cooling especially toward the end of the cycle, it is sometimes advantageous to introduce some solute such as salt to the juncture of the ice and the chamber wall in order to reduce the temperature of the melted ice at that point. I have also found that an accelerating effect can be achieved by adding to the condensate within the chamber, some similar compound which reduces its vapor pressure.

In the form of apparatus shown and described herein, means are provided for continuously removing the water produced by condensation within the chamber. I have found it desirable to remove such water continuously during the cooling cycle so that it is not necessary to cool said condensate to the final desired temperature. In this connection, it will be realized that the condensate produced during the early stages of the cooling cycle will have a temperature considerably greater than the final desired precooling temperature.

Referring now to the drawings for a more detailed description of the simple form of apparatus embodying my invention, it will be seen that the chamber 11 is of a generally cylindrical shape disposed with its axis horizontal, and is provided with a pair of hinge mounted hermetically sealed doors 10, one being mounted at each end of the chamber 11 (one not shown). Within the chamber 11 are installed two parallel rows of conveyor rollers 13 adapted to support and allow longitudinal movement of pallets 21 upon which is loaded the crated produce 12. Cakes of ice 17 are supported on an ice rack or bunker 22 secured to one side of the chamber 11. The ice bunker 22 has its bottom surface sloping toward the chamber 11 so that the ice slides inwardly against the chamber wall to effect an intimate heat transfer contact between the wall and the ice.

After the ice 17 has been loaded on the bunker 22 and the produce 12 has been placed in the chamber 11, the doors 10 are shut so that the chamber is made airtight. Air is then pumped out of the chamber 11 by means of a pump 15 mounted on the top of the chamber, the pump being connected to the interior of the chamber through a suitable conduit 16.

The inner end of the conduit 16 is connected to a longitudinally disposed manifold 23 having a series of induction openings spaced therealong, and so arranged that air is inducted substantially equally along the length of the chamber 11. It will be observed that all gas being inducted into the vacuum pump inlet manifold 23 is constrained to a flow path in close contact with the refrigerated portion of the wall, such constraint means being an inner-lining baffle 14. Accordingly, the water vapor constituent of the air-vapor mixture is largely removed by condensation on the refrigerated wall surface, thus making it necessary for the vacuum pump 15 to remove only substantially pure air. This arrangement makes possible the use of a pump of relatively small volume flow capacity as compared with the vacuum cooling systems which pump out all of the gases including the evaporated water vapor.

When the pressure within the chamber is reduced to a point where it is substantially equal to the vapor pressure of water at the then temperature of the produce 12, pumping may, in some cases, be stopped and the exhaust conduit 16 closed by means of a valve 24 therein. Thereafter, the heat transfer operation will be automatic and continuous, the moisture evaporating from the produce 12 and condensing on the refrigerated surface of the chamber wall. As long as the temperature of the produce 12 is substantially greater than that of the refrigerated surface, the process will continue at a relatively rapid rate, slowing gradually, however, as the temperatures of the produce 12 and the wall approach each other. More rapid cooling can be accomplished by continuing to operate pump 15, thus drawing off any air or other non-condensable gas that may be present tending to form an insulating blanket over the refrigerated wall surface.

As the water vapor from the produce 12 condenses on the inner surface of the refrigerated chamber wall, it releases its latent heat of vaporization to the wall. This heat is conducted through the wall to the ice 17 at its surface of contact with the outer surface of the chamber, and some of the ice is melted. The rate at which the ice is melted is proportional to the rate of cooling of the produce and the consequent rate of evaporation and condensation. The water formed by the melting of the ice drains downwardly and is constrained by an exterior shroud 18 to flow in intimate heat transfer contact with the exterior surface of the chamber until its point of discharge at a lower lip 25 of the shroud 18.

In the drawings, the space between the chamber wall and the shroud 18 has been exaggerated for purposes of clarity. By this arrangement a larger refrigerated surface is available for condensation and the water from the melted ice absorbs part of the heat from the condensing vapor so that a minimum weight of ice is required.

It will be realized that in place of the ice rack 22 and the ice 17 therein, conventional cooling coils as are commonly used in mechanical refrigerators, can be secured in close heat transfer relation to a wall of the chamber 11 whereby to cool a portion thereof. In such modification, the temperature of the portion of the wall which is refrigerated can be maintained at a substantially constant value by conventional thermostatic controls employed in connection with mechanical refrigerators of known design.

The condensate forming on the interior refrigerated surface flows by gravity to the bottom of the chamber 11, and thence drains through a drain pipe 19 into a collecting tank 20. The height of the drain pipe 19 must be sufficiently great to establish a head of water which is greater than any probable difference in pressure between the main chamber 11 and the tank 20. Such difference might be due, for example, to a difference in temperature between the chamber 11 and the tank 20. The tank 20 has a sufficient capacity to collect all of the condensate which would be formed by cooling the maximum probable load of material to be cooled.

The tank 20 is formed with a sump 26 into which the drain pipe 19 extends and in the bottom of which is located a drain valve 27. The drain valve 27 is preferably of an automatic type such as that illustrated in Figure 2. In a particular form illustrated, a conical drain valve 27 is seated in a complementary seat 28 and supported on one end of a balance beam 31 on the other end of which is a counterweight 32. Secured to the upper part of the valve plug 27 is a tubular member 29 open at the upper end and pierced by small peripheral holes near the base. The weight and balance of the elements connected to the beam 31 are such that when the pressure in the tank 20 is equal to atmospheric and the upper tubular portion 29 of the valve port 27 is filled with water, the sum of the moments about the fulcrum 33 is such that the plug 27 drops and the drain valve port is opened, draining the condensate from the tank 20.

After the condensate is drained from the tank 20 and also from the tubular member 29 (through the holes 30), the counterweight 32 develops sufficient moment about the fulcrum 33 to return the valve plug 27 to its seat 28. When the main chamber 11 is thereafter evacuated, a corresponding reduction in pressure is produced in the empty tank 20, the latter being enclosed and sealed by the plug 27. The greater external atmospheric pressure forces the plug 27 into even more intimate sealing contact with the seat 28.

As previously stated, it is sometimes desirable to accelerate the cooling rate toward the end of the cycle. To this end, a distribution pipe 34 supplied with a freezing-point-lowering solution (e. g., brine) from a solution hopper 35 under the control of a valve 36, is mounted longitudinally above the ice 17 and is pierced along its length with uniformly spaced ports. Thus, chemical solution may be fed into the juncture of the ice and the chamber surface with a resultant lowering of the melting temperature of the ice.

As an additional or alternative means for accelerating the cooling cycle, a similar distribution pipe 37 fitted with spaced spray nozzles 38 is located inside the chamber 11 and so positioned that the nozzles 38 may spray a vapor pressure reducing solution against the inner refrigerated surface of the chamber. As this chemical solution mixes with the condensate on the refrigerated surface, the vapor pressure of the mixture is reduced. This reduction in vapor pressure increases the pressure differential between the main part of the chamber (containing the produce 12) and the condensing zone adjacent the refrigerated surface; thus the rate of the vapor flow from the main part of the chamber is increased with a consequent increase in the rate of cooling.

When the produce 12 has been cooled to the desired temperature, air is admitted to the chamber 11 through an inlet valve 39 in the vacuum pump conduit 16. As soon as the pressure inside the chamber 11 has reached atmospheric, the access doors 10 at the end of the chamber 11 are opened and the cooled produce 12 is removed from one end following which (or concurrently therewith) additional produce to be cooled is loaded into the chamber through the other door. After this produce is loaded into the chamber, the doors are closed and sealed, and the cooling process is repeated.

The tank 20 assumes atmospheric pressure simultaneously with the main chamber 11 because of the interconnecting drain pipe 19. As previously explained in the description of the tank drain valve, when the condensate tank pressure is atmospheric, the valve operates to drain the collected condensate. The automatic operation of the valve always places the tank in readiness for the next cooling cycle.

While the method and apparatus shown herein are fully capable of achieving the objects and providing the advantages hereinbefore stated, it will be realized that they are capable of some modification without departure from the spirit of the invention. For this reason, I do not mean to be limited to the forms shown and described, but rather to the scope of the appended claims.

I claim:

1. A method of cooling material having surface moisture thereon which includes the steps of: placing the material to be cooled in an airtight enclosure; refrigerating a wall of said enclosure; removing substantially all air from said enclosure to effect rapid evaporation of said surface moisture; introducing a vapor-pressure-reducing material into said chamber adjacent said refrigerated wall to lower the vapor pressure of moisture condensing thereon; and leaving said material in said enclosure until the temperatures of said material and said wall are substantially equal, due to latent heat of evaporation being taken up from said material by said evaporated moisture and given up at said wall by condensation of said moisture thereon.

2. A method of cooling material having surface moisture thereon which includes the steps of: placing the material to be cooled in an airtight enclosure; placing a body of refrigerant against an exterior portion of the wall of said enclosure to refrigerate said wall portion; exhausting said chamber to remove substantially all air therefrom and to effect rapid conversion of said surface moisture into water vapor; directing the flow of said air and water vapor from said chamber past the interior surface of said wall portion in heat transfer relation therewith; and leaving said material in said enclosure until the temperature of said material and wall portion are substantially equal due to latent heat of evaporation being taken from said material by said moisture evaporated therefrom and given up at said wall portion by condensation of said moisture thereon.

3. A method of cooling material having surface moisture thereon which includes the steps of: placing the material to be cooled in an airtight enclosure; placing a body of refrigerant having a temperature of substantially 0° centigrade against an exterior surface of the wall of said enclosure; removing substantially all the air from said enclosure to effect rapid evaporation of said surface moisture and to cause condensation of said evaporated moisture on the interior surface of said wall; continuously draining condensed moisture from said enclosure; and leaving said material in said enclosure until the temperatures of said material and wall are substantially equal due to latent heat of evaporation being taken from said material by said evaporation and given up at said wall by condensation of said moisture thereon.

4. A method of cooling material having surface moisture thereon which includes the steps of: placing the material to be cooled in an airtight enclosure having heat conducting walls; placing ice against the outer surface of said enclosure; removing substantially all the air from said enclosure to effect rapid evaporation of said surface moisture; and leaving said material in said enclosure until the temperatures of said material and said wall are substantially equal, due to latent heat of evaporation being taken up from said material by said evaporated moisture and given up at said wall by condensation of said moisture on the interior surface thereof.

5. A method of cooling material having surface moisture thereon which includes the steps of: placing the material to be cooled in an airtight enclosure having heat conducting walls; placing ice against the outer surface of said enclosure; removing substantially all the air from said enclosure to effect rapid evaporation of said surface moisture; introducing a freezing-point-lowering solution into the juncture of said ice

and enclosure to lower the temperature thereat; and leaving said material in said enclosure until the temperatures of said material and said wall are substantially equal, due to latent heat of evaporation being taken up from said material by said evaporated moisture and given up at said wall by condensation of said moisture thereon.

6. A method of cooling material having surface moisture thereon which includes the steps of: placing the material to be cooled in an airtight enclosure having heat conducting walls; placing ice against a first portion of the outer surface of said enclosure; flowing water produced by melting of said ice past a second portion of said outer surface; removing substantially all the air from said enclosure to effect rapid evaporation of said surface moisture; constraining the flow of air leaving said enclosure to a path first past an interior surface portion opposite said second exterior portion and then past an interior surface portion opposite said first exterior portion; and leaving said material in said enclosure until the temperatures of said material and said wall are substantially equal, due to latent heat of evaporation being taken up from said material by said evaporated moisture and given up at said wall by condensation of said moisture thereon.

7. In apparatus for vacuum treatment of material having surface moisture thereon: an airtight chamber having a sealable access door to admit material for treatment in said chamber; means secured in heat transfer contact with a portion of the wall of said chamber to refrigerate said wall portion; evacuating means including a pump connected to said chamber to withdraw fluid therefrom; and baffle means in said chamber to constrain the flow of fluid therefrom to a path in intimate heat transfer contact with said refrigerated wall portion.

8. In apparatus for vacuum treatment of material having surface moisture thereon; an airtight chamber having a sealable access door to admit material for treatment in said chamber; means secured in heat transfer contact with a portion of the wall of said chamber to refrigerate said wall portion; means including a distribution conduit within said chamber to supply a vapor pressure reducing fluid to said refrigerated wall portion; and evacuating means including a pump connected to said chamber to withdraw fluid therefrom.

9. In apparatus for vacuum treatment of material having surface moisture thereon: an airtight chamber having a heat conducting wall and a sealable access door to admit material for treatment in said chamber; means to support a quantity of ice outside of said chamber and against the exterior surface of a portion of said wall; and evacuating means including a pump connected to said chamber to withdraw fluid therefrom.

10. In apparatus for vacuum treatment of material having surface moisture thereon: an airtight chamber having a sealable access door to admit material for treatment in said chamber; means to support a quantity of ice against a first portion of the wall of said chamber; means adjacent said ice supporting means to direct the flow of melted ice in a path in heat transfer relation with a second portion of said wall; and evacuating means including a pump connected to said chamber to withdraw fluid therefrom.

11. In apparatus for vacuum treatment of material having surface moisture thereon: an airtight chamber having a sealable access door to admit material for treatment in said chamber; means to support a quantity of ice against a portion of the wall of said chamber; means adjacent said ice supporting means to supply melting point reducing fluid to the juncture of said ice and chamber; and evacuating means including a pump connected to said chamber to withdraw fluid therefrom.

12. In apparatus for vacuum treatment of material having surface moisture thereon: an airtight chamber having a sealable access door to admit material for treatment in said chamber; means to support a quantity of ice against the exterior of a first portion of the wall of said chamber; means adjacent said ice supporting means to direct the flow of melted ice in a path in heat transfer relation with the exterior of a second portion of said wall; evacuating means including a pump connected to said chamber to withdraw fluid therefrom; and baffle means in said chamber to constrain gas leaving the same to a path past the interior surface of first said second wall portion and then said first wall portion.

13. In apparatus for precooling produce having surface moisture thereon: a cylindrical airtight chamber having heat conducting walls and disposed with its axis horizontal, said chamber having sealable access doors in the end walls thereof to admit material for cooling therein and internal conveyor means to support said material for axial movement through said chamber; an ice bunker secured to a side of said chamber and adapted to support a quantity of ice in heat transfer contact with a portion of said chamber wall; and a gas pump connected to said chamber to withdraw air and/or vapor therefrom.

14. The construction of claim 13 further characterized by having a shroud member surrounding a portion of said chamber wall under said bunker, and slightly spaced from said chamber, the space between said chamber and shroud being communicated with said bunker whereby to pass water produced by melting of ice in said bunker in heat transfer contact with said chamber wall.

15. The construction of claim 13 further characterized by having an internal baffle in said chamber supported in closely spaced relation with said chamber wall and extending over an interior surface opposite said bunker, the space between said wall and baffle being open at one edge to the interior of said chamber and closed at the opposite edge, and communicated adjacent said closed edge with said pump, whereby gas withdrawn from said chamber by said pump passes through said space and in heat transfer contact with a portion of said wall refrigerated by ice in said bunker.

16. The construction of claim 13 further characterized by having a container and distribution conduit mounted above said bunker positioned and adapted to deliver a melting-point-reducing solution to the juncture point of said chamber wall and ice in said bunker.

17. The construction of claim 13 further characterized by having a distribution conduit inside said chamber positioned and adapted to deliver a vapor-pressure-reducing solution into said baffle space, whereby to mix said solution with moisture condensed on said chamber wall and lower the vapor pressure of the resultant mixture.

18. In apparatus for vacuum treatment of materials having surface moisture thereon: an airtight chamber having a sealable access door to

admit material for treatment in said chamber; refrigerant flow-directing means secured in heat transfer contact with a portion of the wall of said chamber to refrigerate said portion, said flow-directing means being arranged to direct refrigerant in a predetermined path across said portion whereby to produce a decreasing temperature gradient thereacross; evacuating means including a pump connected to said chamber adjacent the coldest point in said wall portion to withdraw fluid from said chamber; and baffle means in said chamber to constrain the flow of fluid therefrom to a path in the direction of said decreasing

temperature gradient and in intimate heat transfer contact with said refrigerated wall portion.

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