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METHOD AND APPARATUS OF REFRIGERATION
USING CRYOGENIC LIQUID
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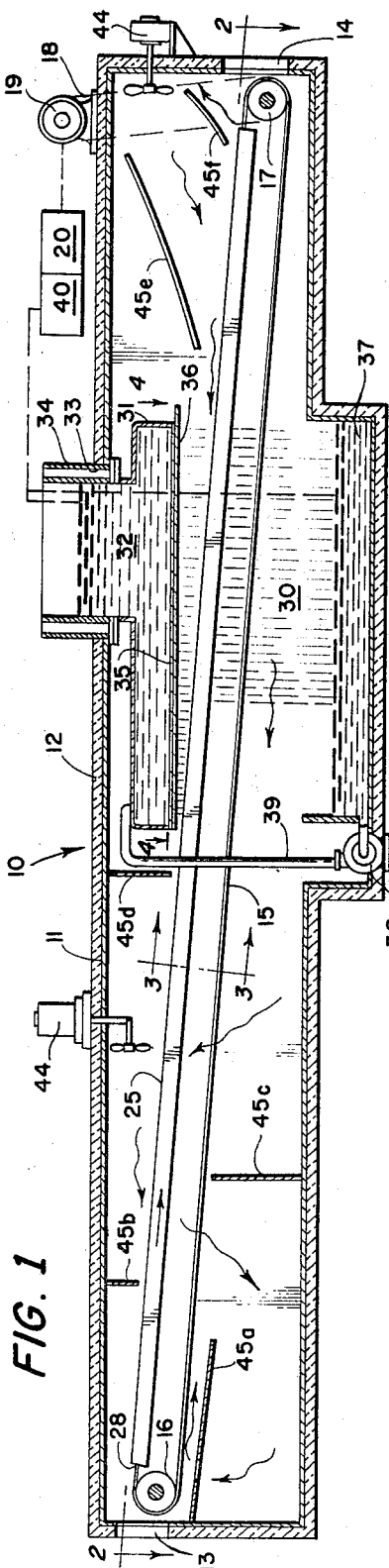


FIG. 1

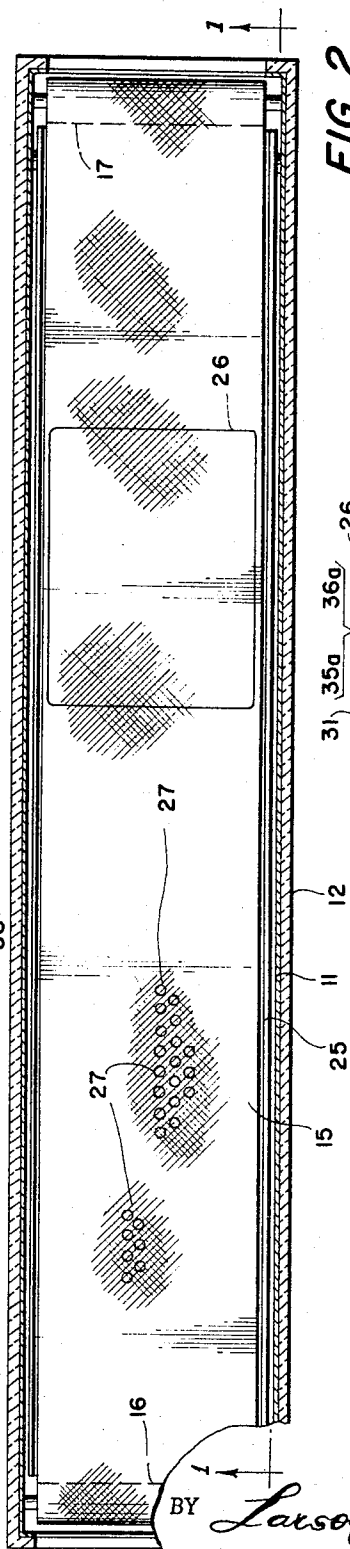


FIG. 2

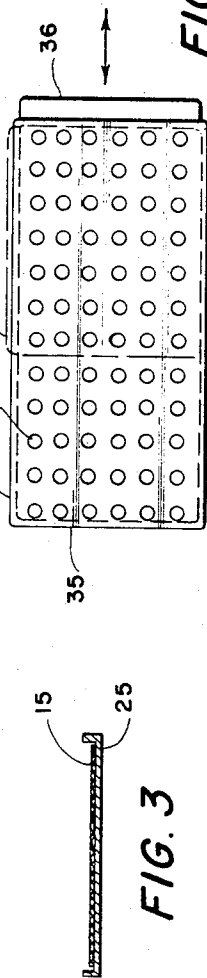


FIG. 3

FIG. 4

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METHOD AND APPARATUS OF REFRIGERATION USING CRYOGENIC LIQUID

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ABSTRACT OF THE DISCLOSURE

A method and an apparatus for refrigerating a product wherein the product is passed through a housing on a foraminous conveyor in close proximity to a stationary slide member. A shower of cryogenic liquid deposited on the product collects as a pool in the spaces of the foraminous belt contacting both the product and the slide to form a conductive heat transfer path therebetween. Means are also provided for capturing the refrigerating capacity of the gases evaporated from the shower by directing the same along the bottom of the slide member to cool the same and passing the refrigerant capacity onto the product by conduction to precool the product.

This invention relates to refrigeration, and in particular it relates to an improved method and apparatus for refrigerating a product by placing the product in contact with a low temperature liquid.

Numerous methods and apparatus have been developed for producing a desired low temperature in products, such as, for example, in quick freezing an article of food. One such method, which is shown, for example, in the patent to Robert H. Hill, Patent No. 2,447,249, issued Aug. 17, 1948, involves freezing the article by bringing it into contact with a cryogenic liquid such as liquid air, liquid nitrogen, etc.

However, since cryogenic fluids are relatively expensive, the economic success or failure of the chosen method or apparatus will be largely dependent upon the efficiency with which the method or apparatus utilizes the available refrigeration capacity of the cryogenic liquid. Of those methods shown in the Hill patent for bringing the liquid into contact with the article, it is believed that the superior method for effecting quick freezing of an article is that method in which the article is passed beneath a liquid shower. However, this method is inherently inefficient since the liquid is evaporated long before maximum use of its refrigeration capacity can be made. It is possible to recapture a portion of the lost refrigeration capacity by passing the evaporated gas towards the incoming articles to precool the articles by convection before they pass beneath the shower. However, although a portion of the refrigeration capacity of the fluid may be captured, the fact remains that too much of it is lost, as a result of which the shower method remains relatively expensive and inefficient.

Thus, it is a purpose of the present invention to provide an improved method and apparatus for quick freezing articles by the liquid shower procedure wherein use of the refrigerant capacity of the cryogenic fluid is maximized. Consequently, it is contemplated that with the present invention the cryogenic liquid shower procedure will be rendered far more efficient and economical than has been possible heretofore.

The improved method and apparatus of the present invention result from a proper application of the three basic heat transfer methods, radiation, conduction and convection, to the art of refrigeration. For fast freezing of foods conduction is by far the best method. The difference be-

tween touching an ice cube and holding one's finger even a short distance away graphically demonstrates the superiority of conduction for the quick transfer of heat. It might seem, therefore, that maximum heat transfer efficiency could be obtained by submerging the article in a pool of cryogenic liquid. However, for the following reasons this would not always be feasible. First, the cost would be prohibitive. Large quantities of cryogenic fluid would be necessary while the refrigeration capacity of the evaporated gas would be lost. This would amount to a considerable loss since most gasses have a considerable refrigeration capacity warming up from the evaporation temperature (for example, -320° F. for liquid nitrogen) to room temperature. Secondly, the agitating effect of the shower would be lost. In fact, the submersion technique has the disadvantage in quick freezing that a coating of small insulating bubbles form on the surface of the article thereby delaying the freezing action.

In previous shower type quick freezing procedures conduction has been employed only in the area of the shower. The evaporated gasses have been used to precool the incoming product solely by convection.

In the present invention, however, greater use of conduction is made both in the shower stage and in the precooling stage to insure maximum utilization of every pound of the cryogenic fluid. The precooling section of the apparatus upstream from the shower has been redesigned in such a manner that the refrigeration capacity of the evaporated gasses directed to the incoming articles is captured and transferred to the product primarily by conduction and secondarily by convection. Also, the arrangement of the shower itself has been improved so that a greater proportion of the falling liquid remains in the liquid state as it falls onto the product. Means are also provided for directing a portion of the liquid into a pool beneath the product for freezing the bottom of the product by conduction.

Briefly summarizing, the structure of the present invention includes an enclosed and fully insulated housing open only to allow entry and discharge of the product and entry of the cryogenic fluid. A moveable conveyor such as an endless belt travels from one end of the apparatus to the other. In a preferred form of the invention the belt is inclined downwardly from the entrance opening to the discharge opening. The belt is of a foraminous structure such as, for example, wire mesh.

Mounted directly beneath and in contact with the underside of the moveable conveyor is a stationary shelf-like member referred to hereinafter as the "slide freeze." Preferably the slide freeze will contact the underside of the moveable conveyor along its entire length from a point near the entrance opening to a point near the discharge opening. However, it will be appreciated that certain advantages of the invention can still be realized even if the slide freeze extends for only a portion of the entire length of the conveyor.

At a point approximately midway through the travel of the conveyor belt there is provided a means for depositing a shower of cryogenic liquid upon the product. The slide freeze is cut away beneath a portion of the shower to form a main opening in the slide freeze through which liquid falling off of the product may pass to a sump located beneath the moveable conveyor and from which liquid may be recirculated back to the liquid reservoir above the product. The means for depositing the liquid shower includes a tank mounted above the conveyor and having a plurality of apertures in the bottom thereof through which the liquid falls to the product. The size of the apertures may be controlled. However, it is contemplated that the apertures will be large enough so that the liquid falls to the product under substantially isentropic and constant pressure conditions. In contrast to the

present invention, previous methods employ an isenthalpic spray of the liquid to the product. With an isenthalpic spray the pressure of the fluid is substantially reduced as it passes through the apertures, as a result of which much of the fluid is evaporated before even contacting the product.

According to another feature of the invention some of the liquid is allowed to fall onto the slide freeze. This liquid collects on the slide freeze beneath the product thereby refrigerating the bottom of the product by conduction before the liquid falls through the said main opening to the sump.

The invention further includes an arrangement of blowers and baffles for obtaining maximum utilization of the refrigeration capacity of the evaporated gas as it warms up to room temperature from the extremely low evaporation temperature (for example -320° F. with liquid nitrogen) by directing the cold gasses to the upstream side of the conveyor to precool the incoming products. In the past, precooling was accomplished solely by convection. However, with the present invention the evaporated gasses upstream from the shower not only cool the product by convection but they also cool the large surface area of the slide freeze by convection. This refrigeration capacity of the evaporated gasses which is captured by the slide freeze is then transferred to the product through the conveyor to cool the product by conduction. Thus, with the present invention much of the refrigeration capacity of the gasses which has heretofore been lost is now captured and utilized. In fact, it has been found that the slide freeze may increase the overall efficiency of the apparatus by approximately 30%. In addition, the slide freeze is also partially cooled by conduction from that portion of the liquid shower which falls onto the slide freeze before falling into the sump.

In tests with the present invention it has been shown that approximately 35% of the refrigeration capacity utilized by the product is provided by conduction from the gasses through the slide freeze while 17% is provided by convection and approximately 48% by the contact of the liquid with the product. This is in contrast to the previous methods where all refrigeration capacity utilized by the product was derived either by contact with the liquid refrigerant or by convection.

Other structural features further enhance the operation of the invention. The conveyor is wholly contained within the housing so that it is not subjected to outside conditions. The housing is constructed in three sections, the precooling section, the liquid shower section and the discharge section. The three sections are easily bolted together so that the unit may be easily assembled and completely dismantled for servicing, cleaning, etc.

In addition, the overall apparatus is constructed so that it can serve as a module in a larger apparatus. That is, it may be conveniently attached side by side with other similar units to provide a larger apparatus having any desired width.

The apparatus also includes a means for varying the speed of the movable conveyor and for varying the quantity of liquid deposited by the shower. In this manner the quantity of refrigeration capacity applied to any given product may be accurately controlled.

Thus, it is an object of this invention to provide an improved method and apparatus for refrigerating articles.

It is another object of this invention to provide an improved method and apparatus for refrigerating articles by contact with a liquid shower wherein the cooling capacity of the evaporated gasses are captured and utilized for precooling by conduction.

It is another object of this invention to provide an apparatus for refrigerating articles including a stationary heat conductive slide freeze member in contact with a moveable conveyor on which the product is mounted.

It is another object of this invention to provide a method and apparatus for refrigerating articles by a shower of

cryogenic liquid wherein the liquid falls downwardly to the product under isentropic conditions.

It is another object of this invention to provide a method and apparatus for refrigerating an article with a cryogenic liquid shower wherein a portion of the liquid is captured as a pool beneath the product to cool the product by conduction.

It is another object of this invention to provide an enclosed refrigerating apparatus wherein the moveable conveyor and its support means are fully enclosed within the apparatus.

It is still another object of this invention to provide an improved method and apparatus for refrigerating articles including a stationary slide freeze heat conducting member in contact with a moveable conveyor on which the product to be refrigerated is mounted.

Other objects and the attendant advantages of the present invention will become apparent from the detailed description to follow of a preferred embodiment of the invention together with the attached drawings. However, it should be understood that the following detailed description and drawings are solely for purposes of illustration and that the invention is capable of numerous modifications and variations within the spirit and scope of the invention:

In the drawings:

FIGURE 1 is a side elevational view of the apparatus wherein the side cover has been removed.

FIGURE 2 is a plan view taken along line 2—2 of FIGURE 1.

FIGURE 3 is a sectional view taken along line 3—3 of FIGURE 1.

FIGURE 4 is a plan view taken along line 4—4 of FIGURE 1.

Referring now to the drawings, and in particular to FIGURE 1, there is shown a refrigerating apparatus 10 illustrating a preferred embodiment of the present invention. The apparatus includes an outer housing 11 formed from a suitable material, for example, stainless steel, and is covered with a suitable thermal insulation 12, for example, urethane.

The apparatus includes three basic sections, A, B and C. The product to be refrigerated enters the apparatus at inlet opening 13 and is precooled in section A. In section B a shower of cryogenic liquid is deposited onto the product. And finally, in section C, the temperature of the product is stabilized before the product is discharged through discharge opening 14.

The housing 11 is designed for low heat loss, easy accessibility, cleanliness and long, reliable life. To provide ease in assembling the apparatus the three sections A, B and C may be constructed separately and bolted together. Also, one side of the unit may be completely removed for cleaning and for free access to the moving parts.

In addition, the apparatus 10 is constructed in such a manner that it may form a module of a larger freezing apparatus formed by placing a number of similar units side by side. For example, the apparatus 10 as shown in FIGURE 1 with the near side wall removed may be attached to another similar apparatus having the adjacent side wall removed to form an apparatus having a width double that of apparatus 10. It follows, of course, that any number of units 10 may be placed together side by side to form a freezing apparatus of any desired width.

A foraminous endless belt conveyor 15 is mounted within the housing 11 and is moveable about a first roller 16 located adjacent inlet opening 13 and a second roller 17 mounted adjacent the discharge opening 14. Movement of the conveyor is provided through the belt 18 connecting a variable speed motor 19 to the second roller 17. The foraminous conveyor belt 15 may be formed of any suitable heat conductive material, for example, stainless steel mesh. The conveyor extends the entire length of the machine at a slightly downwardly inclined angle

to facilitate flow of the product therealong. The belt is completely contained within the housing structure and uses special "warm" bearings for ultra-low heat leak and to prevent ice formation. At no point in its travel is any portion of the belt exposed entirely to atmospheric conditions.

An important feature of the present invention is a stationary shelf-like slide freeze member 25 which is stationarily mounted within the housing structure immediately below and in contact with the lower surface of that portion of conveyor 15 on which the product travels. Further, the slide freeze member is so arranged that it supports the said portion of conveyor 15. The slide freeze 25 may be formed of any suitable heat conducting material, for example, stainless steel, aluminum, etc. Referring to FIGURE 2 there is shown a main opening 26 in the slide freeze through which the liquid from the liquid shower may fall. In addition, a plurality of openings 27 are provided in the slide freeze between inlet opening 13 and main opening 26 to facilitate flow of gaseous refrigerant through the slide freeze. The purposes of the main opening 26 and the additional openings 27 will be discussed in more detail below.

Section B of the apparatus includes the structure for depositing a shower of refrigerating liquid onto the product. Although any suitable low temperature refrigerating liquid may be employed, in a preferred operation of the invention it is contemplated that liquid nitrogen will be utilized. Thus, the invention will be described with particular reference to a liquid nitrogen cryogenic liquid. However, it is to be understood that the use of liquid nitrogen is intended merely for purposes of illustration.

A tank 31 having a supply of liquid nitrogen 32 therein is supported in the housing 11 at openings 33 at the top of section B. A portion of the reservoir extending above the housing is insulated by an insulating jacket 34. Referring to FIGURE 4, the bottom of the tank 31 is formed by a metallic plate 35 having formed therein apertures 35a and a moveable plate 36 which overlaps plate 35 and has apertures 36a formed therein. As shown in FIGURE 4 the apertures 35a and 36a are normally in registry with each other so that the liquid 32 can pass freely through the apertures 35a and 36a to form a liquid shower 30. The amount of liquid flow can be controlled by moving plate 36 horizontally relative to plate 35 to move the apertures 36 out of registry with aperture 35a.

Although the size of the liquid flow openings are controlled by movement of plate 36, it is contemplated that in a preferred operation of the invention the liquid nitrogen will fall onto the product under substantially isentropic constant pressure conditions. The shower will be strong enough to break up insulating bubbles which may form on the surface of the product. However, it is important to note that the shower should not be in the form of a spray. Spray freezing uses isenthalpic expansion from a high pressure container of liquid nitrogen through a nozzle, and this expansion causes part of the liquid nitrogen to become immediately gaseous before touching the product. In the present invention the shower falls on the product at an atmospheric pressure and substantially all of the liquid will remain as liquid until evaporated by contact with the product.

For purposes of economics the liquid which is not evaporated is collected in a sump 37 and recirculated by a pump 38 through a pipe 39 back to the tank 31.

The apparatus further includes a plurality of blowers 34 and a plurality of strategically arranged baffle members 45a through 45f which are arranged to collect the evaporated nitrogen gas and direct the same to precooling section A of the apparatus.

The operation of the apparatus may be controlled by varying the speed of the conveyor 15 by control unit 20 and the quantity of liquid flowing from the tank 31 by control unit 40 which controls the position of plate 26 and the level of the liquid 32 in tank 31. In addition,

the apparatus may include suitable control systems such as necessary alarm circuits, safety shutoffs, thermometers, and controls for both maximum product quality and operator safety.

Thus, it can be seen that the various structural features of the invention cooperate with each other to provide a substantially new and improved mode of operation of a shower type refrigerating apparatus.

As the product on conveyor 15 moves beneath the tank 31 it is drenched with liquid nitrogen in the shower 30. However, a first portion of the slide freeze 25 beneath the tank 31 at the upstream end of the shower is not cut out to allow the liquid nitrogen to fall through the slide freeze to sump 37. Therefore, at this upstream end of the shower 30 the liquid collects as a pool beneath the product in the spaces between the strands of the wire mesh conveyor belt 15, between the product and the slide freeze. In this manner it is possible to refrigerate the bottom of the product by conduction from the liquid nitrogen. The product then moves through the shower to that portion above the main opening 26 in slide 25. Here the liquid, after contacting the product, falls through the foraminous conveyor and through the main opening 26 to sump 37 wherefrom it is recirculated to the tank 31.

While much of the product cooling occurs in the shower 30, it is essential for economical operation that maximum use be made of the evaporated gasses. This is so because liquid nitrogen has almost as much refrigeration capacity as a gas warming up from -320° F. to room temperature as it does as a liquid.

It has been known to direct this gaseous nitrogen upstream from the shower to precool the incoming products. However, with previous procedures the precooling was accomplished almost exclusively by convection heat transfer between the product and the flowing gasses. An important feature of the present invention is the more efficient use of the refrigerant capacity of the evaporated gasses for precooling by employing conduction as well as convection. This is accomplished through the mechanism of the stationary slide freeze. With cold gaseous nitrogen, heat transfer of the product by convection is a function of the speed of gas movement across the surface, the area of surface to be cooled the temperature difference between the gas and the product, and time. However, conduction heat transfer is a function of the conductivity of the material, the area of transfer, the temperature difference and time. Even if the gas is sped up to hurricane velocities, the speed of heat transfer by convection is still much less than by conduction.

The slide member collects and stores a large amount of available refrigeration energy from its continuous exposure to the convection flow of cold evaporated nitrogen gas. This stored refrigeration capacity is then transferred to the product as required by the quick, efficient means of conduction.

Blowers 44 and baffles 45a through 45f recirculate the evaporated gasses counter-currently from the discharge end of the apparatus to the charging end along the path indicated by the arrows in FIGURE 1. It will be noted that the gas passes through convection holes 27 in the slide member 25. Thus, the evaporated gas is directed around and through the slide freeze so that the cooling capacity of the gas can be effectively transferred to the slide freeze by convection, from which it is transferred to the product by conduction through the conveyor belt 15.

Other operational advantages of the invention may be noted. Since the arrangement allows greater transfer of heat in the precooling section A and the discharge section C, it is possible to provide a more uniform change in temperature of the product during its travel through the apparatus from the inlet end to the discharge end. This will allow not only more economical freezing of a product but also a more uniform temperature gradient slope as a result of which thermal shock in the product will be less apt to occur.

Another feature of the invention is that the end of the slide members 28 adjacent the inlet end 30 may be constructed and arranged to scrape the conveyor belt 15 as it passes thereover to remove ice formations from the conveyor belt.

Although the invention has been described in considerable detail with respect to a preferred embodiment thereof and preferred methods of operation, it should be understood that the invention is capable of numerous modifications and variations within the spirit and scope of the invention as defined in the appended claims.

I claim:

1. An apparatus for refrigerating a product comprising a housing, a foraminous conveyor in said housing, at least a portion of which conveyor is adapted to support and convey a product in the housing, a stationary slide member in said housing below the undersurface of said portion of the conveyor and in close proximity thereto, at least a portion of said slide member including means for at least momentarily retaining a pool of liquid, means for depositing a shower of cryogenic liquid on said portion of the slide member and on the product as the product is supported on the said portion of the conveyor, the last said means being such that at least a portion of said shower falls as liquid on the product and on the said portion of the slide member, the said portion of the conveyor being positioned relative to the said portion of the slide member such that some of said cryogenic liquid from said shower may collect as a pool on said portion of the slide member to such a depth that it fills some of the openings in the foraminous conveyor and contacts both the slide member and the product concurrently to form a path for heat flow by conduction between the product and the slide member.

2. The apparatus of claim 1 wherein the slide is in contact with the undersurface of said portion of the conveyor.

3. The apparatus of claim 1 wherein the means for retaining a pool of liquid includes upstanding sides on the slide member.

4. An apparatus as claimed in claim 1 wherein said portion of the conveyor and said slide member extend through said housing at an angle inclined with respect to the horizontal.

5. An apparatus as claimed in claim 4 wherein said portion of the conveyor and said slide member are inclined downwardly in the direction of movement of the product on the conveyor.

6. An apparatus as claimed in claim 1 wherein said conveyor is an endless belt, said housing is substantially enclosed except for a product inlet opening and a product outlet opening, and said belt is mounted on and is moveable about a first roller mounted within said housing adjacent said product inlet opening and a second roller mounted within said housing adjacent said product outlet opening.

7. An apparatus as claimed in claim 6 wherein the said portion of the conveyor which conveys the product and which is in contact with the slide member moves from said first roller toward the second roller and the part of the belt returning from said second roller to said first roller is located below said portion of the belt.

8. An apparatus as claimed in claim 6 wherein said housing includes at least a first and a second side wall, the said rollers being connected to the first side wall, and the second side wall being removeable without interrupting movement of the said belt or rollers.

9. An apparatus as claimed in claim 1 wherein said slide member includes a main opening located in the path of said liquid shower for allowing the liquid to fall through the slide.

10. An apparatus as claimed in claim 9 wherein said housing is substantially enclosed except for a product inlet opening at one end of the housing and a product outlet opening at the other end of the housing, and said slide member extends at least from a point adjacent said

inlet opening to said shower, and said slide includes additional apertures between said inlet opening and said main opening for the flow of gaseous refrigerant therethrough.

11. An apparatus as claimed in claim 10 including blower means for blowing gaseous refrigerants in said housing in the direction towards said inlet opening and below said slide member.

12. An apparatus as claimed in claim 8 wherein said slide extends substantially the full length of the housing from a point adjacent said inlet opening to a point adjacent said outlet opening.

13. An apparatus as claimed in claim 12 wherein said means for depositing refrigerating fluid includes a shower means for depositing a shower of refrigerating liquid on said product.

14. An apparatus as claimed in claim 13 wherein said shower means is constructed to deposit the liquid on the product under substantially isentropic conditions in which the pressure of the liquid remains substantially constant as the liquid flows from the shower means to the product to be refrigerated.

15. An apparatus as claimed in claim 1 wherein said shower means includes a tank mounted in said housing above said conveyor and adapted to hold a supply of cryogenic liquid, said tank having a plurality of apertures in the bottom thereof through which the refrigerating liquid may flow from said tank to said product.

16. An apparatus as claimed in claim 15 including adjusting means for varying the size of said apertures in the bottom of said tank.

17. An apparatus as claimed in claim 16 wherein said adjusting means includes a pair of adjacent parallel plates mounted at the bottom of said tank and each plate having apertures and means for moving one plate relative to the other to vary the registry of the apertures in one plate with those in the other plate.

18. An apparatus for refrigerating a product comprising a housing having an inlet end and an outlet end, a conveyor in said housing having a portion adapted to support and convey a product in the housing, a stationary slide member formed of a heat conductive material mounted in said housing below the undersurface of said portion of the conveyor in contact therewith, means for depositing a shower of cryogenic liquid on the product as the product is supported on the said portion of the conveyor, said slide member including a large main opening located in the path of the liquid shower for allowing liquid from the shower to fall therethrough, a major portion of the bottom of the slide member between the main opening and the inlet end being imperforate and means for directing the gases evaporated from the liquid shower towards the said inlet end beneath the said slide member to cool the said bottom of the slide member between the inlet end and the shower.

19. The apparatus of claim 18 wherein said slide member includes additional apertures between said inlet end and said main opening for the flow of gaseous refrigerant therethrough.

20. The apparatus of claim 18 wherein said means for directing includes a blower means located on the side of the shower towards the outlet end for blowing gaseous refrigerant towards the inlet end and baffle means for directing the flow of blown gaseous refrigerant through the liquid shower and towards the inlet end beneath the slide member.

21. The apparatus of claim 18 wherein said slide member and said portion of the conveyor are inclined downwardly from said inlet end towards said outlet end, and said means for depositing a shower includes a tank mounted above the said portion of the conveyor in close proximity thereto to limit the flow of gaseous refrigerant towards the inlet end above the stationary slide member.

22. The apparatus of claim 21 wherein the means for directing includes a blower means and baffle means for directing refrigerating gas from a point above the slide

member near the outlet end through said main opening and towards the inlet end beneath the slide member.

23. An apparatus as claimed in claim 18 wherein said conveyor is foraminous and at least a portion of said slide member includes means for at least momentarily retaining a pool of liquid on the slide member between the main opening and the inlet end, and wherein at least a portion of the shower falls on the said portion of the slide member so that some of the cryogenic liquid collects as a pool on the said portion of the slide member to such a depth that it fills some of the openings in the foraminous conveyor and contacts both the slide member and the product concurrently to form a path for heat flow by conduction between the product and the slide member.

24. An apparatus as claimed in claim 23 wherein the conveyor and slide member are inclined downwardly towards the outlet end and said portion of the slide member is located upstream from the main opening such that the liquid collecting as a pool subsequently travels down the slide and through the main opening.

25. An apparatus as claimed in claim 24 wherein said slide member includes additional apertures between said inlet end and said main opening for the flow of gaseous refrigerant therethrough.

26. A method of refrigerating a product including the steps of:

- (a) passing a product through a chamber between an inlet end and an outlet end on a foraminous conveyor mounted above and in close proximity to a stationary slide member, a portion of which slide member is capable of at least momentarily retaining a pool of liquid,
- (b) depositing a shower of cryogenic liquid on the product as it moves through the chamber such that at least a portion of said shower falls as liquid onto the product and onto said portion of the slide member, and
- (c) collecting some of said cryogenic liquid from said shower as a pool on said portion of the slide member between the slide member and the product of such depth that it fills some of the openings in the foraminous conveyor and contacts both the slide member and the product concurrently to form a path for heat transfer by conduction between the product and the slide.

27. The method of claim 26 wherein the stationary slide member includes a main opening through which the liquid falls and wherein a major part of the bottom of the slide member between the main opening and the inlet end is imperforate, including the step of directing gases evaporated from said shower toward the inlet end beneath the slide member to cool the bottom of the slide member.

28. The method of claim 26 wherein the step of passing the product through the chamber includes passing the product downwardly from the inlet end to the outlet end.

29. A method for refrigerating a product comprising the steps of:

- (a) passing the product through a chamber between an inlet end and an outlet end on a foraminous conveyor mounted above and in contact with a heat conductive stationary slide member,
- (b) depositing a cryogenic liquid on the product such that some of the liquid falls onto the product in a liquid state and falls through a main opening in the stationary slide member, a major portion of the bottom of the stationary slide member between the main opening and the inlet end being imperforate, and
- (c) directing gases evaporated from said shower toward the inlet end beneath the bottom of the said slide member to cool the bottom of the slide member such that the refrigerating capacity of the gases is transferred by conduction through the bottom of the slide member and through the foraminous conveyor to precool the product between the inlet end and the shower.

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