

Jan. 12, 1971

J. K. MORAN  
CONTINUOUS FREEZER

3,553,973

Filed June 23, 1966

6 Sheets-Sheet 1

FIG. 1

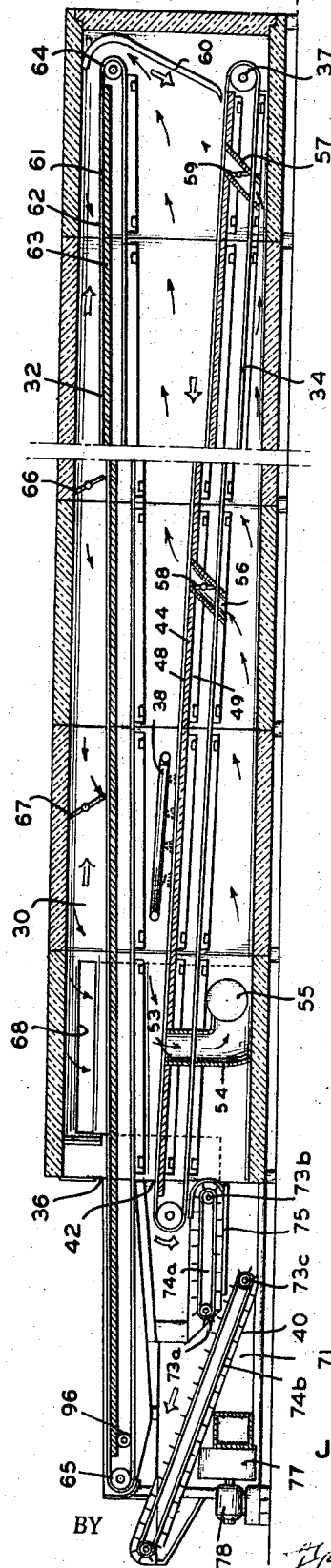
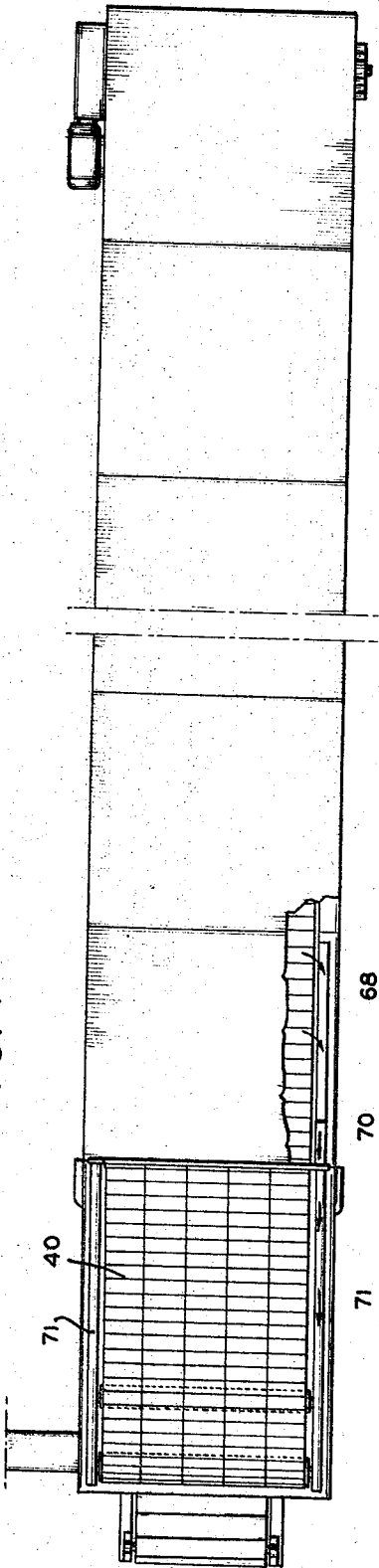


FIG. 2

INVENTOR

JACK K. MORAN

BY

*John A. ...*  
ATTORNEYS

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FIG. 3

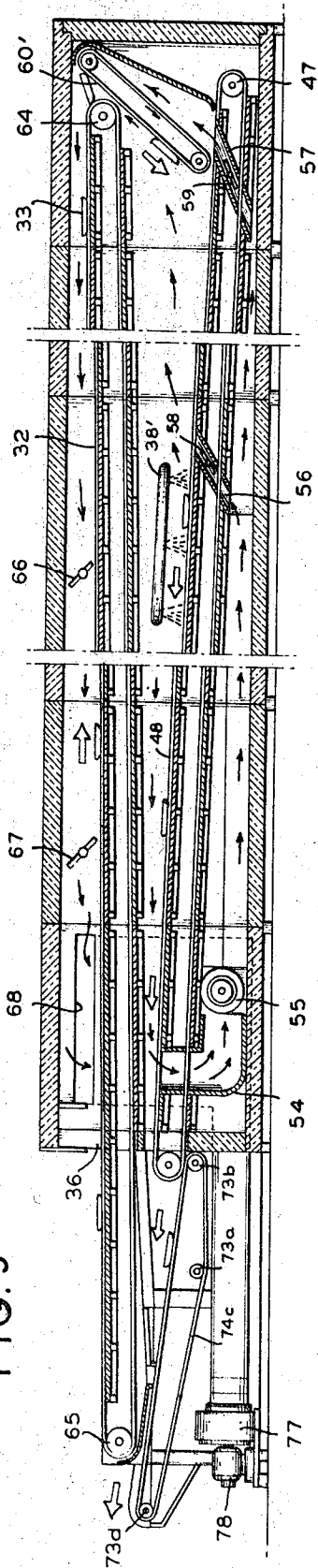
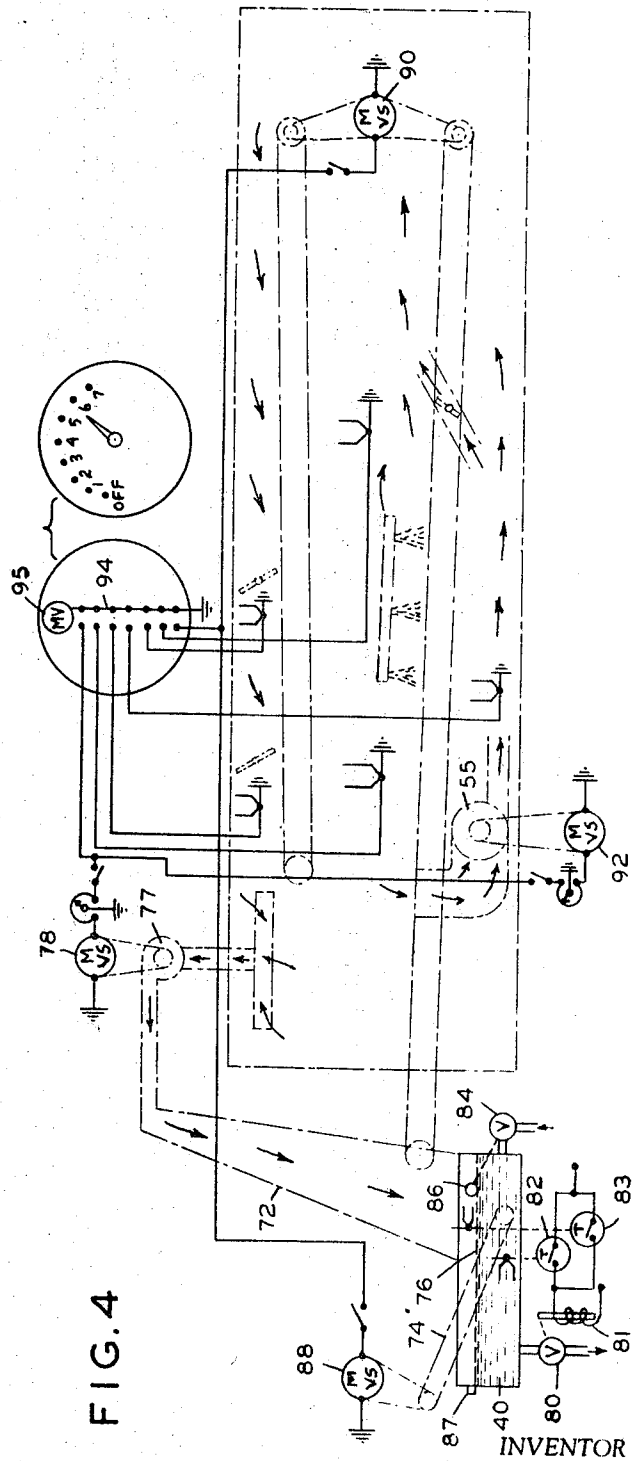


FIG. 4



JACK K. MORAN

BY *Hyatt Sawyer*  
*Hyatt Sawyer*  
ATTORNEY

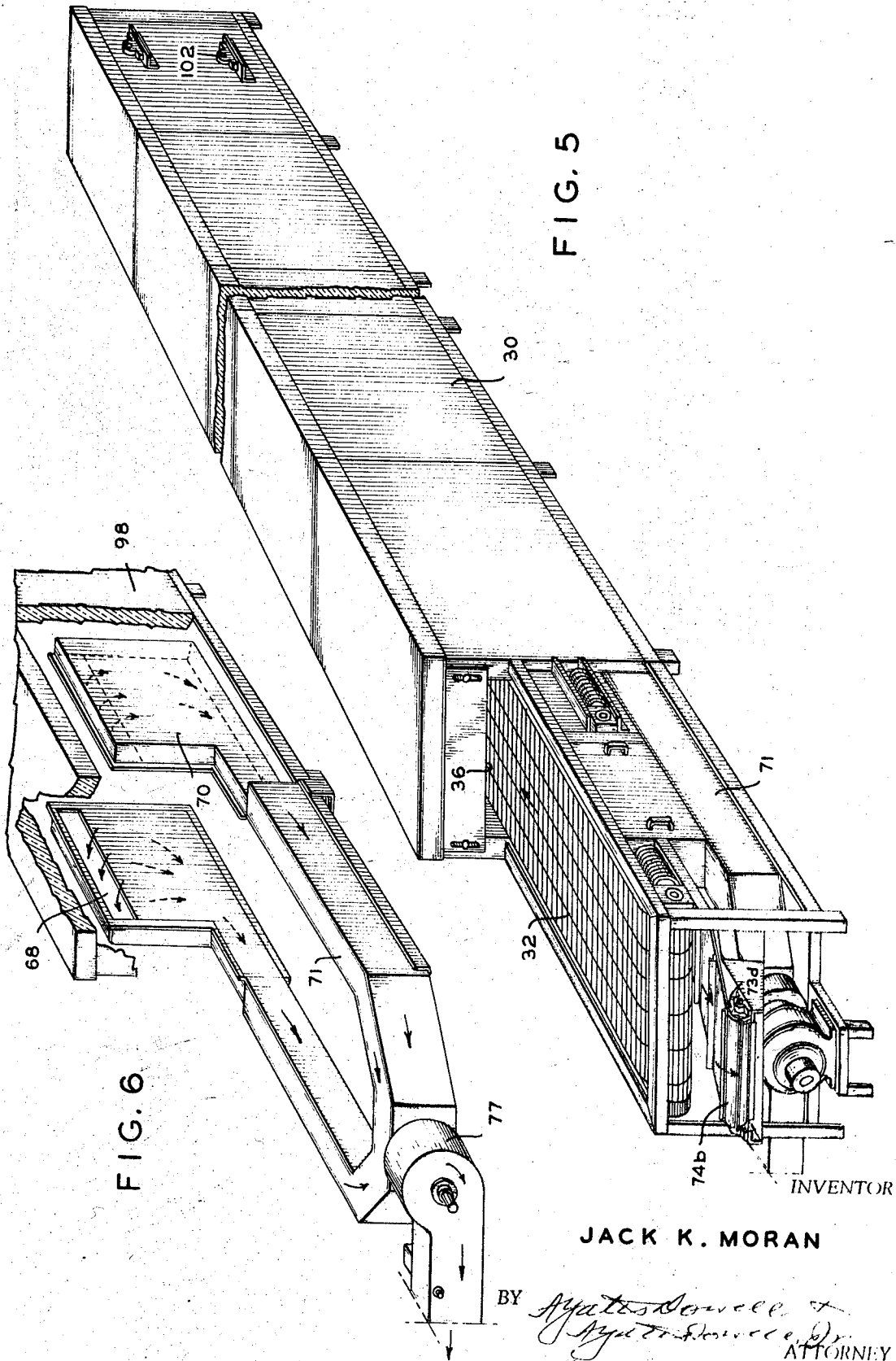
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FIG. 7

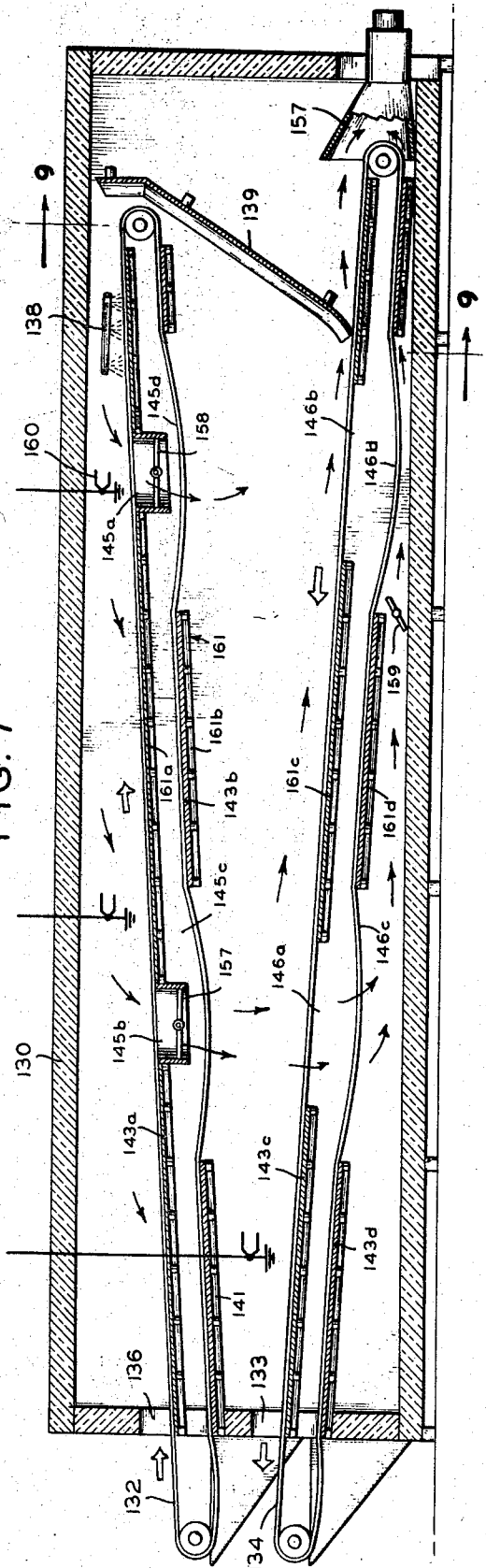


FIG. 9

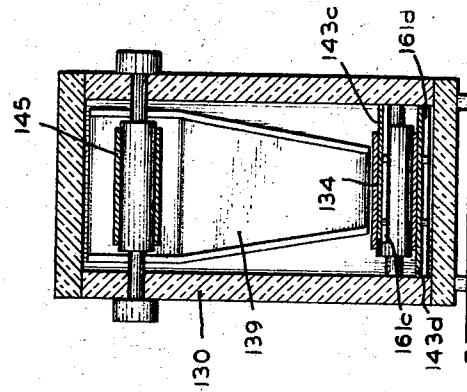
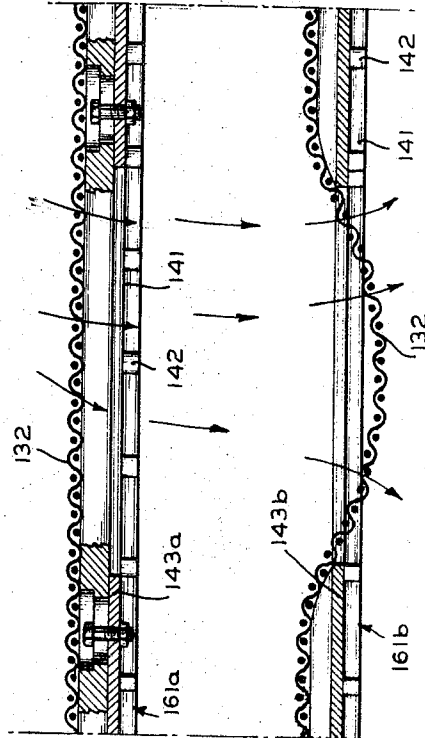


FIG. 8



INVENTOR

JACK K. MORAN

BY *Nyato Dancov*  
*Nyato Dancov*  
 ATTORNEY

Jan. 12, 1971

J. K. MORAN  
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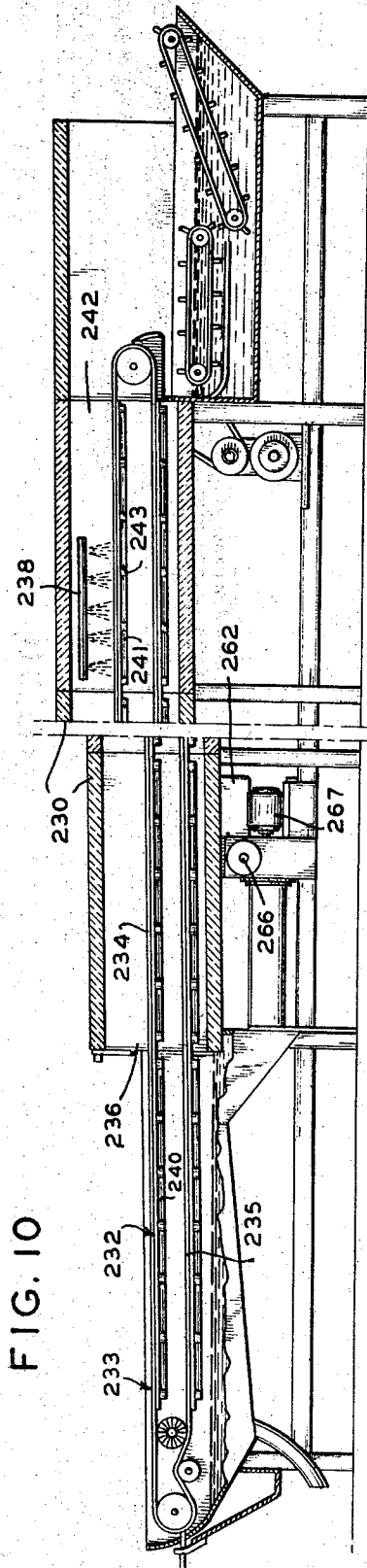


FIG. 10

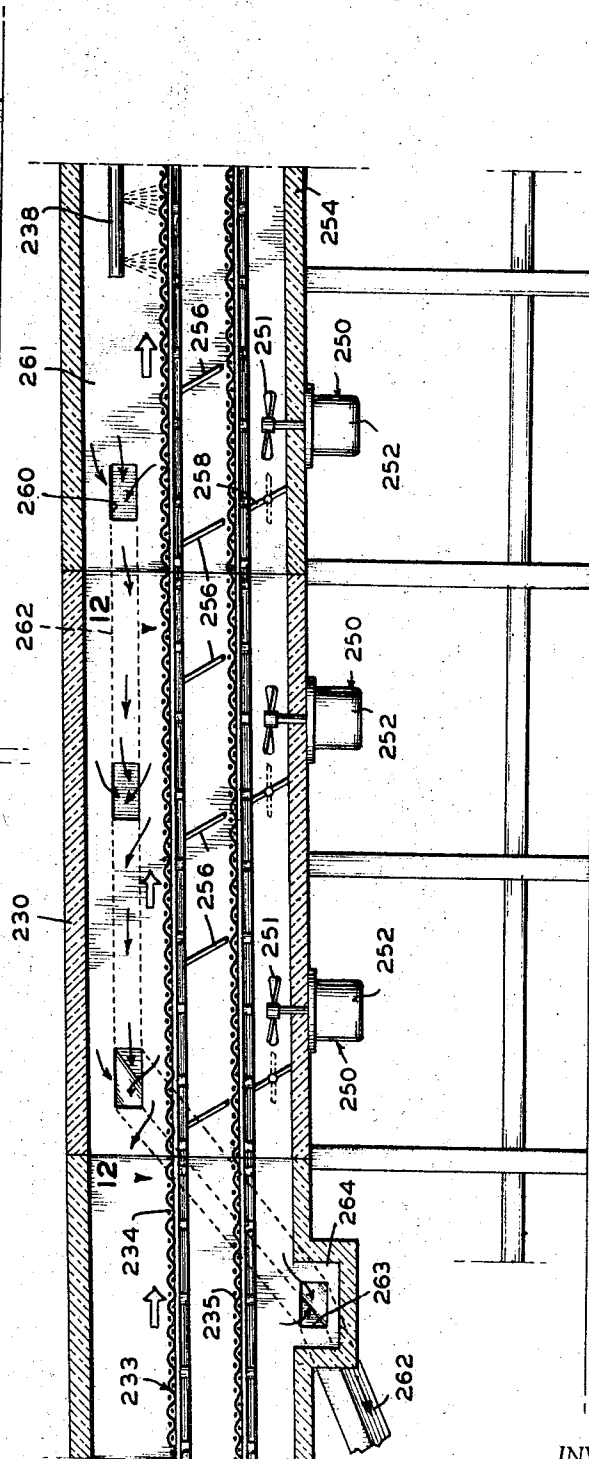


FIG. 11

INVENTOR

JACK K. MORAN

BY *Hyatt Rosenberg*  
*Hyatt Rosenberg*  
ATTORNEY

Jan. 12, 1971

J. K. MORAN

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CONTINUOUS FREEZER

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FIG. 12

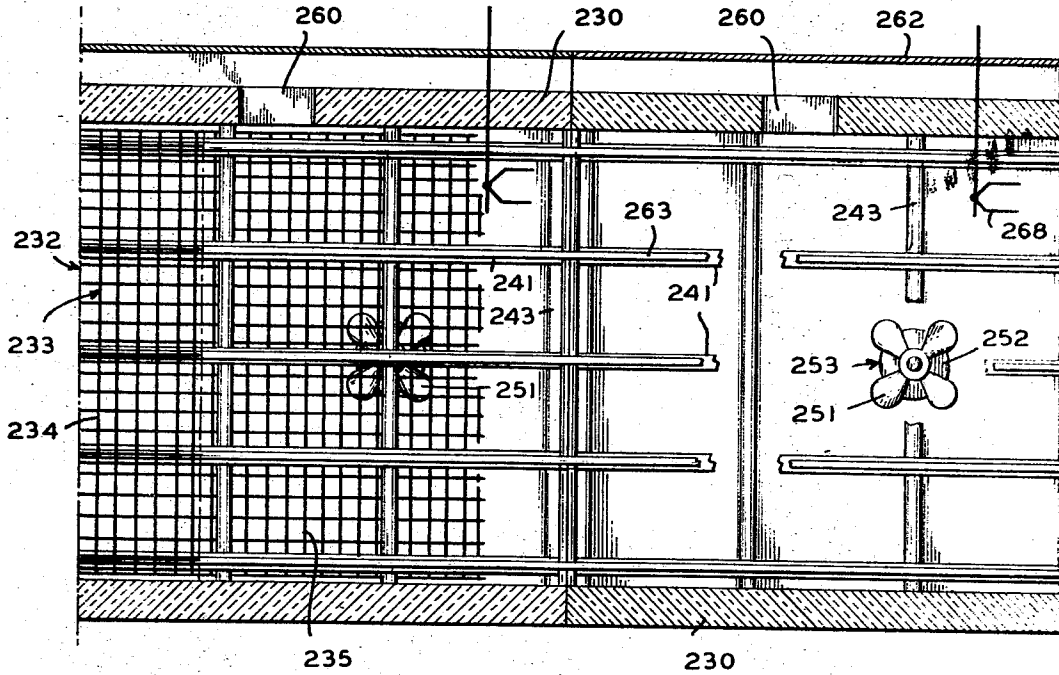
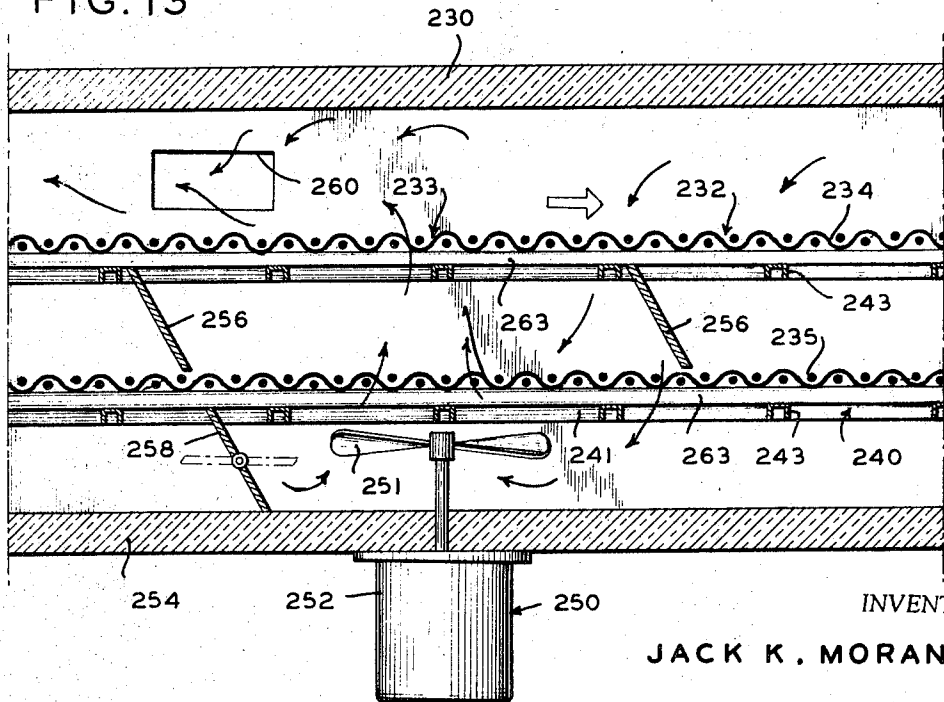


FIG. 13



INVENTOR

JACK K. MORAN

BY *[Signature]*  
ATTORNEY

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**CONTINUOUS FREEZER**  
Jack K. Moran, 8571 Hollyhock Ave.,  
Largo, Fla. 33540  
Filed June 23, 1966, Ser. No. 559,923  
Int. Cl. F25d 3/10

U.S. Cl. 62—63

6 Claims

## ABSTRACT OF THE DISCLOSURE

Cryogenic freezing of articles is carried out in tunnel structure in which the objects are sprayed with cryogenic liquid at a selected location and volatilized refrigerant is removed from and returned to the path of travel at selected locations, the speed of movement of the objects and the handling of the volatilized refrigerant being determined in accordance with temperature requirements.

This invention relates to the art of freezing perishable items, particularly to a freezing apparatus and method in which successive food items continuously are frozen while being carried by a conveyor through a spray of a liquid refrigerant, particularly a cryogenic liquid such as nitrogen.

Cryogenic liquids, according to The American Society of Heating, Refrigerating, and Air-Conditioning Engineers Guide and Data Book are those which boil at temperatures of  $-250^{\circ}$  F. at atmospheric pressure. This is substantially below the temperature range of refrigerants now generally used commercially.

The possibility of freezing articles by subjecting them to the action of such cryogenic liquids has long been recognized. As pointed out by the said publication, the rapid increase since 1947 in the rate of use of liquid oxygen in steel and chemical production, and as an oxidizing agent in the missile and rocket industry, has been a stimulus for the emergence of this field. Liquid nitrogen which boils at  $-320^{\circ}$  F. at atmospheric pressure has been recognized as useful for the freezing of articles, particularly food, because of the lack of a fire hazard, its germ killing effect, and its cost. However, despite these advantages, great difficulties have been experienced in constructing continuously operating units utilizing nitrogen or other cryogenic fluids.

The low temperature of cryogenic liquids causes freezing of moving parts, and wear, and shattering, of the parts because of the brittleness and differences in the expansion and contraction rates of different materials. Furthermore, liquid nitrogen is still expensive and it is desirable to utilize its cooling effect to its maximum capabilities.

Temperature variations within freezers utilizing nitrogen create mechanical stresses. Higher temperatures areas near the entrance, where the temperature is close to that of the ambient room, contract to a significantly lesser extent than the area near that occupied by liquid nitrogen. As a result, moving parts jam and parts subjected to expansion and contraction or mechanical stress break. The material processed may not be adequately frozen, since the speed of movement may be too great to permit the cold temperature of gases striking the product surface to reach and cool the interior.

Assuming that a freezer is designed which may adequately freeze small articles such as peas, it may not be able to freeze the interior of larger articles such as turkeys. There has been lacking a clear teaching of how the design of a particular type structure may be varied to accommodate such different articles.

Because of the cost of refrigerants it is desirable to utilize their heat extraction effect to a maximum extent. Refrigerant vapors may be used for precooling articles

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to be frozen or for glazing frozen articles with a coating of ice to prevent freezer burn, that is, desiccation caused by moisture evaporation. However cryogenic liquid refrigerants are quite likely to freeze water solid, hence it is not too likely to be used to merely cool water which must remain in the liquid state for such uses.

The problems outlined above, while most crucial with cryogenic liquids have also made more difficult the commercial use of other refrigerants which are liquids only at low temperature or high pressure, for example, carbon dioxide, ethane and ethylene whose boiling points at atmospheric pressure are  $-109^{\circ}$ ,  $-127^{\circ}$  and  $-135^{\circ}$  F. respectively.

It is desirable that a commercial freezer be able continuously to freeze articles supplied to it, but provision of a suitable continuous cryogenic freezer has been difficult because of the problems previously described and, accordingly, much effort has been directed to freezers working on the principle of immersion of batches of articles in a bath of liquid nitrogen.

Among the objects of this invention are to provide a practical efficient commercially feasible apparatus to:

- (1) continuously freeze articles by the use of a cryogenic liquid;
- (2) utilize to the maximum extent the cooling effect of the cryogenic liquid and gases;
- (3) precisely control temperature levels and relations in the various portions of such a freezer;
- (4) utilize the plenum system of ventilation to concentrate cryogenic vapors about articles to be frozen, and to prevent entrance of ambient air;
- (5) put a glaze of frozen liquid on articles previously frozen by a cryogenic refrigerant;
- (6) continuously move articles through such a freezer on a conveyor;
- (7) freeze different types of articles by simple design variations of the freezer;
- (8) use a minimum amount of water in the glazing step of the process;
- (9) recover and reuse the refrigerant; and
- (10) use the recovered refrigerant to precool the product introduced.

Other objects and advantages of the invention will be apparent from the following description considered in conjunction with the accompanying drawings in which:

FIG. 1 is a plan view of a cryogenic liquid freezer illustrating one application of the invention;

FIG. 2, a vertical sectional view on the line 2—2 of FIG. 1, the product and vapor flow being shown schematically;

FIG. 3, a sectional view similar to FIG. 2, illustrating a different arrangement of the apparatus of FIG. 2;

FIG. 4, a schematic view illustrating the electric controls of the apparatus of FIG. 2 in solid lines, with certain structural features illustrated in dotted lines;

FIG. 5, a perspective view of the freezer of FIG. 1;

FIG. 6, a fragmentary perspective view of a portion of the freezer of FIG. 1;

FIG. 7, a sectional view similar to FIG. 2 of a different embodiment of the invention;

FIG. 8, an enlarged sectional view of the belt supporting portion of FIG. 7;

FIG. 9, a sectional view on the line 9—9 of FIG. 7;

FIG. 10, a sectional view similar to FIG. 2 illustrating still another freezer according to the present invention, a portion of it being broken away;

FIG. 11, a fragmentary view illustrating the portion broken away from FIG. 10, specifically the area of the freezer in which gas flow takes place;

FIG. 12, a fragmentary enlarged sectional view on the line 12—12 of FIG. 11; and

FIG. 13, a side elevation of FIG. 12.

Briefly stated, this invention comprises apparatus which precisely controls the amount and relation of refrigerant directed to various areas of a chamber in which a cryogenic fluid is directed upon articles carried on a conveyor passing through such chamber. Thermostats and thermo-  
 electric couples are located at various points in the chamber to sense the temperature at these several points. The vapor flow is controlled and directed by baffles moved to desired positions in accordance with the temperature sensed. The product to be frozen is carried by suitable means such as a woven wire conveyor. Stainless steel plates are mounted directly below the conveyor and serve as the bottom of a plenum chamber in which the vapor flows. The conveyor permits gases to pass readily there-  
 through in a manner to surround the articles moving in the chamber. Stainless steel plates are solid except at a few points where they have openings to permit gas to flow to the area beneath the conveyor. In the embodiments illustrated in FIGS. 2 and 7, a second conveyor is mounted below the first conveyor and includes a similar stainless steel plate defining a flow channel which is a secondary plenum chamber. The cryogenic fluid is sprayed on articles traveling on one conveyor and the vapor produced thereby flows to the end of the channel of that conveyor and then is directed to the flow channel associated with the other conveyor. A rack structure is provided for supporting the conveyor and it carries a brass wear strip secured to a stainless steel support frame. Since the conveyor is made of stainless steel woven wire, the softer brass strip takes the wear. A lost motion connection is provided between the stainless steel supporting frame and the brass wear strip to accommodate the different contraction rates of the two materials.

The freezer chamber or tunnel consists of spaced stainless steel inner and outer walls containing expanded foam plastic insulation therebetween. The contiguous ends of the sections are of a construction to interfit and form a tight joint and may have conventional cylindrical plastic gaskets therebetween.

After certain of the products are frozen, they are moved quickly through a glazing tank containing water maintained at a desired level and at a temperature just above the freezing point. The water in contact with the articles freezes to form a glaze or coating of ice.

A precise control is provided to immediately flush the water from the glaze tank if there is danger it will freeze. A flush valve is provided and is actuated by thermostats which sense excessively low temperatures either of the water or the freezer exhaust gases used to cool the water.

Referring to the drawings, FIGS. 1 to 6 illustrate a freezer comprising a cooling chamber or tunnel 30, in which are mounted upper and lower conveyors 32 and 34, which carry goods to be frozen from an inlet 36, beneath a liquid nitrogen spray head 38, out the tunnel discharge 42 and through a glaze tank 40.

The liquid nitrogen flows from the spray head onto the product along an imperforate stainless steel plate 44 which slopes downwardly toward the rear end of the tunnel and extends across the cooling tunnel just below the article carrying run of the conveyor to form a channel which serves as a plenum chamber.

The lower conveyor 34 extends about drive rollers 46, 47, with each run of the conveyor supported by brass wear strips 48 bolted to plates 44. Plates 44 in turn are fixed to frame 49 within the tunnel. The mounting is described in more detail hereafter in conjunction with the description of the freezer of FIG. 5. An opening 53 in plate 44 permits nitrogen vapors to be drawn into a duct 54, located below conveyor 34, by a blower 55. This blower directs the vapors to either ducts 56 or 57 passing between the runs of conveyor 34 and leading to the area above this conveyor. Plate type baffles 58, 59 are rotatably mounted in these ducts and are manually actuable to selectively control the vapor flow,

Blower 55 forces vapors upwardly past a funnel-shaped guide slide 60 to the area above upper conveyor 32. The mounting structure of the upper conveyor 32 generally is similar to that of lower conveyor 34 and includes frame 61, an imperforate stainless steel plate 62, brass wear strips 63, and drive rollers 64 and 65.

Drive rollers 46, 47 and 64 are mounted in Teflon-type bearings 102 extending through side walls 98 and 99 of the tunnel. A motor 90 (FIG. 4) is mounted on the exterior of the tunnel, where it will not be affected by the cold interior temperatures of the tunnel, and is arranged to drive both rollers 64 and 47.

Both the upper conveyor 32 and the lower conveyor 34 are foraminous or made of stainless steel wire mesh.

Plate type baffles 66 and 67 (FIG. 2) are rotatably mounted in the area above conveyor 32 and control gas flow. An exhaust duct 68 is mounted near the conveyor inlet 36 and exhaust gases pass there from through a duct 70 to a heat exchanger 71 mounted near the glaze tank 40. An exhaust blower 77 is arranged to exhaust gases through the heat exchanger 71.

Four drive rollers 73a, 73b, 73c and 73d are rotatably mounted in the glaze tank walls. 73a and 73b are mounted in the same plane near the top of the glaze tank; 73c is mounted near the bottom of the glaze tank; and 73d is mounted at one end of the glaze tank well above the water surface.

Appropriate conveyor belts 74 can be disposed about these rollers to provide a number of different arrangements for carrying articles either through the glaze tank or above it as desired when not used (FIG. 3). FIG. 2 illustrates a conveyor 74a arranged to carry articles along a horizontal baffle plate 75 mounted within glaze tank 40 below the water surface 76 and onto a conveyor 74b located about drive rollers 73c and 73d.

FIG. 3 illustrates an alternative arrangement utilized when glazing is not desired. Conveyor belt 74c is entrained about rollers 73a, 73b and 73d and articles are carried above the glaze tank 40.

A flush valve 80 is located in the bottom of the glaze tank 40 and is actuated by a solenoid 81 energized by closure of either of two thermostat switches 82 or 83 mounted within the glaze tank 40. An inlet valve 84 controlled by a ball float 86 supplies ambient temperature water to the glaze tank 40 whenever its level falls below the desired level 76 (FIGS. 2 and 4). An overflow drain 87 permits excess water to flow from glaze tank 40 when, for example, warm water is introduced to prevent the contained water from becoming too cold and freezing. Variable speed motors are used to drive the various conveyors and blowers. Motor 88 drives glaze tank conveyor 74, motor 90 drives the conveyors 32 and 34, motor 92 (FIG. 4) drives blower 55, and motor 78 drives blower 77. Rheostat type speed controls have been found satisfactory for the blower motors 78, 92, and commercially available silicon controlled rectifier-type circuits have been used to vary the speed of the conveyor motors 88 and 90.

A number of thermo-couple units 93 are located in various portions of the freezer, for example, near adjustable plate type baffles 59, 66, 67 (FIG. 2), near the spray head 38, the internal blower 55, and variable speed motor 90. These are connected through a selector switch 94 to a milli-voltmeter or pyrometer potentiometer 95 which measures the minute electric potential generated in the selected thermo-couple which thereby indicates the temperature at the given point.

A cleaning brush 96 (FIG. 2) is rotatably mounted to roll over and clean the woven wire of upper conveyor 32 just after it leaves the cooling tunnel.

In use, articles to be frozen are introduced onto an area 97 of the upper conveyor 32 just before the cooling tunnel inlet 36. The articles are carried into the tunnel 30 and are precooled during their travel to the remote end of the upper conveyor 32. They then slide down

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funnel-shaped guide or conveyor 60. This deposits them on the lower conveyor 34 at points well spaced inwardly of the side walls 88, 89 of the tunnel. This permits cool gases completely to surround articles on the lower conveyor. Precooling of products continues on lower conveyor 34. When the product reaches spray head 38, it is struck by a spray of liquid nitrogen or other cryogenic fluid which immediately refrigerates the product with more or less vaporization since the articles are well above the liquid nitrogen boiling point of  $-320^{\circ}$  F. Time may be required for the product to be frozen throughout depending on the thickness thereof, the spray head being located an appropriate distance from the tunnel discharge. In practice, the freezer is designed to freeze particular articles and the spray head is positioned as close to the inlet 36 as is feasible. If the spray head is close to the entrance, the articles are frozen to an undesirably low temperature; hence, in practice, the spray head is usually near the freezer discharge 42, particularly when the product is small, for example, with shrimp and small vegetables. If larger articles are to be frozen, such as turkeys, the spray head will be positioned at some distance from the discharge opening 42 and perhaps even above the upper conveyor 32.

Normally, the spray head 38 is positioned above the lower conveyor 34. The cryogenic vapor produced below spray head 38 fills the channel or plenum chamber formed by stainless steel plate 44 and completely surrounds the upper or article carrying run of conveyor 34. This plethora of vapor keeps the ambient air away from articles to be frozen and in general forces the stagnant ambient air out of the cooling tunnel 30 in an action which is similar to the plenum system of ventilation used in some buildings. Some of the vapor flows downhill in the plenum formed by the stainless steel plate 44 and some of it is drawn uphill through openings 53 and duct 54 to internal blower 55 which blows it beneath the conveyor and upwardly through ducts 56 or 57. It then rises past funnel or conveyor slide 60 at the rear end of the device to the space above upper conveyor 32, where it flows downhill to exhaust outlets 68, and is sucked into exhaust duct 70 where it flows to the exhaust blower 77 which forces it into heat exchanger 71 and cools the water in glaze tank 40.

Because of the extremely cold temperature of the cryogenic liquid, there is considerable danger of excessive cooling at various areas. This might cause moving parts such as drive rollers 64 and 47 or baffles 56 to 57 to become immovable. Metal parts such as the conveyor belts may be excessively contracted and may become brittle and break. The articles may be excessively frozen. To prevent this, the temperature in the several areas of the freezer, particularly near the various baffles, is regularly checked by the use of a selector switch 94, thermocouples 93, and milli-volt meter 95. Appropriate variations of the baffle positions, the conveyor speed, and internal and exhaust blowers are made so that excessive freezing does not occur. Those skilled in the art of freezing know appropriate formulas, such as those set out in the beofre-mentioned ASHRAE Guide and Data Book for computing the amount of heat that must be extracted from articles to be frozen. Knowing the specific heat that can be extracted with the cryogenic fluid, rough settings of conveyor speed and blower speed are made. Thereafter these may be varied as required from observation and experimentation. To meet the needs of different products, the speed of the glaze conveyor motor 88 is adjusted so that a desired weight of water is frozen onto the articles during their passage through the conveyor. For example, with shrimp, 2 ounces of ice per pound of product has been found desirable. If the temperature of water in glaze tank 40, or of exhaust vapors supplied to heat exchanger 71, becomes too low the water automatically is discharged through valve 80, and the tank is refilled with warmer water.

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FIG. 3 illustrates a variation of the freezer of FIGS. 1-2. This type of structure may be used to freeze articles not requiring a protective glaze, and in which it is desired to have the same surface upwardly on both upper conveyor 32 and lower conveyor 34; for example, food carried in metal foil trays or pans. Upon reaching the end of the upper conveyor 32, the forward edges of the articles are tipped upwardly by a tripping conveyor belt 60'. Once free of the upper conveyor, the trailing edge of the articles slides downwardly by means of the tipping conveyor in a direction opposite to the upwardly moving conveyor belt. The lower surface of the article is in contact with the tipping conveyor. Upon reaching the lower edge of the tipping conveyor, the articles pass onto the lower conveyor 34 with their upper surfaces still facing upwardly. The spray head 38' is positioned in a slightly different location above the lower conveyor than was the case with the freezer of FIG. 2.

When a glaze of ice is not required, the glaze tank 40 may be left unused. Instead the glaze tank conveyor belt 74c is located about rollers 73a, 73b and 73d and is run in a direction reverse to that utilized with glaze tank conveyor 74a illustrated in FIG. 2.

Except for the variations noted, the freezer of FIG. 3 is otherwise identical to that of the freezer of FIG. 2.

#### FIGS. 7-9 EMBODIMENT

According to another embodiment of the invention, a cooling chamber or tunnel 130 includes an upper conveyor 132 and a lower conveyor 134 which carry products to be frozen from an inlet 136 past a spray head 138. This position of the spray head 138 above the upper conveyor is particularly useful with large articles, such as turkeys, which require considerable time for the extraction of heat from their interiors. Upon reaching the end of the upper conveyor 132 the product slides down chute 139, and onto the lower conveyor 134 from whence it is carried to the cooling tunnel discharge 133.

The structures of both upper conveyor 132 and lower conveyor 134, likewise may be of wire mesh, and have supporting structure similar to that of upper conveyor 32 and lower conveyor 34 of the FIGS. 2 and 3 embodiment. The supporting structure for both the upper and the lower run of each conveyor is a frame structure 161 including longitudinal stainless steel beams 141 and transverse beams 142 supporting imperforate stainless steel plates 143. Plates 143a and 143b of the upper conveyor slope upwardly from article inlet 136 to chute 139; plates 143c and 143d of the lower conveyor 134 slope upwardly from the chute 139 to cooling tunnel discharge 133.

Plate 143a of the upper run of the upper conveyor is substantially continuous except that it has a front opening 145a and rear opening 145b therein. Immediately below these openings, plate 143b which supports the lower run of the upper conveyor, is interrupted the full width in areas 145c and 145d. Similar openings 146a, 146b, 146c, and 146d are found in the steel plates 143c and 143d supporting the runs of lower conveyor 134. Openings 146a, 146b, 146c, and 146d are below the corresponding openings 145a, 145b, 145c, and 145d of the upper conveyor 132. Frame structures 161b and 161d which support the lower steel plates 143b and 143d, respectively, of the conveyors are interrupted in the region of openings 145c, 145d, 146c and 146d. Rotatable baffle 157 is positioned between the upper and lower conveyors beneath openings 145b and 145c. Rotatable baffle 158 is positioned between the upper and lower conveyors below openings 145a and 145d. Baffle 159 is rotatably mounted below lower conveyor 134 in the area between openings 146c and 146d to selectively block the passage between lowermost stainless steel plates 143d and the tunnel bottom.

Thermocouples 160 are placed at various points within the chamber or tunnel where it might be desired to sense or detect the temperature.

Between openings 145c and 145d and 146c and 146d

there are areas in which excess length of the woven wire conveyor belt can sag through these openings. This permits absorption of the excess belt length supplied to accommodate the extreme contraction that takes place due to the variation between the ambient temperature and that present during operation of the freezer.

In operation, goods to be frozen are admitted at article inlet 136 and are carried to cryogenic refrigerant spray head 138 where liquid refrigerant is sprayed upon the articles. The refrigerant flows down the upper stainless steel plate 143a; however, some of its passes through openings 145a and the remainder through openings 145b in order to precool goods before they reach the spray head 138. The vapor passing through openings 145a and 145b passes down upon the stainless steel plate 143c supporting the upper run of the lower conveyor. A portion of it flows downhill towards exhaust duct 157 and a portion of it passes through the openings 146b and 146c and thereafter flows underneath the lower conveyor 132 towards the exhaust duct 157. Heat is extracted from the articles by the refrigerant as it travels on the lower conveyor. Baffles 157, 158 and 159 are positioned in accordance with the temperatures indicated by thermocouples 160 to control the flow and accumulation of vapor in various areas.

#### FIGS. 10-13 EMBODIMENT

According to another embodiment of the invention, the freezer may comprise a cooling chamber or tunnel 230 having a single conveyor 232 therein. This conveyor is formed of a woven stainless steel wire belt 233. Its upper run 234 and lower run 235 are supported by frames 240 of open construction and formed of longitudinal beams 241 and transverse beams 243. The frames are made in removable sections. Brass wear strips 263 are secured to longitudinal members 241.

A spray head 238 is fixed near the cooling tunnel discharge 242 and a plurality of fans 250 are mounted below the lower run 235 of the conveyor with rotary blades 251 arranged for rotation in a plane parallel to and below the conveyor belt, but a sufficient distance above the tunnel bottom to permit vapor to be sucked from below the blades. Fan motors 252 are mounted beneath the tunnel bottom wall 254.

Between upper run 234 and lower run 235 of the conveyor and above each fan 250 are arranged baffles 256 which slope upwardly toward the conveyor article inlet 236. Above each fan at a point between upper run 234 and the tunnel roof an opening 260 (FIG. 11) is positioned in the tunnel side wall 261. A duct 262 connects this opening and the exterior of the tunnel. Baffles 258 are mounted for rotation about a transverse axis between lower run 235 and tunnel bottom 254. If rotated so that their lower edges contact the tunnel bottom, they form a weir or obstruction that holds a pool of vapor immediately below a fan blade 251.

Beyond the last fan 250 and just before tunnel inlet 236 a depression is located in the tunnel bottom wall which forms a sump. An opening 263 in the side of this sump leads to duct 262.

Exhaust blower 266 powered by a variable speed motor 267 draws nitrogen vapor through duct 262.

Thermocouples 268 are placed at various locations along the length of the cooling tunnel to measure the temperature at such locations.

In operation, matter to be frozen is placed on the portion of upper run 234 of the conveyor located exteriorly of the cooling tunnel. Such matter is carried into the tunnel through inlet 236 and is precooled by nitrogen vapor. Upon reaching the area beneath spray head 238 such matter is contacted by the liquid nitrogen and the temperature of such matter substantially reduced. Vapor produced by the liquid nitrogen passes through the foraminous stainless steel belt 233 and the frame 240 to the bottom of the cooling tunnel. The fans 250, 75

whose blades are spaced above the bottom of the tunnel, draw the nitrogen vapor beneath themselves and then drive it upwardly through the previous or foraminous belts. Movable baffles 258 form a pool of vapor beneath fan blades 251 and prevent vapor on the article inlet side of the fans from being drawn beneath it. Fixed baffles 256 direct vapors discharged from fans 250 toward the article inlet. The arrangement of fans and baffles causes vapor flow in a direction opposite article movement on the conveyors. The suction created by the exhaust fan 266 through the openings 260 helps to draw the vapor directly up through the belt. The action of succeeding fans and the fixed baffles 256 is strong enough that most of the vapor is drawn downstream to the next fan. Any remaining vapor which passes between the last fan and the article inlet settles in sump 264 and is drawn through opening 263 by the exhaust fan.

Temperatures are sensed at various locations by thermocouples 268 and appropriate manipulation of the movable baffles 258 are made. The general effect of the draft of the longitudinally spaced fans 250 and the fixed baffles 256 is to flow the refrigerant vapor along the tunnels. However, the movable baffles 258 serve as weirs, or adjustable height dams, which control this flow by accumulating vapor at points below fan blades 251. Appropriate manipulation of baffles 258 can control the amount of vapor drawn from particular openings 260 into duct 262.

It will be readily apparent that there is provided a freezer utilizing a cryogenic liquid able to continuously freeze articles to which applied and in which the temperature in the various areas can be precisely controlled by appropriate positioning of baffles or control of blower and motor speeds, and in which by the relatively simple procedure of varying the position of the spray head while assembling, the freezer can be converted to treat various types of products.

It will be obvious to one skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof, and therefore, the invention is not limited by that which is illustrated in the drawings and described in the specification, but only as indicated in the accompanying claims.

What is claimed is:

1. The method of freezing objects comprising,
  - (a) moving the objects in a path at a controlled rate;
  - (b) spraying a liquid refrigerant upon the said objects at a selected location along the said path;
  - (c) removing volatilized refrigerant from such path and thereafter returning the volatilized refrigerant to a plurality of locations in the path;
  - (d) selectively controlling the amount of volatilized refrigerant returned to said other locations;
  - (e) causing a portion of the volatilized refrigerant to flow in a direction reversely to the direction of travel of the objects;
  - (f) sensing the temperature of a plurality of areas in the path;
  - (g) controlling the speed of movement of objects in the path, the amounts of vapor removed from the path, and the amount of vapor returned to the path in accordance with the temperature sensed; and
  - (h) spraying the liquid refrigerant upon the material at a location along the path of movement which is selected in accordance with the heat transfer requirements of the material to be frozen.
2. Apparatus for freezing objects comprising,
  - (a) a support structure;
  - (b) means carried by the support structure for moving goods to be frozen from a receiving to a discharge position along a path;
  - (c) an insulated cooling tunnel surrounding the said path;
  - (d) said means for moving goods including means forming upper and lower objects carrying means

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mounted for movement in the cooling tunnel and sloping uphill in the direction of travel with the upper carrying means mounted for movement in a direction reverse to that of the lower carrying means for carrying goods from an inlet to the end of the upper path, thence to the beginning of the lower path, and thereafter to an outlet point receiving area of the lower carrying means;

- (e) means carried by the support structure for spraying a liquid refrigerant which volatilizes upon goods moving in said path; 10
- (f) means for directing vapor produced by volatilization of the said refrigerant liquid away from the spraying area to a second area along the movement path, and directing said vapor on objects carried in said path at the second area; 15
- (g) means carried by the support structure for controlling the amount of vapor striking articles in the second area;
- (h) in which the spraying means is located above one surface of a carrying means upstream of its object receiving point; a chamber means surrounds each object carrying means for directing vapors along the objects carrying means; and means are provided for directing vapor from the chamber of the carrying means having the refrigerant spraying means to the chamber of the other carrying means whereby vapors flow first along one means and then along the other. 20

3. The structure of claim 2 in which the refrigerant spraying means is located above the upper carrying means and openings are provided along the upper carrying means for passage of vapor to the lower carrying means. 30

4. The structure of claim 2 in which a discharge opening for vapor is located at the lower end of the chamber of the lower carrying means. 35

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5. The structure of claim 2 in which means are provided for selectively obstructing the means for directing vapor from one chamber to the other.

6. The structure of claim 2 in which means are provided to sense the temperature at selected areas within the cooling tunnel and to open and close the said obstruction means in response to said temperature variations.

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WILLIAM E. WAYNER, Primary Examiner

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