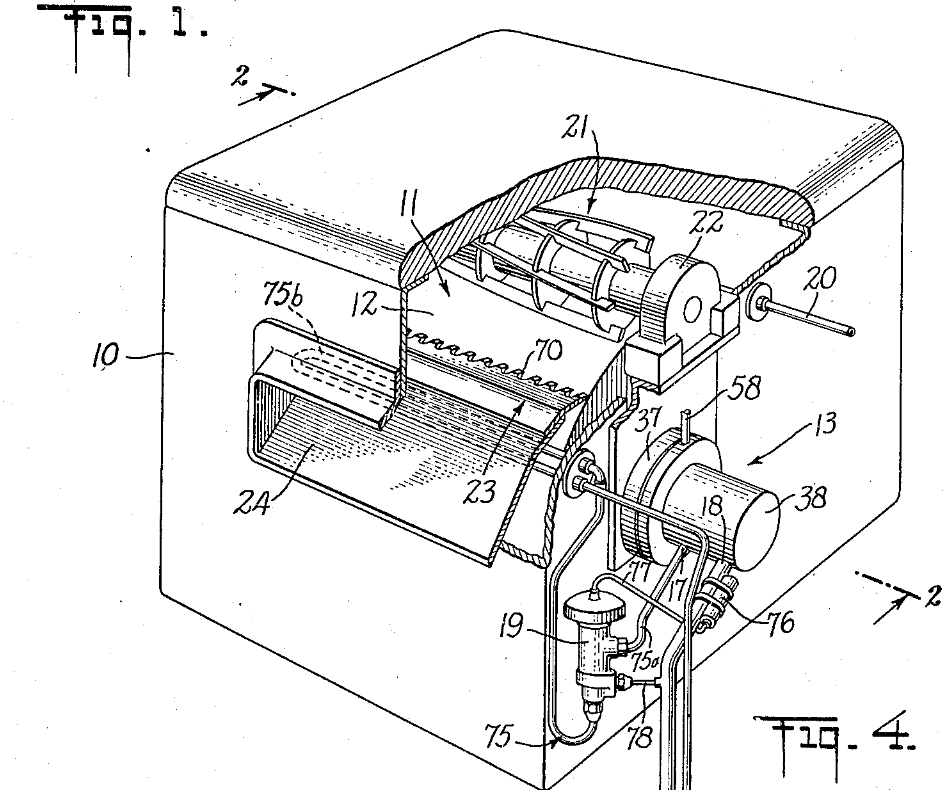
March 21, 1944. F. M. RAVER 2,344,922

REFRIGERATION

Filed Jan. 13, 1941 3 Sheets-Sheet 1

FIG. 1.



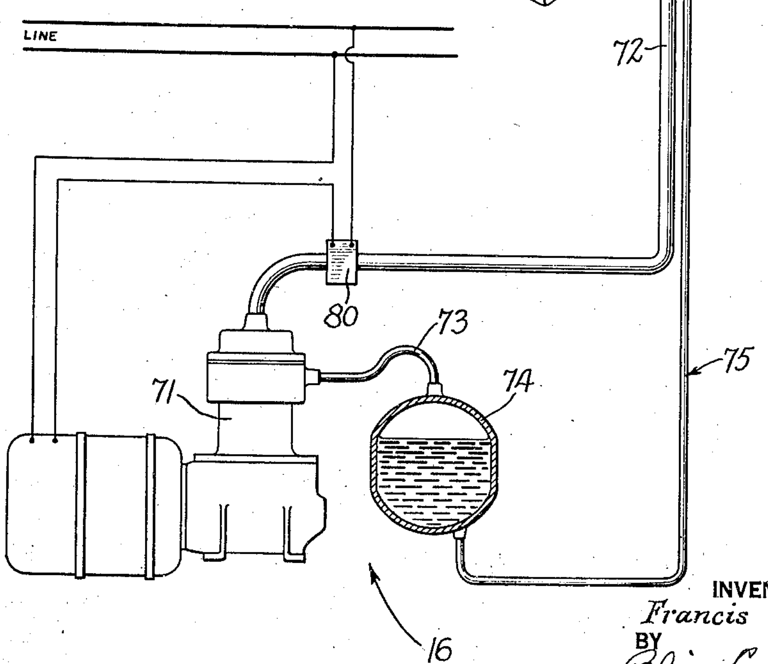
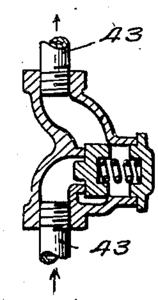


FIG. 4.



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REFRIGERATION

Filed Jan. 13, 1941 3 Sheets-Sheet 2

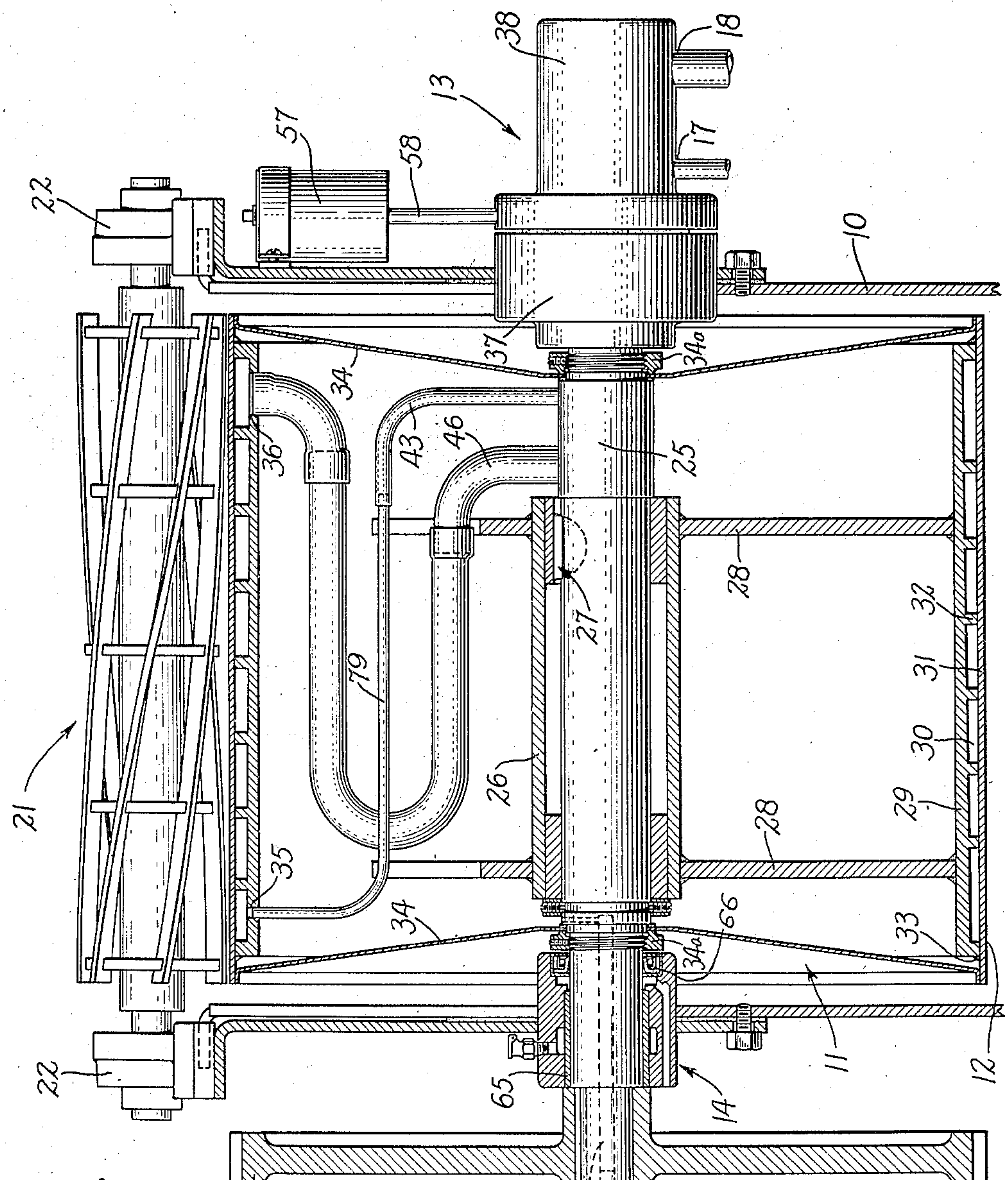

FIG. 2.

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REFRIGERATION

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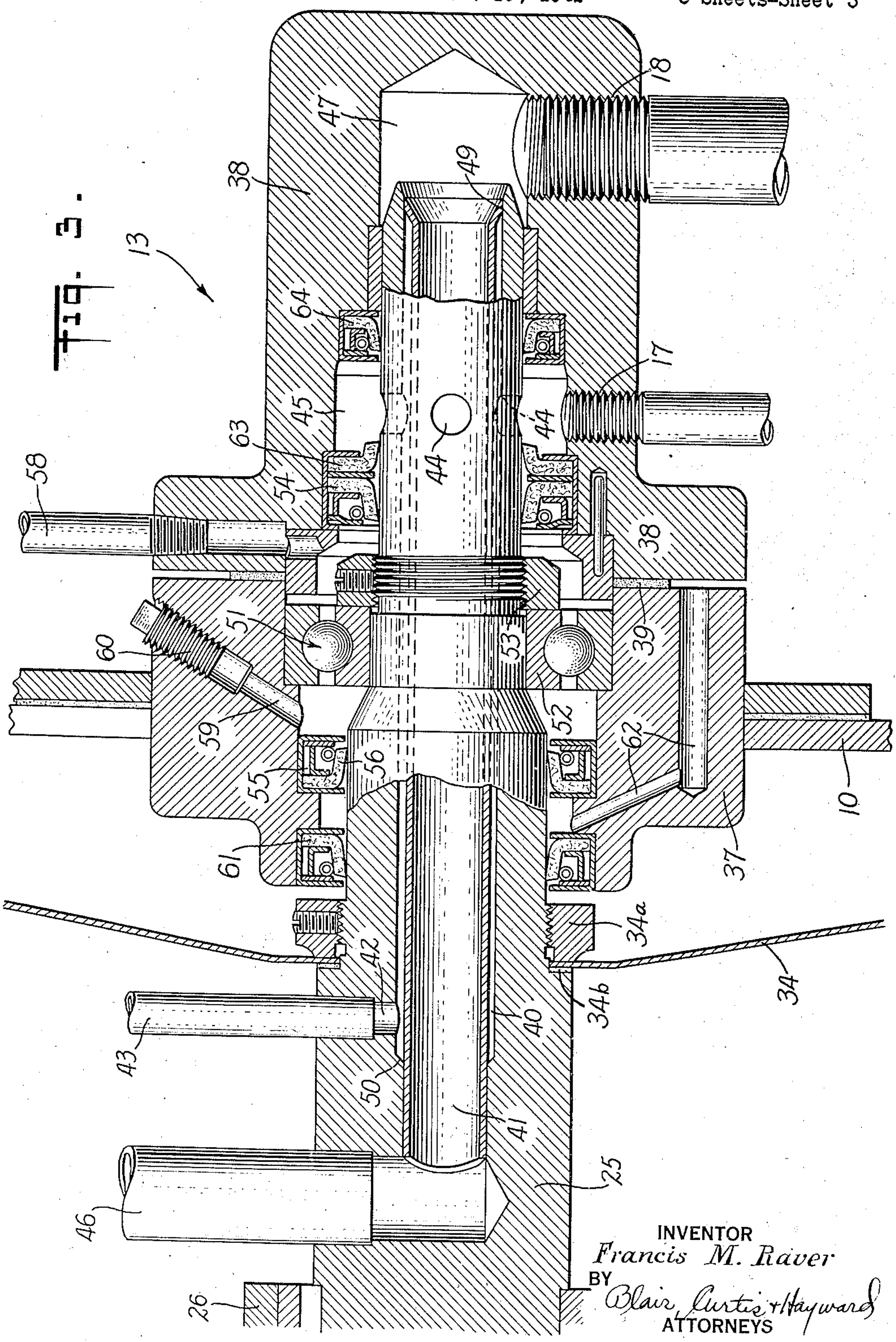

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Patented Mar. 21, 1944

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UNITED STATES PATENT OFFICE

2,344,922

REFRIGERATION

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Application January 13, 1941, Serial No. 374,274

12 Claims. (Cl. 62—106)

This invention relates to improved apparatus for refrigerating material, and more particularly to the refrigeration of material to convert it from a liquid state into a solid state such as the freezing of water to make ice. The present invention is an improvement over that disclosed in my copending application Serial No. 307,973.

An object of the present invention is to provide improved apparatus for freezing liquids.

Other objects will be in part obvious and in part pointed out hereinafter.

In the drawings:

Figure 1 is a perspective view of apparatus embodying the invention and showing diagrammatically a refrigerating system supplying cooled refrigerant to a rotatable freezing surface;

Figure 2 is a vertical axial section (partly in elevation) taken on line 2—2 of Figure 1;

Figure 3 is an enlarged vertical axial section of a bearing assembly which permits relative movement between a shaft supporting the rotatable freezing surface and its bearings, and which seals the bearings against escape of the refrigerant; and

Figure 4 is a detail diagrammatically showing a spring loaded valve.

The present embodiment of the invention deals primarily with the congealing of a liquid, such as water, on a substantially rigid freezing surface and the removal of the congealed liquid from the surface in the form of flakes in contradistinction to finely comminuted ice or "snow" which may be scraped from a sheet of ice remaining on a rigid surface on which it is frozen. The problem of removing ice or other aqueous fluids congealed on a rigid freezing surface is difficult because of the tenacity with which the congealed material clings to the freezing surface, and also because of the peculiar characteristics of congealed substances, such, for example, as the hardness, brittleness and tensile and compressive strengths.

It has long been recognized that scraping ice from a freezing surface to remove it has many disadvantages such as consuming considerable power and producing a product which because of its fineness and other qualities is limited in its use as a refrigerant. Also, in the freezing of foodstuffs it is often impractical to subject them to a scraping action because of the damage done to the product.

In the above mentioned co-pending application there is disclosed a novel method and apparatus for making ice by which the ice is frozen in sheet form on a smooth substantially rigid metal cylindrical surface. Then successive portions of the ice sheet are removed from the freezing surface by a radial pushing and wedging action rather than by a tangential scraping or cutting action. Furthermore, the temperature of the ice at the point of removal is controlled to regulate the hardness and brittleness of the ice to maintain these characteristics at such values that the wedging and pushing action frees the successive strips or portions of the ice sheet completely from the freezing surface. In the present invention certain aspects of the invention are improved.

Referring to Figure 1, a tank 10 or compartment containing a tank is shown housing and supporting a rotatable freezing cylinder generally indicated at 11 and having a cylindrical freezing surface 12. The cylinder, as shown in Figure 2, is rotatably supported in bearing assemblies generally indicated at 13 and 14, respectively, and is driven from its left end by a gear 15. Liquid refrigerant compressed in a refrigerating system generally indicated at 16, Figure 1, enters the evaporating space of the rotating cylinder through an inlet connection 17 in bearing assembly 13 and the spent gaseous refrigerant leaves through an outlet connection 18 in the same bearing assembly. The temperature of the surface 12 of the cylinder (evaporator) is maintained at the desired value by means of a reducing valve 19 of usual construction and operated by the temperature and pressure of the spent refrigerant.

The water in the tank is maintained at the desired level by any suitable means such as a float valve, not shown. The make-up water controlled by the float valve is sprayed onto the surface 12 above the water level through a pipe 20.

As the cylinder 11 rotates an ice sheet builds up on the surface 12 and is removed by a cutting wedge unit generally indicated at 21 which in appearance resembles a lawn-mower cutter. It has a plurality of helical wedging blades and is mounted in bearings 22 (Figure 2) to rotate freely about an axis directly above and parallel to the cylinder 11. The axis is so adjusted that the sharp edges of the helical wedges very nearly contact, but do not, the surface 12. As the cylinder 11 rotates and the surface 12 moves past the ice-removing unit 21 the ice on the surface 12 contacts and rotates the wedging units with the result that each helical wedge removes a strip of ice from the ice sheet and simultaneously frees the ice from the surface 12 in the form of flakes. As the cylinder continues to rotate, the flakes fall onto and are removed from the surface

12 by an ice-collecting plate generally indicated at 23. The flakes pass down the plate through a chute 24 provided in the side of the tank 10.

The present invention provides for a novel construction of a rotating evaporator which is "series" operated rather than "flooded" operated, and also provides for a novel construction by which the liquid refrigerant is introduced into the cylinder and the spent refrigerant removed from the cylinder without the use of stuffing boxes and insulation.

Referring to Figures 2 and 3, the cylinder 11 is supported on a shaft 25 which runs in the bearing assemblies 13 and 14. The cylinder itself is supported on the shaft in the following manner: A sleeve 26 is keyed to the shaft by "Woodruff" keys generally indicated at 27. Suitably secured to the sleeve, as by welding, are two spiders 28. The spiders 28 support on their outer peripheries and are secured to an inner shell 29 of the evaporator. As shown, the inner shell comprises a section of steel pipe provided with a helical groove 30 around its outer periphery. The outer shell 31 of the evaporator and the one which has the surface 12 is preferably of a material such as stainless steel and is shrunk over the inner shell to provide tight contact between the outer shell 31 and helical ribs 32 forming the helical groove 30. The inner and outer shells are welded together around their ends as indicated at 33 to seal the helical space 30 between the inner and outer shells from atmosphere.

The space between the inner shell 29 and the shaft 25 is also sealed from the atmosphere by means of light gage stainless steel heads 34 welded to the inner periphery of the inner shell along its edge portions. The heads 34 (Figure 3) are tightly secured with respect to the shaft 25 by clamps 34a which thread on the shaft 25 and clamp the heads 34 between gaskets 34b and suitable shoulders provided on the shaft 25. The connection of each head both to the inner shell and to the shaft is thus made fluid-tight so that the interior of the cylinder is gas filled and is sealed from atmosphere and from the water in the tank 10. This construction provides the required insulation between the interior of the evaporator and the water in tank 10 so that no ice forms on the heads 34.

The helical groove that runs around the evaporator between the inner and outer shells 29 and 31 provides the evaporator space in which the evaporation of the liquid takes place to cool the surface 12. The liquid refrigerant enters the helical groove 30 through an intake port 35 in the left side of the evaporator as shown in Figure 2, and the spent refrigerant leaves the evaporator through the port 36.

The connection between the liquid refrigerant inlet 17 in the bearing assembly 13 and the inlet port 35 and the connection between the outlet port 36 and the outlet connection 18 will now be described. The connection provides for the necessary rotating movement between the ports 35 and 36 and the stationary connections 17 and 18. Referring to Figures 2 and 3 the bearing assembly 13 is shown as housed within a split casing, one section 37 of which extends through and is secured to the side wall of the tank 10. The other section 38 which might be described as a cover section is bolted to the section 37 by suitable bolts, not shown, and a gasket 39 between the sections makes the fit between the two sections fluid-tight.

The end of the shaft 25 extending through the bearing assembly 13 is provided with outer and inner concentric passages 40 and 41, respectively. The outer concentric passage has an outlet port 42 which is connected by a tube 43 with the inlet port 35 of the evaporator. The outer concentric passage also has inlet ports 44 which open into an annular passage 45 into which the liquid refrigerant connection 17 opens so that the liquid refrigerant passes to the inlet port 35 through the annular passage 45, the inlet ports 44, the outer concentric passage 40, the port 42 and the tube 43.

The inner concentric passage 41 is connected at its inner end through a tube 46 with the outlet port 36 of the evaporator groove 30. The outer end of the inner concentric passage opens into a chamber 47 into which the spent refrigerant connection 18 opens. The inner and outer concentric passages are sealed, one from the other, as shown at 49 and 50. With this construction warm liquid refrigerant entering the bearing assembly 13 is utilized to prevent the cold spent refrigerant from cooling the bearing assembly 13 to the freezing point so that no water freezes on the section 37 exposed to the water in the tank 10. Furthermore, this temperature condition is obtained without the use of insulation.

The shaft 25 is supported in the bearing assembly 13 by a ball bearing 51, the outer race of which is fitted into the section 37, and the inner race 52 of which is secured with respect to the shaft by a clamping ring 53 threaded onto the shaft 25. Thus the bearing 52 not only provides for rotation of shaft 25 but also serves as a thrust bearing to take care of the end thrust caused by the pressure of the refrigerant.

The liquid refrigerant is prevented from escaping from the annular passage 45 through to the water in the tank 10 by the following seal construction: Opposed seals 54 and 55 are provided on either side of the ball bearing 51. The seals are of known construction and are preferably of a spring pressed expanding gasket type with the sealing member 56 being of some material such as rawhide, "neoprene," or the like. The seal 54 permits passage of fluid to the left between the seal and the shaft, but resists passage of fluid contrariwise. The seal 55 prevents passage of fluid to the left along the shaft.

The space between the seals 54 and 55 is preferably filled with oil run in from a chamber 57 through a line 58 connecting with the space between the seals. As the oil is run in the displaced air is allowed to escape from the space through a passage 59 normally closed by a plug 60. After the space is filled with oil the chamber 57 is covered and tightly sealed to withstand pressure.

In operation, when the high pressure of the liquid refrigerant reaches the seal 54, it seeps past the seal and (if the refrigerant is a preferred form, i. e., one which is miscible with oil) it dissolves in the oil present in the space and raises the pressure thereof. The increased oil pressure forces both seals 55 and 54 into close contact with the shaft 25 and the relatively high viscosity of the oil prevents its escape past the seal 55. Also, in the event that the pressure of the liquid refrigerant for any reason is reduced, as when the ice-making machine is not in operation, the seal 54 prevents the pressure that has built up within the space between the two seals from escaping. In this novel manner the pressure of the liquid refrigerant is utilized to accomplish the desirable sealing action.

On the inner end of the section 37 is mounted an additional seal 61 adapted to prevent water from the tank 10 from reaching the seal 55. And any water which might possibly seep past the seal 61 is drained out through a passage 62 which empties into the space between the sections 37 and 38.

Next to the seal 54 is provided an additional seal 63 provided to prevent the liquid refrigerant from passing too rapidly into the oil filled space between the seals 54 and 55.

The liquid refrigerant is prevented from escaping from the annular passage 45 to the low pressure chamber 47 by means of a similar seal 64 of known construction.

Referring to Figure 2, the left end of shaft 25 runs in a sleeve bearing 65 mounted within the bearing assembly 14. A water seal 66 similar to the seal 61 prevents water in the tank 10 from reaching the sleeve bearing. A normally plugged passage 67 connects the interior of the cylinder.

Referring to Figure 1, the ice-collecting plate 23 comprises a bent plate, the upper forward surface of which is substantially horizontal. Inasmuch as the ice made by the machine of the present embodiment may be as thin as one-eighth of an inch or less, the leading edge 70 of the ice-collecting plate 23 is positioned closer than one-eighth of an inch to the surface 12 of the cylinder so that the blade picks off the freed ice flakes from the cylinder. But since the ice-removing unit 21 does not operate to remove the ice until the ice thickness builds up to approximately one-eighth of an inch, an ice sheet builds up on the surface 12 and moves past the plate 23 during a short period following the putting of the machine in operation. This ice thickness, although not sufficient for the ice-removing unit to operate upon, is sufficient to contact the plate 23 which scrapes on the ice sheet as the cylinder surface 12 moves past the plate. This scraping action puts an abnormally heavy load on the motor rotating the cylinder 11 and to reduce this load in the present invention the leading edge 70 of the plate 23 is serrated as shown in Figure 1. The serrations act to materially reduce the resistance of the scraping action to the cylinder movement during the period in which the ice thickness is built up to the normal operating thickness.

Referring again to Figure 1, the refrigerating system, as shown, is adapted to work on a refrigerant such as dichlorodifluoromethane. The system includes a motor driven compressor 71 connected by a line 72 with the outlet connection 18 of the bearing assembly 13. The output of the compressor passes through the usual condenser, diagrammatically shown at 73, whence it passes to a tank diagrammatically shown at 74 in which the liquid refrigerant is stored under a pressure of approximately 125 pounds per square inch and at a temperature which is normally in the neighborhood of 100° F. Between the tank 74 and the intake connection 17 of the bearing 13 is a line generally indicated at 75 in which is provided the usual control valve 19 which in the present embodiment reduces the pressure from approximately 125 pounds per square inch down to 40 or 50 pounds per square inch and simultaneously reduces the temperature down to between 40 to 50 degrees Fahrenheit. This control valve is made responsive by a thermo element 76 and connecting line 77 filled with the liquid refrigerant to the temperature of the gas in the line 72. It is also made responsive to the pressure in the line 72 through a line connection 78. The connections 77 and 78 are connected with oppositely acting bellows in the usual manner and the bellows are spring loaded so that the valve 19 passes enough refrigerant to maintain the gas in the line 72 in a super-heated condition as desired.

So that the entering liquid refrigerant may heat the bearing assembly 13 as described, the forty to fifty pound pressure in the line 75a leaving the valve 19 and the corresponding temperature is maintained substantially through to the inlet port 35 of the evaporator by providing suitable means in the line 43 between the outlet port 42 of the concentric passage 40 and the inlet port 35. In the present embodiment this is accomplished by providing a restriction 79 in the tube 43 so that the pressure of the refrigerant after leaving the control valve is not allowed to drop until it enters the evaporator proper. Other means of maintaining this pressure could be used, such, for example, as a spring loaded valve in line 43 as shown in Figure 4. By providing this restriction the desired temperature of the refrigerant necessary to prevent freezing up of the bearing assembly 13 is ensured. Also the system is preferably arranged and adjusted to provide for sufficient velocity of the refrigerant through the passageways in the bearing assembly 13 to ensure adequate heating of the bearing assembly to prevent its freezing up.

Referring to Figure 2, the evaporating groove 30 is provided with a constantly increasing cross-sectional area to constantly increase the capacity of the evaporator from the entering end to the leaving end to take care of the increased volume of the fluid as the liquid vaporizes. This increasing capacity of the helix gives the desired increase in velocity of the refrigerant as it passes through the evaporator, which velocity is desirable to ensure the oil present in the liquid refrigerant being carried through the evaporator and back to the compressor, and to ensure adequate and uniform cooling of the surface 12 across its entire width. With this construction, therefore, the evaporator may be run as a series evaporator, thus requiring less refrigerant and a less complicated system than would be necessary if it were run as a flooded evaporator.

Referring again to Figure 1, it is desired to have the tank 10 as small as possible and to correspond in size closely to that of the cylinder 11. Consequently there is relatively little circulation of the water through the tank and there is a tendency for the water layer directly beneath the ice-collecting plate 23 to attain a temperature approximately that of 32° F. (when water is being frozen) so that ice particles collect and build up in the water beneath the plate 23. In the present invention this tendency is eliminated by supplying a small amount of heat to the layer of water directly beneath the plate 23. To this end the liquid refrigerant line 75 leaving the tank 74 instead of passing directly to the valve 19 is caused to loop as indicated at 75b in the water layer directly beneath the plate 23. The heat of the liquid refrigerant is sufficient to keep the ice particles from collecting or any ice from forming in this area.

Referring to Figure 1 again, there is preferably provided in the line 72 a pressure-responsive switch 80 adapted to cut out the compressor motor drive in the event that the pressure in the line

12 drops below the normal operating pressure as would take place if, for example, the cylinder 11 stopped rotating and ice started to build up on the cylinder to reduce the heat transfer. Provision of such a safety device ensures against the possibility of the water in the tank 10 freezing solid and damaging the apparatus.

As various embodiments might be made of this invention, and as various changes might be made in the construction herein described, all without departing from the scope of the invention, it is to be understood that all matter herein sets forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In ice-making apparatus supplied with refrigerant by a compressing system, in combination, a rotatable evaporator, a rotatable shaft for supporting said evaporator, a stationary bearing assembly for supporting said shaft, a passage in said shaft for conducting liquid refrigerant through said shaft to said evaporator and a passage in said shaft for conducting gaseous refrigerant from said evaporator through said shaft, the outer ends of said passages respectively opening into separated chambers in said bearing assembly connected respectively with the high and low pressure sides of said compressing system, means in said bearing assembly for preventing said liquid refrigerant from escaping along said shaft to atmosphere including opposing spring pressed seals of the expanding gasket type around said shaft, and means for filling the space between said seals with a viscous liquid miscible with the liquid refrigerant whereby the pressure of the liquid refrigerant raises the pressure of the viscous liquid between the seals, which pressure is thereafter held independently of the refrigerant pressure by the action of said seals.

2. In ice-making apparatus supplied with refrigerant by a compressing system and including a rotatable evaporator, a rotatable shaft for supporting said evaporator, a stationary bearing assembly for supporting said shaft, said evaporator and the side of said stationary bearing assembly adjacent said evaporator being exposed to water being frozen, and a passage in said shaft for conducting liquid refrigerant through said shaft to said evaporator and a passage in said shaft for conducting gaseous refrigerant from said evaporator through said shaft, the outer ends of said passages respectively opening into separated chambers in said bearing assembly and being connected respectively with the high and low pressure sides of said compressing system, in combination, means in said bearing assembly for preventing said liquid refrigerant from escaping along said shaft to atmosphere comprising two opposing spring pressed seals of the expanding gasket type around said shaft, means for filling the space between said seals with a viscous liquid miscible with the liquid refrigerant whereby the pressure of the liquid refrigerant raises the pressure of the viscous liquid between the seals, which pressure is thereafter held independently of the refrigerant pressure by the action of said seals, and sealing means around said shaft between said spring pressed sealing means and said water to prevent water from reaching said spring pressed sealing means, freezing and destroying said pressure between said spring pressed sealing means.

3. In ice-making apparatus supplied with refrigerant by a compressing system and including a rotatable evaporator, a rotatable shaft for supporting said evaporator, a stationary bearing assembly for supporting said shaft, said evaporator and the side of said stationary bearing assembly adjacent said evaporator being exposed to water being frozen, and a passage in said shaft for conducting liquid refrigerant through said shaft to said evaporator and a passage in said shaft for conducting gaseous refrigerant from said evaporator through said shaft, the outer ends of said passages respectively opening into separated chambers in said bearing assembly and being connected respectively with the high and low pressure sides of said compressing system, in combination, means in said bearing assembly for preventing said liquid refrigerant from escaping along said shaft to atmosphere comprising two opposing spring pressed seals of the expanding gasket type around said shaft, means for filling the space between said seals with a viscous liquid miscible with the liquid refrigerant whereby the pressure of the liquid refrigerant raises the pressure of the viscous liquid between the seals, which pressure is thereafter held independently of the refrigerant pressure by the action of said seals, and a seal in said bearing assembly for preventing water from reaching said first named seals.

4. In ice-making apparatus supplied with refrigerant by a compressing system and including a rotatable evaporator, a rotatable shaft for supporting said evaporator, a stationary bearing assembly for supporting said shaft, said evaporator and the side of said stationary bearing assembly adjacent said evaporator being exposed to water being frozen, and outer and inner concentric passages in said shaft for respectively conducting warm liquid refrigerant through said shaft to the evaporator and cold spent refrigerant from said evaporator to the compressing system, said warm refrigerant serving to keep the bearing assembly above freezing temperature, the outer ends of said passages respectively opening into separated chambers in said bearing assembly, which chambers are connected respectively with the high and low pressure sides of said compressing system, in combination, means in said bearing assembly for preventing said liquid refrigerant from escaping along said shaft to atmosphere comprising two opposing spring pressed seals of the expanding gasket type around said shaft, means for filling the space between said seals with a viscous liquid miscible with the liquid refrigerant whereby the pressure of the liquid refrigerant raises the pressure of the viscous liquid between the seals, which pressure is thereafter held independently of the refrigerant pressure by the action of said seals, and another seal in said bearing assembly about said shaft to prevent water from reaching said first named seals, said warm refrigerant serving to keep ice from forming on said last named seal.

5. A rotatable evaporator comprising an inner shell having a helical groove around its outer periphery and an outer shell shrunk over said inner shell to form with the groove an evaporator helical passageway bounded by the outer and inner shells, a shaft, and means for supporting said evaporator on the shaft, said shaft having outer and inner concentric passageways for respectively conducting warm liquid refrigerant through the shaft to the evaporator and cold spent liquid refrigerant from the evaporator, said warm liquid refrigerant serving to maintain said shaft above the freezing temperature, and end heads for sealing the space between said

shaft and said inner shell whereby the interior of the shell is protected from the atmosphere.

6. In ice-making apparatus, in combination, a tank, a cylinder mounted in said tank and rotatable about a horizontal axis, said cylinder having a freezing surface and being over 50% submerged in liquid to be frozen, an ice-freeing unit mounted above said cylinder, and an ice-collecting plate for collecting ice from the cylinder after it is freed from the freezing surface by said ice-freeing unit, said collecting plate being slightly above the water level, and means beneath said ice-collecting plate for heating the water therebeneath to prevent ice from collecting in the water under said plate.

7. In ice-making apparatus, in combination, a rotatable evaporator having a freezing surface, a tank for supplying water to said evaporator and in which said evaporator is partially submerged, an ice-freeing unit for freeing from said freezing surface ice formed thereon, a refrigerant compressing system, a connection for conducting liquid refrigerant from said compressing system to said evaporator, a return connection for conducting the gaseous refrigerant from said evaporator to said compressing system, and a control valve for controlling the supply of refrigerant to said evaporator to maintain the desired temperature-pressure relationship in the return connection, and a pressure-operated switch in said return connection for cutting out the operation of said compressing system in the event that pressure in said return connection drops below a predetermined value.

8. In ice-making apparatus, in combination, a tank, a cylinder mounted in said tank and rotatable about a horizontal axis, said cylinder having a freezing surface over 50% submerged in a liquid to be frozen, an ice-freeing unit mounted above said cylinder for freeing from said freezing surface ice formed thereon, and an ice-collecting plate for collecting ice from the cylinder after it is freed from the freezing surface, said ice-collecting plate being slightly above the water level, and means for heating the layer of water beneath the ice-collecting plate to prevent ice from collecting in the water under said plate.

9. In ice-making apparatus, in combination, a tank, a cylinder mounted in said tank and rotatable about a horizontal axis, said cylinder having a freezing surface over 50% submerged in a liquid to be frozen, an ice-freeing unit mounted above said cylinder for freeing from said freezing surface ice formed thereon, and an ice-collecting plate for collecting ice from the cylinder after it is freed from the freezing surface, said ice-collecting plate being slightly above the water level, and means for maintaining the temperature of the layer of water beneath the ice-collecting plate sufficiently above freezing temperature to prevent ice from collecting in the water under said ice-collecting plate.

10. A rotatable evaporator having an external freezing surface adapted to be supplied with liquid to be frozen, a shaft, said evaporator comprising a shell mounted on said shaft and spaced therefrom and provided with a refrigerant series evaporator passageway close to said freezing surface, and thin uninsulated metal end heads sealed to said shell and said shaft and cooperating therewith to imprison a body of gas within the confines of said shell whereby the heat transfer between refrigerant in said passageway and said end heads is reduced and the temperature of said end heads is kept above freezing temperature.

11. A rotatable evaporator having an external freezing surface adapted to be supplied with liquid to be frozen, said evaporator comprising a shell and having a series evaporator passageway running around said evaporator close to said freezing surface, a shaft for supporting said evaporator provided with outer and inner concentric passageways for conducting liquid refrigerant to and from said evaporator and connections from said respective passageways to an inlet and outlet of said series evaporator passageway, and thin uninsulated metal end heads sealed to said shell and said shaft and cooperating therewith to imprison a body of gas within the confines of said shell whereby heat transfer between refrigerant in said passageway and said end heads is reduced and the temperature of said end heads is kept above freezing temperature.

12. A rotatable evaporator having an external freezing surface, a shaft, said evaporator comprising a shell mounted on said shaft and spaced therefrom and provided with a refrigerant series evaporator passageway close to said freezing surface, and thin uninsulated metal end heads sealed to said shell and said shaft and cooperating therewith to imprison a body of gas within the confines of said shell whereby the heat transfer between refrigerant in said passageway and said end heads is reduced and the temperature of said end heads is kept above freezing temperature, and a tank for holding liquid to be frozen, and said evaporator and end heads being at least partially immersed in the liquid in said tank.

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