United States Patent

Lyman

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[54] ICE MAKING APPARATUS

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[52] **U.S. Cl.** .....**62/354,** 100/93 S, 264/28, 425/378

[51] **Int. Cl.**.....**F25c 1/14**

[58] **Field of Search** .....107/14; 100/117, 145, 93 S; 18/125 M, 125 SA, DIG. 55; 62/347, 354, 74, 320, 75; 264/329 28 X; 425/378

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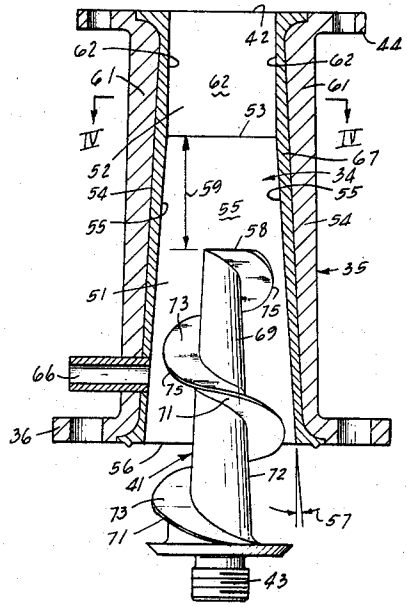
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[57] **ABSTRACT**

A rotatable compression auger and nozzle assembly includes helical flights disposed within a bore having a non-circular cross section and lined with a liner having a low thermal conductivity. An optimum angulation of the helical flights insures that an ice slush product neat the auger bonds to ice particles in free portions of the bore, and the axial alignment of the auger relative to the configuration of walls of the bore is predetermined to give either hard or uncompressed ice.

5 Claims, 4 Drawing Figures

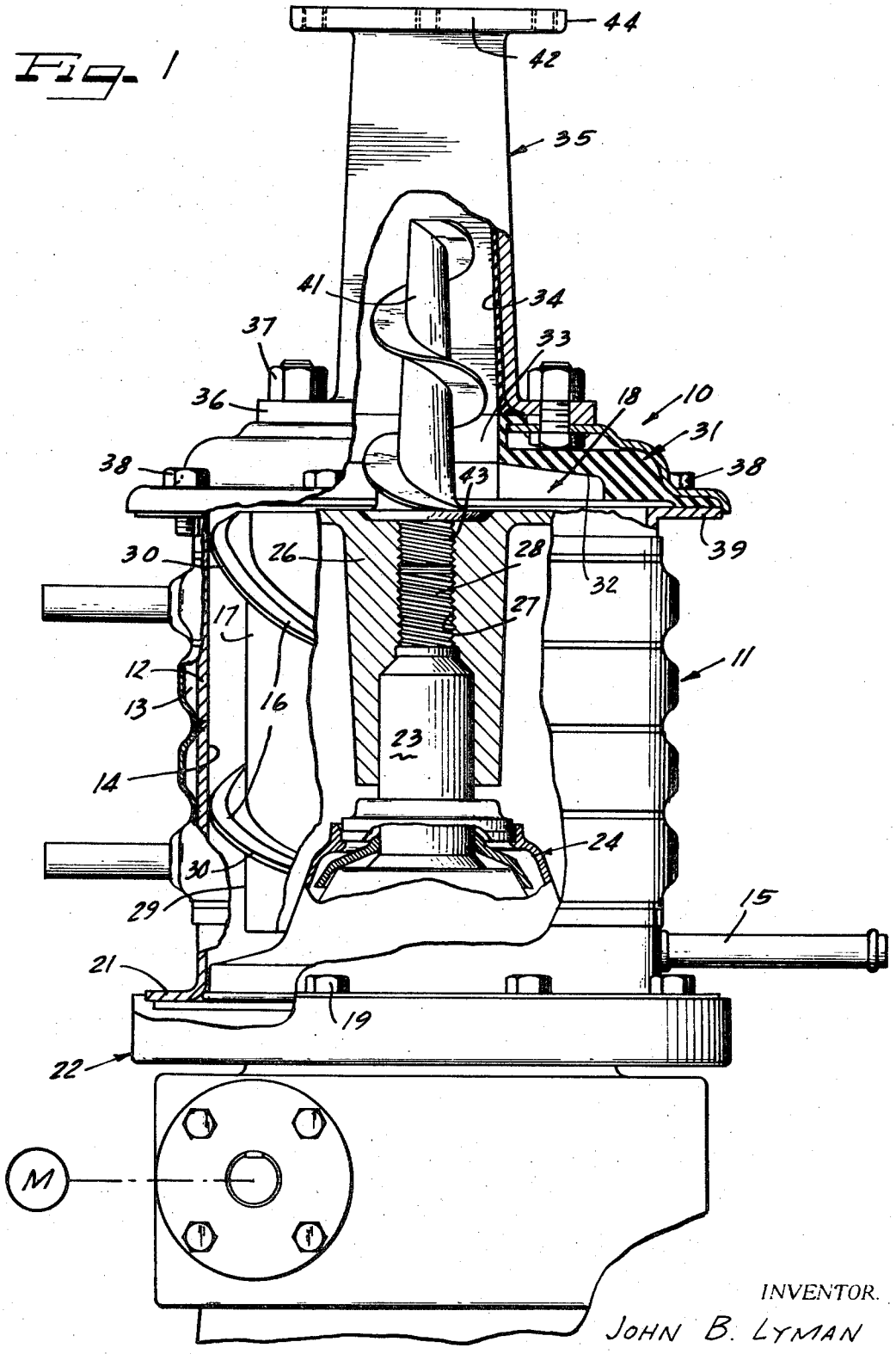


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Fig. 1



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Fig. 2

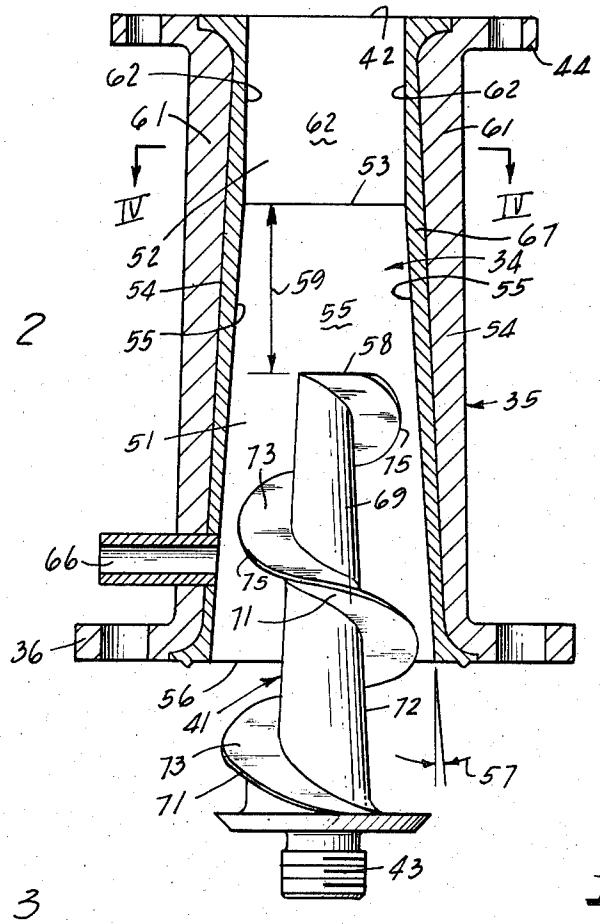


Fig. 3

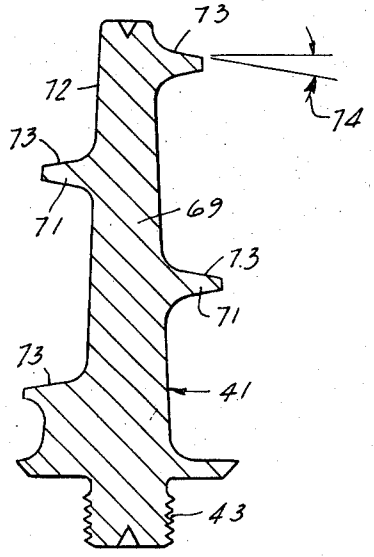
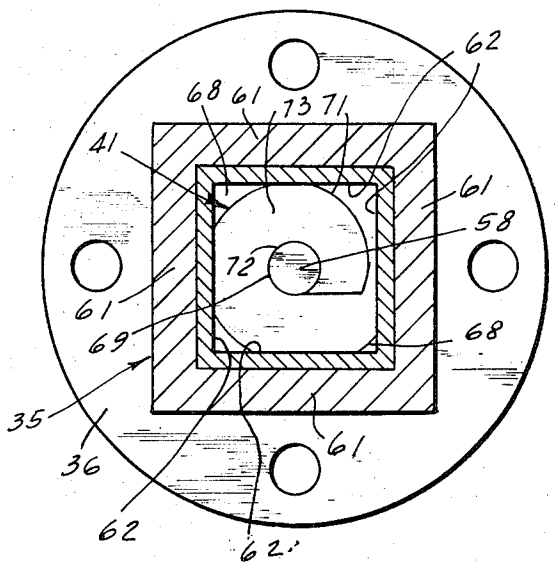


Fig. 4



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ICE MAKING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to ice makers and more particularly refers to compression means for compacting and compressing an ice flake slush into a hard, rigid ice product.

2. Description of the Prior Art

In one form of ice maker, heretofore provided, ice products are produced by continuously harvesting and compressing an ice flake slush formed on a refrigerated cylinder wall provided by an upright, tubular member having an internal refrigerated bore surface sized to cooperate with helical flights of a rotatable harvesting auger disposed in scraping relationship thereto.

Means for compressing the ice flake slush into a finished ice product have included a screw shaft rotatable within a nozzle. Heretofore, the nozzle has included inwardly extending ribs or ridges to retard rotation of the ice slush with the auger. Also, the screw shaft or augers have generally been of the type utilized for conveying grain, coal, melting thermoplastic materials and the like and have not been specifically designed for compacting and compressing ice flake slush. When rotated in a non-circular nozzle, the screw shafts heretofore utilized had a tendency to rotate without advancing ice particles disposed in corners of the nozzle, sometimes referred to as "spin-out."

SUMMARY OF THE INVENTION

Ice maker compression means, constructed in accordance with the principles of the present invention, include means forming a nozzle having a lined throughbore arranged to cooperate with selectively designed, helical flights of an auger for compacting an ice slush, including flakes and particles, into a hard, rigid ice column emerging from the nozzle.

In order to retard rotation of the ice slush with the rotating auger, the nozzle throughbore has a non-circular, transverse, cross sectional configuration. The throughbore may advantageously have a cross section arranged in the form of a regular, geometrical shape, for example a square, an equilateral triangle, a regular pentagon, etc. The bore is lined with material having low thermoconductivity such as plastic or other synthetic material.

The compression auger has an outermost end terminating inwardly of a juncture plane between first and second bore portions so that the ice particles may come together into a solid mass within the compression or first portion of the nozzle bore.

In order to reduce "spin-out" i.e., a tendency for the compression auger to rotate without advancing ice particles in corners of the non-circular nozzle bore, the helical flights of the auger are specifically configured at optimum angulations to axially advance the ice slush through the nozzle and also to laterally outwardly drive the ice particles into bonding engagement with the ice slush disposed in the free portions of the bore near the bore wall surfaces, and in particular slush disposed in the corners. The lateral driving force may advantageously be provided by outwardly inclining axially outwardly projecting surfaces of the helical flights so that the ice slush is driven both axially and laterally outwardly as the auger rotates.

By changing the relationship of the end of the auger relative to the first and second portions of the bore, the compression means will produce hard ice if positioned as shown in the drawings or if the distance is substantially fore-shortened, it will produce uncompressed ice.

The first or compression portion of the nozzle bore receives the ice flake slush and is characterized by slanted wall surfaces converging axially outwardly of the nozzle, thereby compressing and compacting the ice slush to remove air and excess water as the slush advances therethrough.

The second portion of the nozzle bore extends axially beyond the first portion and has slanted wall surfaces converging outwardly at a rate less than that of the first portion wall surfaces for holding the compressed slush in a rigid column to permit bonding of the flakes and particles into a solid, hard mass.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view with portions broken away to illustrate additional details of an ice maker apparatus having compression means constructed in accordance with the principles of the present invention;

FIG. 2 is an enlarged, partial view of the ice maker shown in FIG. 1 and illustrates a longitudinal section of a nozzle with its related compression auger shown in elevation;

FIG. 3 is a longitudinal sectional view of the compression auger illustrated in FIG. 2 and constructed in accordance with the principles of the present invention;

FIG. 4 is a sectional view taken approximately along line IV—IV of FIG. 2.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to the drawings, an ice maker of the present invention is shown generally at **10** and includes an evaporator unit **11** having an internal bore forming a cylindrical wall **12**. An integrally formed evaporator passageway **13** has a refrigerant or coolant expanded thereinto by a refrigeration system through an expansion valve. Water is introduced into the evaporator internally of the wall **12** through an inlet conduit **15** disposed near a base of the unit **11**. The water tends to freeze on the wall **12** in the form of a thin film of ice. One or more helical flights **16** formed or carried on a rotating harvesting auger **17** cooperate with the wall **12**, which, in effect, forms a freezing and scraping surface **14**, whereby thin films of ice formed on the freezing and scraping surface **14** will be continuously harvested. The auger **17** progressively advances a mixture of ice particles, including slush and chunks upwardly in the unit **11** towards a collection chamber **18** superjacent the evaporator unit **11**.

Suitable fastening means, such as bolts **19**, attach a radially outwardly extending flange **21** formed on the evaporator unit **11** to a drive housing **22**. A shaft **23** is disposed centrally of the evaporator unit **11** and has a lower end portion supported within axially spaced bearing means in the drive housing **22**. Gear reduction means are driven by a prime mover such as an electric motor M. The shaft **23** is disposed coaxially of the evaporator bore and has a driven connection with the gear reduction means. Water is prevented from enter-

ing the drive housing 22 by seal means including a shaft seal 24 engaging the shaft 23.

The harvesting auger 17 includes a central hub portion 26 having a throughbore. A threaded portion 27 of the bore receives an upper threaded end portion 28 of the shaft 23 to support the harvesting auger 17 for corotation with the driven shaft 23. A cylindrical portion 29 formed on the harvesting auger 17 and spaced concentrically inwardly of the refrigerated, scraping surface 14 has an outer diameter relatively larger than a diameter of the shaft 23 and carries the helically extending flights or blades 16, which have scraping edges 30 for engaging the scraping surface 14 to harvest the thin film of ice as the harvesting auger 17 rotates relative to the surface 14.

The collection chamber 18 is formed by a generally circular or inverted cup-shaped cap means generally indicated at 31 and having a plurality of channels 32 receiving the ice flake product from the harvesting auger 17. Each of the channels 32 extends in a generally spiral path of increasing cross-section for conducting the flake ice product discharged from the evaporator unit 11 upwardly into a central passageway 33 leading into an internal bore 34 of a compression and forming nozzle 35. The nozzle 35 has a generally outwardly extending flange 36 secured to the cap means 31 by suitable fasteners, such as nut and bolt assemblies as at 37 and the cap means 31 are suitably secured by a plurality of circumferentially spaced bolts 38 to a radially outwardly extending flange 39 on the evaporator unit. Thus, the drive housing 22, the evaporator 11, the cap means 31 and the compression nozzle 35 are detachably secured in a stacked relationship by the fastening means 19, 37 and 38.

In order to compress the flake ice product harvested from the refrigerated scraping surface 14 into a solid ice product, a compression auger 41 mounted for corotation with the harvesting auger 17 receives the flake ice product from the collection chamber 18 and squeezes the ice particles through the nozzle bore 34 to remove excess water and form an emergent solid column of ice at an upper end 42 of the nozzle 35. The compression auger 41 has a depending, threaded stud 43 engaged into the threaded bore 27 of the harvesting auger.

If desired, appropriately configured extrusion means may be attached to an outwardly extending flange 44 at the upper end 42 of the nozzle 35 for forming the emerging, solid column of ice into a desired configuration. The extrusion means may be designed to transversely shear the emerging column of ice into ice cubes or otherwise shape the column into desired configurations, for example, chipped ice, shaved ice, cracked ice or small ice cubes.

In accordance with the principles of the present invention, the nozzle bore 34 has a first portion 51 receiving and compressing the ice flake slush and a second portion 52 extending outwardly beyond the first portion from a juncture plane 53 between the coaxial portions for holding the ice flakes and particles in a compressed state to permit the particles to bond together into a hard, solid column emerging from the nozzle upper, exit end 42.

Rotation of the slush with the rotating compression auger 41 is retarded by forming the nozzle portions 51 and 52 with non-circular, transverse cross sections. Advantageously, the nozzle bore portions 51 and 52 may have a cross sectional configuration formed in the shape of a non-circular, regular geometrical shape, for example an equilateral triangle, a square, a regular pentagon, etc. As illustrated in the drawings, the nozzle bore 34 has a square transverse cross sectional configuration.

The first bore portion 51 is characterized by four walls 54 forming bore wall surfaces or compression surfaces 55 converging axially and extending from an entrance end 56 of the nozzle 35 and to the juncture plane 53. The compression surfaces 55 are inwardly slanted at an angle indicated at 57 and sized to provide a percentage reduction in cross sectional area of the first bore portion 51 between the nozzle entrance end 56 and the juncture plane 53 selected for producing an ice product having a desired hardness. The hardness of the ice product generally increases with an increase in the percentage reduction. As the ice slush advances from the nozzle entrance end 56 to the juncture plane 53, the slanted wall surfaces 55 coact with the slush to create a restraining drag on the advancing ice slush, thereby compacting the particles and flakes into a hard mass.

In order to enable the compacted and compressed ice particles and flakes to completely fill the bore first portion 51 and thus form a solid ice mass within the nozzle 35, the bore first portion extends axially outwardly beyond an outermost, terminal end 58 of the compression auger 41. It should be noted that the hardness of the ice product produced by the nozzle 35 and the compression auger 41 is a function of the percentage reduction in cross sectional area of the bore first portion 51 and of the distance 59. The distance between the compression auger end 58 and the juncture plane 53, as indicated at 59 establishes a relationship between the auger and the nozzle which may be selectively varied to produce a finished ice product of a desired hardness. Thus, using an exemplary structure as illustrated in the drawings a loosely compacted ice product is formed when the distance 59 is about 0.4 inches and a hard, rigid ice product, suitable for forming clear ice cubes, results when the distance 59 is about 1.0 inch.

A corresponding number of four walls 61 of the nozzle 35 extend axially outwardly of the walls 54 and form the bore second portion 52. The walls 61 have slanted inner wall surfaces or action surfaces 62 defining the bore portion 52 and converging outwardly toward the nozzle exit end 42. The action surfaces 62 converge at a lesser rate than the convergence of the compression surfaces 55, thereby to slightly compress the solid mass of ice as the same moves from the juncture plane 53 to the nozzle exit end 42. In such manner, the solid mass of ice is confined into a column and held under a slight compression for enabling the ice particles and flakes to bond together into a solid, rigid ice column emerging from the nozzle exit end 42.

As one example of the nozzle 35 of the present invention, good ice production results with an angle 57 of 3½°, whereas each of the action surfaces 62 of the bore second portion 52 is slanted inwardly of a longitudinal axis of the nozzle bore 34 by an angle of approximately ¾°. The compression surfaces 55 have an axial length

of about 3.3 inches, thereby resulting in a percentage reduction in cross sectional area in the order of 50 percent, at the 3½° angle. That specific configuration consistently produced a rigid, hard ice column from an ice slush, including flakes and particles.

Excess water and air is forced from the ice slush, as the same is compressed and compacted in the nozzle bore **34** and is vented through a drain port **66** disposed near the entrance end **56** of the nozzle **35**.

A liner **67**, composed of a material having a low thermoconductivity, such as rubber or plastic, may be molded or otherwise formed in the nozzle **35**. The liner **67** forms the compression surfaces **55** and the action surfaces **62** and, due to its low thermoconductivity prevents adhesion of the ice slush to the surfaces.

It is contemplated by the principles of the present invention to form the compression auger **41** with a configuration selected to laterally outwardly drive and compress the ice slush so that ice particles and flakes in a central region of the nozzle bore **34** are compressed into bonding engagement with ice particles disposed near the compression surfaces **55**, and in particular with ice particles disposed in corners as at **68** of the non-circular bore **34**. In that manner, rotation of the ice slush, due to frictional drag between the rotating auger **41** and a portion of the slush adjacent thereto, is retarded, since the slush is compacted into a solid mass having a non-circular configuration in transverse cross section.

Thus, the compression auger **41**, constructed in accordance with the present invention, includes a central shaft portion **69** and helically extending flights **71** projecting outwardly from a periphery **72** of the shaft portion. The helical flights **71** axially advance the ice slush from the nozzle entrance end **56** and outwardly through the nozzle bore **34**, thereby causing coaction between the ice slush and the compression or action surfaces **55** and **62** to compress the slush to a solid mass. Also, axially outwardly extending surfaces **73** of the helical flights **71** are inclined outwardly of a right section of the auger shaft **69** to form a surface for laterally outwardly driving the ice particles and flakes as the compression auger **41** rotates within the nozzle bore **34**.

An optimum angle of inclination, as indicated at **74**, of the surfaces **73** relative to a right section of the auger shaft portion **69**, in the order of about 30° provides a desired lateral driving force for bonding the ice slush into a solid mass completely filling the nozzle bore **34**.

The auger shaft periphery **72** has a conical configuration formed complementally to the taper or slant of the compression surfaces **55**. Outer peripheral edge portions **75** of the flights **71** closely confront the compression surfaces **55** and lie on a conical plane tapered complementally to the compression surfaces.

Frictional drag between the rotating compression auger **41** and the ice slush passing through the nozzle **34** may be further reduced by finishing and polishing outer surfaces of the auger, including the shaft outer periphery **69** and the inclined, axially outwardly projecting surfaces **73**. The compression auger outer surfaces may advantageously be finished and polished by appropriate means so that the surface finish is in the order of 25 r.m.s. or less.

From the foregoing description, it should be noted that "spin-out" of the compression auger **41**, i.e., a tendency for the compression auger to rotate within the nozzle bore **34** without axially advancing ice flakes and particles disposed in the corners **68** of the bore, is reduced by forming the helical flights **71** with the axially outwardly projecting surface **73** inclined outwardly of a right section of the auger as herein disclosed and by finishing and polishing the auger outer surfaces to a smooth finish, as disclosed above, thereby producing a denser ice product than would otherwise be possible.

Although those versed in the art may suggest various minor modifications, it should be understood that I wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of my contribution to the art.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A combination ice auger and compression unit comprising
   - harvesting means including a vertically disposed rotatable harvesting auger and freezing chamber for continuously harvesting an ice product from the freezing surface of the chamber,
   - mechanical transfer means for directing the ice product into a compression zone,
   - and a compression unit comprising rotatable screw blades to axially advance the ice product in the compression zone,
   - said compression unit comprising means forming a nozzle bore through which said screw blades squeeze the ice product,
   - said nozzle bore having walls forming slanted action surfaces in two axially adjacent zones,
   - said action surfaces in the first of said zones converging inwardly relative to a longitudinal axis of the bore and extending towards the outlet end of said bore and disposed at an angle of convergence in the order of about 3½°, thereby to compress the ice product into a hard column.

2. A combination ice auger and compression zone as defined in claim 1 and further characterized by said nozzle bore having said slanted action surfaces in said first zone terminating at a juncture plane between said first and second zones and said slanted action surfaces in said second zone being slanted inwardly of a longitudinal axis of said bore at an angle in the order of about ¾°, thereby to confine the ice product in the form of a hard ice column and holding the ice product under slight compression to bond the ice product together into a solid, rigid ice column.

3. A combination ice auger and compression unit as defined in claim 2 wherein said rotatable screw blades comprise compression auger means rotatable within said nozzle and extending partially through said first zone, said compression auger means having an outer terminal end spaced inwardly of said juncture plane a distance sufficient to extrude the harvested ice product into a hard ice column,
   - said distance being in the order of at least about 1.0 inch.

4. A combination ice auger and compression unit as defined in claim 2 and further characterized by said nozzle bore having a length resulting in a percentage reduction in cross-sectional area of in the order of about 50 percent.

5. A combination ice auger and compression unit as defined in claim 1 and further characterized by said compression unit having a drain port formed to drain said nozzle bore in said first zone near an entrance end thereof for venting air and excess water forced from the mass of ice particles advanced through said nozzle bore.

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