An ice making apparatus includes a tray made of a thermally conductive material which has two opposite sides. Each side has a plurality of cavities for receiving water, when facing up. The water is frozen to form ice units conforming to the shape of the cavities. The cavities are shaped to have a smooth contour and are coated with a non-wetting material. After the water in the cavities in the side of the tray that is facing up is frozen, the tray is rotated such that the ice units are dislodged and are collected in a receptacle. The other side of the tray is now filled with water; the heat of the water flows thermally to the opposite side. An embodiment also includes a mechanically driven finger bar with prongs to dislodge the ice.
EFFICIENT ICE MAKER

[0001] This application claims priority from provisional application Ser. No. 61/571,992, titled "Efficient Ice Maker," filed Jul. 8, 2011.

BACKGROUND OF THE INVENTION

[0002] This invention relates to an improved apparatus for making pieces of ice.

[0003] Ice makers are in common use in all household refrigeration appliances. They include apparatus to receive water within designated cavities and to form ice cubes within the designated cavities. The ice cubes are extracted from the cavities by, typically, using a heating mechanism to loosen the outer surface of the ice cubes from the surface of their associated cavities and a motorized mechanism to mechanically eject the formed ice cubes.

[0004] The most common known type of motorized ice cube ejector mechanism installed by manufacturers in household refrigerators uses electric heaters which consume in the range of 9% to 14% of the total energy used by the refrigerators. The known systems use metal trays with cavities into which water is allowed to flow and then frozen to form ice cubes. Once the ice cubes are formed the metal trays are heated such that the outer surfaces of the ice cubes begin to melt. This allows the easy extraction of the ice cubes from the tray by use of a comb shaped rotating shaft to scoop the ice cubes out. After the ice cubes are extracted, they are allowed to fall into a storage bin below the ice maker.

[0005] The use of heaters in the ice makers presents many problems. For example, the amount of energy to heat the ice cubes represents a very significant loss of energy. The consumption and loss due to the heating when viewed from a national and global perspective represents a loss of millions of dollars worth of energy. Also, the ice cube heaters can fail, causing overheating which may lead to inoperability and/or extensive damage and present a fire hazard.

[0006] It is therefore an object of the invention to provide for an improved ice maker which does not require a heating mechanism. Operating without the use of an electric heater is desirable to meet safety and environmental concerns and to provide greater economic and efficient operation of the ice maker.

SUMMARY OF THE INVENTION

[0007] Ice making equipment embodying the invention includes a tray made of a material which has high thermal conductivity. Cavities are formed in the tray to receive water which gets frozen to form "ice units." The cavities are shaped as spherical caps, with large radii and with sides that slope down smoothly and continuously such that the ice units do not stick to any corners, straight lines, or flat surfaces. Therefore, in the discussion to follow and in the appended claims, the term "ice unit" is used, instead of the term "ice cube," because the shape of the pieces of ice made in accordance with the invention will generally have a shape which resembles a spherical cap.

[0008] The surface of the cavities is coated with a material, such as fluorinated ethylene propylene resin (FEP), that is non-wetting and non-sticking. After the ice units are formed, the tray can be rotated and the ice units fall out of the tray into a receptacle.

[0009] In accordance with an additional aspect of the invention, the ice making tray is made with two opposite sides (side A, side B), each side having cavities for receiving water and forming cavities. After ice is formed in the cavities located on one side (e.g., side A) of the tray, the tray is rotated to let the ice units fall into a receptacle. The cavities in the other side (e.g., side B) of the tray (which now faces up) can then be filled with water. The heat of the water in side B flows thermally to side A due to the thermal conductivity of the metal tray and heats the outer surface of the cavities in side A (which is facing down). The thermal energy of the water heats up the outer surface of any ice units which may still be attached to the cavities of side A. The water in the cavities on side B can then be frozen to produce a new batch of ice units which will be dislodged and extracted in a similar manner to those formed in side A.

[0010] The need for an electric heater is eliminated by making use of: (a) the physical properties of water, ice and metals; (b) the geometry of the cavities; and (c) a non-wetting and non-sticking coating. The result is a substantial saving in the amount of energy needed to make ice units (or pellets).

[0011] In accordance with another aspect of the invention, to ensure that all the ice units formed in a side of the tray are extracted, the ice making apparatus may include a mechanically driven finger bar with prongs for pushing out any remaining ice units in the tray surface.

[0012] Thus, the ice units formed in side A or side B can be easily removed when a tray with cavities is rotated and the use of a heater is not needed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] In the accompanying drawings, which are not drawn to scale, like reference characters denote like components; and

[0014] FIG. 1 is an isometric view of a double sided tray embodying the invention with cavities formed on both sides of the tray;

[0015] FIG. 2 is a cross sectional diagram of a tray embodying the invention;

[0016] FIG. 3 is an isometric view of an ice making tray embodying the invention and an assembly configured to be mounted in a household refrigerator freezer compartment.

[0017] FIG. 4 is an isometric diagram showing the ice making tray being rotated and the use of a "finger bar" for pushing out any remaining ice units in the tray surface;

[0018] FIG. 5 is an isometric diagram of a "finger bar" for pushing ice units out of cavities in accordance with the invention; and

[0019] FIGS. 6A, 7A, 8A, and 9A are idealized cross sectional diagrams illustrating the role of a finger bar in pushing ice units out of cavities as a tray is being rotated, in accordance with the invention; and

[0020] FIGS. 6B, 7B, 8B, and 9B are idealized isometric drawings of an ice making tray being rotated corresponding, respectively, to the showings of FIGS. 6A, 7A, 8A, and 9A.

DETAILED DESCRIPTION OF THE DRAWINGS

[0021] FIG. 1 is an isometric view and FIG. 2 is a cross sectional view of a double sided tray 202 with cavities (200a, 200b) formed on both sides (e.g., top 106a and bottom 106b) of the tray. One side of tray 202 may be referred to as side A and the other (opposite) side may be referred to as side B. The components of side A are identified by a reference character
to which is appended the subscript “a” and the components of side b are identified by a reference character to which is appended the subscript “b”.

FIG. 1, with a cut away section 105, and FIG. 2 illustrate that a multiplicity of cavities 200a are formed on one side (e.g., side A shown on top in FIGS. 1 and 2) of the tray and a multiplicity of cavities 200b are formed on the other side (e.g., side B shown on the bottom in FIGS. 1 and 2) of the tray. FIG. 2 is a cross sectional diagram of a tray 202 taken through the center of a row of ice cavities 200a & 200b and showing conduits 201a & 201b.

A multiplicity of conduits, 201a and 201b, are formed between the cavities 200a and 200b along the top and bottom surfaces 106a and 106b to allow water to flow from a water source (not shown) and fill all the cavities along the surface facing up. The injected water will generally be at the same level in all the cavities for producing uniform sized “ice units” (cubes or pellets). Note that side A and side B can be, but need not be, identical.

In the embodiment of FIGS. 1 and 2, the tray 202 is made of aluminum, because aluminum has very good thermal conductivity. However, any other metal or substance having good thermal conductivity may be used instead. At the center of the tray 202, between its and bottom surfaces and front and back sides, there is a central axis 102 about which the tray 202 is rotated.

In operation, by way of example, the cavities 200a on one side (e.g., side A) or surface of the tray (e.g., 106a) are filled with water and the water is frozen in a conventional manner to form ice units (pellets) and hence need not be detailed. Sensors are used to sense the formation of ice units or when the tray reaches a predetermined temperature. When that occurs, the tray is rotated 180 degrees. As the side (side A) containing the ice units starts to face down, the ice units (pellets) formed in surface 106a fall out of the cavities 200a due to gravity and associated rotational forces and into a storage bin (not shown). Then, the cavities 200b on the other side (e.g., side B) or surface (e.g., 106b) of the tray are filled with water. Note that the thermal energy of the water filling cavities 200b may help dislodge any ice unit in cavities 200a which may have remained in place. The water in cavities 200b is then frozen in a conventional manner to form ice units in side B.

As before, the formation of the ice units (or the temperature of the tray/water) is sensed and the tray is rotated 180 degrees. The process of filling the cavities of one side of the tray with water, freezing the water to form ice units and then rotating the tray can be repeated until the ice bin storage is filled, or any predetermined condition is reached. Note that a section 105 is removed in FIG. 1 to show that the top and bottom surfaces can be, but need not be, identical.

In systems embodying the invention the ice units formed within a side of the ice tray tend to fall out easily for the reasons discussed above and as further discussed below.

Applicant recognized that the properties of water and ice are such that water has twice the specific heat of ice. Therefore, in systems embodying the invention, a metal with high thermal conductivity is used as the tray material. Metals with high thermal conductivity include aluminum, silver, copper, and brass. A preferred embodiment uses an aluminum tray 202 which has high thermal conductivity and low specific heat.

Applicant also recognized that coating the surfaces of cavities 200a and 200b, used to form the ice unit (pellets), with a non-wetting and non-sticking coating enables the ice units to be more easily extracted from the cavities 200a and 200b. One such coating is an FDA approved fluorinated ethylene propylene resin (FEP). Thus, a coating of FEP, or any like material, is applied to the surfaces of cavities 200a and 200b of the ice making tray 202 to ensure that the ice units will be easily dislodged. Generally, in manufacturing the product, the entire top and bottom surfaces of each tray may be coated with an FEP or FEP like coating.

Applicant also recognized that the shape of the cavities 200a and 200b should be, preferably, like a spherical cap (e.g., an inverted dome-like fraction of a sphere, with the (inverted) dome being generally smaller than a hemisphere). Each cavity (200a or 200b) is made such that it has a large diameter (when facing up along the horizontal plane) with the sides of the cavities (looking down from the top horizontal plane) sloping down smoothly and continuously such that there are no corners or straight lines or flat surfaces for the ice to stick to. In other words, the cavity is made with gradually widening sides (from the bottom up). By making each cavity 200a or 200b with gradually tapering sides, without straight lines, flat surfaces, or corners, and coating the cavity surface with a non-wetting and non-sticking coating, the ice units (pellets) formed each cavity will be easily dislodged. Thus, the material selected to make the tray 202, and the geometry and coating of the cavities (200a or 200b) allow ice units to be easily dislodged.

As the water poured into a cavity transitions to ice, it expands and the geometry of the cavity and the correspondingly formed ice cube allows it to dislodge and fall out by gravity when turned over. Thus, shaping the ice cube making cavity in this manner forms ice cubes which naturally detach from the cavity and are easy to extract from the form. This removes the necessity of using a heater to partially melt ice and, as noted above, providing great savings in energy usage.

Thus, in accordance with the invention, a tray made of aluminum, which has a high thermal conductivity and with low specific heat, freezes water rather quickly compared to plastic or most other materials. The ice cubes produced in a cavity formed in accordance with the invention can naturally break the surface bond allowing the ice cubes to dislodge from the surfaces of their cavity when turned upside down. This diminishes the need for added heat to loosen ice for removal process.

Note that any ice unit (pellet) left in a cavity (e.g., 200b), in a side (e.g., 106a) which has been rotated so it faces down, is caused to fall out of its cavity when water is injected in the other side (e.g., 106b) of the tray (now the upper side of the tray). Due to the thermal conductivity of the aluminum, the water injected in what is now the upper side of the tray causes the walls of the cavities in the lower side to warm up and cause the outer surfaces of any ice units sticking to the walls of their cavity to become detached. The thermal energy of the newly added water filling the now upper and opposite side, will bring the tray temperature above freezing allowing all ice units to fall away or to be easily dislodged.

Apparatus embodying is designed to be retrofitted for use with exiting ice making equipment using the same mounting scheme, electric connectors and connections and water feed tube and location.

FIG. 3 is an isometric view of an ice making assembly embodying the invention configured to be mounted in a household refrigerator freezer compartment. The tray 202 is shown oriented in a level horizontal plane so that water can fill...
the cavities \(200a\). Water is delivered to the tray \(202\) from the refrigerator connection (not shown) by way of a tube (not shown) extending through a rear wall of the freezer compartment, by way of an orifice \(206\). (Note that this is well known and need not be described.) The water flows into a diverter drum \(203\) and into a port \(209a\) which causes the water to be diverted into two outlets (divertor ports) \(205a\) & \(204a\) to, in turn, cause the water to flow via two channels and conduits \(201a\) to fill ice unit (pellet) forming cavities \(200a\). The conduits \(201a\) (and \(201b\)) allow water to settle uniformly and reach a similar level in all the cavities \(200a\) (and \(200b\)) on that side of the tray.

[0036] The diverter drum \(203\) can also serve as a pivot for rotating axis \(102\) (see FIG. 1) of tray \(202\). A motor \(208\) coupled to the center shaft of tray \(202\) is used to turn tray \(202\) and diverter drum \(203\). After ice has formed in the top side of tray \(202\), the tray \(202\) is turned up side down (rotated 180 degrees) by way of motor \(208\).

[0037] The system as described above is submitted to be such that all ice units (pellets) formed on one side of the tray will be dislodged when that side is turned over (face down). However, in accordance with a still further aspect of the invention, a mechanically driven pronged system of the type shown in FIGS. 4 and 5 may be added to the ice making assembly to mechanically push out of any cavity any ice unit which has not been dislodged.

[0038] FIG. 5 is an isometric drawing of a “finger bar” \(211\) mounted on a bumper plate \(212\) with prongs (ice ejector studs) \(213\) extending vertically therefrom. The finger bar is positioned below the bottom side of tray \(202\) whereby prongs (ice ejector studs) \(213\) push on individual ice units to extract them from their cavities \(200a\), \(200b\).

[0039] In FIG. 4, the tray surface (e.g., side \(A\)) containing the ice cubes has been rotated such that side \(A\) is facing down and its ice units can drop into a receptacle (not shown). After which, the finger bar \(211\) is raised so that its studs contact the ice cubes on side \(A\) by way of spring force to cause individual ice units (which have not fallen out) to be pushed out of their respective cavities \(200a\) until all cavities \(200a\) become empty.

[0040] FIG. 4 shows the addition of finger bar \(211\) mounted at its bottom end on bumper plate \(212\) and having ice cube ejectors \(213\) at its top end. Each time the tray \(202\) is rotated, the finger bar \(211\) is raised so that the prongs (ice ejector studs) \(213\) contact the ice units on the side facing down. The prongs (ice ejector studs) are urged by way of a spring force to cause individual ice units (which have not been dislodged) to be pushed out of their respective cavities (\(200a\) or \(200b\)) until all cavities \(200a\) (or \(200b\)) are emptied.

[0041] Sensors (not shown) provide signals to a microprocessor (not shown) to continue normal operation. That is, when, for example, side \(A\) faces down there is the continuing application of water to the other side (e.g., side \(B\)) of the tray to fill its cavities. Thereafter the water is frozen to form additional ice units. Certain sensors (not shown) provide signals indicating that the water is frozen. Other sensors (not shown) can also provide signals when the receptacle is full. When the receptacle is full, the motor \(208\) will be stopped and water will no longer fill the top side of tray \(202\) until the quantity of ice units in the receptacle is sufficiently depleted. The finger bar \(211\) and/or the bumper plate \(212\) may be used to sense the quantity of ice units in the receptacle.

[0042] FIG. 6A and corresponding FIG. 6B show the tray \(202\) in an initial start condition for producing ice units. The tray \(202\) is positioned as shown in a horizontal orientation. In this position, water is allowed to fill the ice unit forming cavities \(200a\) in side \(A\) of tray \(202\). The water functions to warm tray \(202\). The prongs (ice ejector studs) \(213\) mounted on finger bar \(211\) push against any ice units present in the cavities \(200b\) of side \(B\). Each ice unit in side \(B\) is loosened by the prongs \(213\) on the finger bar \(211\) which push the ice units out of their cavities along a radial curve and the ice units fall away into a receptacle (not shown) located below. Note that, after the ice units have been extracted from side \(B\), the water which filled the cavities \(200a\) in side \(A\) is frozen forming ice units in the cavities \(200a\). The step of freezing the water is similar to known schemes and need not be described.

[0043] In the operation of the ice making apparatus, after water is introduced into the cavities on one side (e.g., side \(A\)), the ice making apparatus is idle during the period of time the water transitions to ice. The idle condition continues until the ice units are formed. The formation of the ice units is sensed via a thermocouple (or any appropriate temperature sensor) which can sense that the freezing temperature has been reached. The sensing mechanism produces a signal applied to a microprocessor (or micro controller), not shown, which then energizes the motor \(208\) which causes the tray \(202\) to be rotated 180 degrees.

[0044] The finger bar \(211\) and the prongs \(213\) are controlled by way of a link \(72\). When, as shown in FIGS. 6A and 6B, the tray is at either of its horizontal positions (0 or 180 degrees) the finger bar \(211\) and the prongs \(213\) are at the highest position to apply a force to the ice units to dislodge the ice units. The prongs \(213\) on finger bar \(211\) contact all individual ice units at a point located sufficiently far from the center of the ice units as shown in FIG. 6A. This enables the ice units to be easily dislodged.

[0045] When the tray \(202\) is rotated 90 degrees from either horizontal positions (0 degrees or 180 degrees), the finger bar \(211\) and its projecting studs is at the lowest position to make clearance of the tray corners. When the tray is at either of its horizontal positions (0 degrees or 180 degrees) the finger bar \(211\) and its projecting studs is at the highest position to apply a force to the ice cubes for extraction. The prongs \(213\) on finger bar \(211\) contact all individual ice cubes at a point located close to the inner edge of the ice cubes as shown in FIG. 6B.

[0046] Following the freezing of the water in side \(A\), the tray \(202\) is made to rotate as shown in FIGS. 7A and 7B (with the tray rotated by 15 degrees). The finger bar \(211\) and the prongs \(213\) are lowered by way of control link \(72\). However, it should be appreciated that any other suitable arrangement to control tray rotation can be used to raise and lower finger bar \(211\) and prongs \(213\). The finger bar \(211\) can be moved along a straight line or it can be pivoted so long as the finger bar \(211\) and prongs \(213\) clear the path of the tray \(202\) as the tray \(202\) rotates.

[0047] FIGS. 8A and 8B show the tray \(202\) rotated 45 degrees and the lowering of the finger bar \(211\) and prongs \(213\) to clear the tray \(202\) as it rotates.

[0048] FIGS. 9A and 9B show the tray \(202\) rotated 60 degrees and the finger bar \(211\) and prongs \(213\) being lowered to clear the tray \(202\) as it rotates.

[0049] It has therefore been shown that apparatus embodying the invention can be used to produce ice units in a cavity mold and that the ice units can be extracted without the need to expand heat energy. The ice units formed can be extracted from their mold inside a freezer compartment of a standard refrigerator or any apparatus devised to produce the ice.
Apparatus embodying the invention can produce ice economically, easily, safely and quickly. As noted above the apparatus can be retrofitted into existing refrigerators or formed as a subassembly in new refrigerators.

While the prongs 213 of finger bar 211 press on ice units on the underside (e.g. side B) of the tray with a spring force, water is filling the top side (e.g., side A) of tray 202, and heat from the water warms the tray 202 to slightly above freezing, causing the outer surfaces of the ice units in cavities 200a to melt. At the same time, the ice units in side B are being forced out by the finger bar 211 and its prongs 213. When all the ice units have been removed from side B, the condition is sensed and a switch sets a microprocessor to wait for ice units to form in the cavities 200a.

Each cycle of filling water is done by way of a tube delivered from the freezer compartment wall, directed to a placement to flow loosely through an orifice 206. Output water is directed into the diverter port 209. A feature of the diverter hub 203 is that it enables water to be split into two channels and to exit via out ports 204 and 205 to fill the cavities 200a, 200b by way of conduits 201a, and 201b, respectively.

Temperature measurement may be made by way of an embedded thermocouple placed in a central location of the tray 202, or any other suitable site. A multiplicity of temperature sensors can be utilized if necessary in a multiplicity of tray locations.

Adjustment for water level control uses a variable timer circuit to fine tune a desired volume of ice.

A microcontroller can control motion of clockwise/counterclockwise rotation and measure and monitor temperature during the sequence of operations.

What is claimed is:

1. Apparatus for making ice units comprising:
   a tray having two opposite sides, each side having a plurality of cavities for receiving water, when the side is facing up, which is to be frozen to form ice units conforming generally to the shape of the cavities; each cavity being coated with a non-wettable coating and being shaped to have a smooth contour with no sharp edges for enabling ice units formed within a cavity to be easily dislodged;
   the tray being rotatable such that when the cavities of one side are up to receive water to be frozen, the cavities of the opposite side face down and ice units contained in the cavities facing down are dislodged; and
   the tray being formed of a thermally conductive material for enabling the heat of the water added to one side to flow thermally to the opposite side to dislodge ice units.

2. Apparatus for making ice units as claimed in claim 1, wherein the tray material is a metal.

3. Apparatus for making ice units as claimed in claim 1, wherein each cavity is shaped like a spherical cap having gradually widening sides extending from its cap.

4. Apparatus for making ice units as claimed in claim 1, wherein the surface of each cavity is coated with a fluorinated ethylene propylene resin (FEP).

5. Apparatus for making ice units as claimed in claim 2, wherein the tray includes conduits formed between, and interconnecting, the cavities of each side to allow water to flow into all the cavities of each side facing up.

6. Apparatus for making ice units as claimed in claim 1 including means attached to the tray for rotating the tray.

7. Apparatus for making ice units as claimed in claim 6 further including a mechanism coupled to the tray for mechanically dislodging ice units from the cavities of a side of the tray facing down.

8. A system for making ice units comprising:
   a tray having two opposite sides, each side having a plurality of cavities for receiving water which is to be frozen to form ice units conforming generally to the shape of the cavities; each cavity being coated with a non-wettable coating and being shaped to have a smooth contour with no sharp edges for enabling ice units formed within a cavity to be easily dislodged;
   means coupled to the tray for rotating the tray and dislodging the ice units such that, when the cavities of one side face up to receive water to be frozen, the cavities of the opposite side face down and ice units contained in the cavities facing down are dislodged; and
   the tray being formed of a thermally conductive material for enabling the heat of the water added to one side to flow thermally to the opposite side to dislodge ice units.

9. A system for making ice units as claimed in claim 8, wherein the tray material is a metal having high thermal conductivity and low specific heat.

10. A system for making ice units according to claim 8, wherein the surface of the cavities is coated with fluorinated ethylene propylene resin (FEP).

11. A system for making ice units according to claim 8, wherein the cavities are generally shaped like spherical caps which, when facing up, have gradually widening sides.

12. A system for making ice units according to claim 8, wherein each surface of the tray includes conduits formed between the cavities to allow water to flow from a water source and fill the cavities along the side of the tray facing up.

13. A system for making ice units according to claim 8, wherein the means coupled to the tray for rotating the tray and dislodging the ice units includes a mechanism with prongs which can be urged upward to dislodge ice units formed in the cavities of the side of the tray facing down.

14. A system for making ice units according to claim 13, wherein the mechanism with prongs includes a bar mounted on a bumber plate with the prongs extending therefrom.

15. A system for making ice units as claimed in claim 13, wherein the mechanism with prongs is driven by a spring force.

16. A system for making ice units according to claim 8, wherein said cavities are generally dome shaped with sides that slope down smoothly, gradually and continuously, such that there are no corners or straight lines or flat surfaces for the ice units to stick to.

17. A system for making ice units according to claim 8, wherein after ice units are formed in one side of the tray, the tray is rotated 180 degrees so the one side faces down and cavities in the other, opposite, side face up and are filled with water and wherein the heat of the water filling the cavities of the other opposite side warm up the tray to loosen the ice units in the one side and ensure that they are ejected.

18. A system for making ice units according to claim 14, wherein said means coupled to the tray for rotating the tray and dislodging the ice units includes a mechanism to raise and lower the finger bar to clear the rotation of the ice tray.

19. A system for making ice units according to claim 8 wherein said means coupled to the tray for rotating the tray includes a motor for selectively causing the tray to rotate at least 180 degrees.

20. A system for making ice units according to claim 8, wherein each side of the tray includes at least two rows of cavities and wherein there is included a dual channel water diverter to concurrently fill the rows with water.