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(54) **Refrigerator having ice maker with flexible ice mold and method for harvesting ice**

(57) A household refrigerator includes an ice maker. The ice maker has an ice mold. The ice mold is made from a thin flexible material, such as stamped aluminum. The ice mold includes ice forming compartments and a rotatable member with fingers for removing ice pieces from the ice compartments as the rotatable member is rotated. The rotatable member also includes a cam projection that contacts and flexes the ice mold as the rotatable member is rotated to at least partially break a bond between the ice pieces and the ice forming compartments.

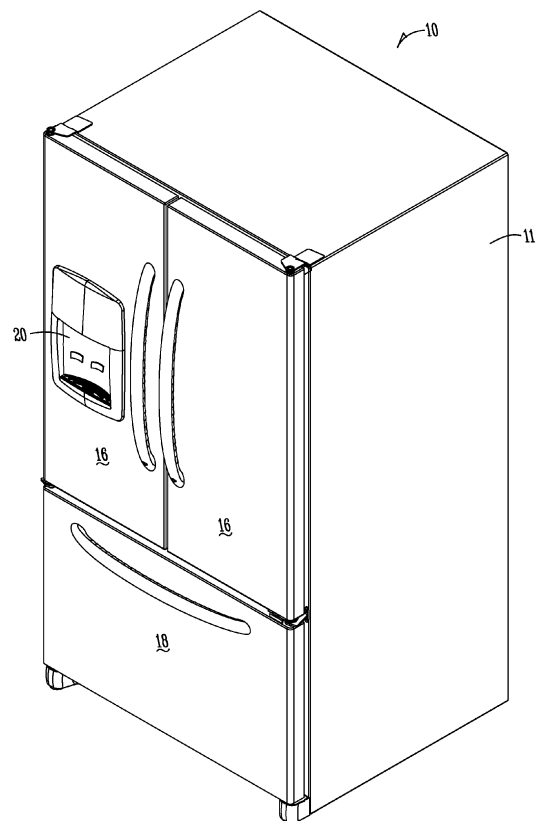


Fig. 1

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Description

[0001] The present invention relates generally to household refrigerators, and more particularly to refrigerators that include an icemaker with a mold for forming and automatically harvesting ice.

[0002] It is known to include an automatic ice maker within a household refrigerator. Typically such an ice maker includes an ice mold with a plurality of open compartments. A complete ice making cycle includes filling the ice mold compartments with water, removing heat from the water to form ice pieces, and harvesting the ice pieces from the mold. It is desirable to reduce the overall time of the ice making cycle in order to maximize the amount of ice that can be produced by an ice maker.

[0003] To remove heat from the water, it is common to cool the ice mold. Accordingly, the ice mold acts as a conduit for removing heat from the water. Therefore, it is desirable to form the mold from a material that conducts heat well in order to quickly remove heat from the water. The most common mechanism for removing heat from an ice mold, and thereby the water within the mold, is to provide cold air from an evaporator to the ice mold. Alternatively, the ice mold may be chilled by direct contact with an evaporator or other conduit of a working refrigerant. As a further alternative, a secondary coolant may be provided to the ice mold to remove heat. It is also known to use thermoelectric devices or the like to cool the ice mold.

[0004] According to one common harvesting mechanism, heat is provided to the ice mold to break the adhesion between the mold and ice. Naturally, the greater the thermal mass of the mold, the greater the amount of energy, and therefore time, is required to sufficiently heat the mold and thereby melt the ice pieces at the interfaces between the mold and the ice pieces.

[0005] After the ice pieces are loosened from the mold by melting, a variety of mechanisms can be used to complete the harvest. According to one method, a rake, or similar element, is passed through the individual ice compartments to eject the ice pieces from the mold. Typically this is accomplished by rotating the rake while the ice mold remains stationary. According to another known mechanism, the ice mold itself is rotated to an inverted position, and the ice pieces are allowed to drop out of the mold under the force of gravity. A twisting force may be applied to the inverted mold to help break the adhesions and urge the ice out of the mold. Commonly, this twisting action is accomplished by including a stop at one end of the ice mold to prevent that end from rotating as far as the other end during the inverting process.

[0006] The present invention provides an improved ice mold and method that reduces the time needed to make and harvest ice cubes.

[0007] According to one embodiment, the present invention improves the harvest process by providing a thin flexible mold that remains generally stationary during the harvesting process. A rotatable rake includes a cam that

contacts a top surface of the mold, thereby flexing the mold and causing adhesion between the ice mold and the ice cubes to be broken, such that the rake can remove the ice cubes from the mold.

[0008] According to another embodiment, the present invention is directed to a refrigerator that has a cabinet and a door for providing access to the cabinet. An icemaker is mounted within the cabinet or on the door. The icemaker includes an ice mold with a plurality of ice cube forming mold sections with upward facing openings. The ice mold also includes an upward facing surface. A supply of water is provided to the ice cube forming mold sections. A rotatable member rotates about an axis that is spaced apart from the upward facing surface by a first distance. The rotatable member includes fingers in alignment with the ice cube forming mold sections such that rotation of the rotatable member about the axis causes the fingers to contact and thereby dislodge and harvest ice cubes from the ice cube forming mold sections. A cam projection extends from the rotatable member to a second distance from the axis, the second distance being greater than the first distance. Whereby rotation of the rotatable member causes the cam projection to contact the upward facing surface of the ice mold to thereby flex the ice mold and at least partially break a bond between the ice cubes and the ice cube forming mold sections to facilitate harvesting of the ice cubes by the fingers. The ice mold may be formed from a single piece of stamped aluminum. A second cam projection may from the rotatable member to a third distance from the axis, the third distance being greater than the second distance. The cam projection may have a low friction surface such that the low friction surface slides freely across the upward facing surface of the ice mold. The ice cube forming mold sections may be concavely curved from front-to-back and from side-to-side. The upward facing surface may have a front edge and rear edge such that when the rotatable member is rotated in a first direction to dislodge and harvest ice cubes, the fingers move generally in a direction toward the rear edge as they contact the ice cubes within the ice cube forming mold sections. The refrigerator may further include an ice cube deflector positioned generally above the upward facing surface proximate the rear edge of the upward facing surface such that ice cubes dislodged from the ice cube forming mold sections are guided over the mold towards the front edge by the deflector as the rotatable member rotates with the fingers in contact with the dislodged cubes. The cube deflector may have a plurality of concavely curved inner surfaces that generally match a curvature of the ice cubes. The cube deflector may include separator walls between the curved inner surfaces to break ice bridges between the cubes. The upward facing surface may have a front edge and a rear edge such that when the rotatable member is rotated in a first direction to dislodge and harvest ice cubes, the fingers move in a direction toward the front edge as they contact ice cubes within the ice cube forming mold sec-

tions. An ice cube deflector may be positioned spaced apart from and above the upward facing surface between the front edge and the axis such that ice cubes dislodged from the ice cube forming mold sections are deflected downwardly over the front edge.

[0009] According to another embodiment, the present invention is directed to a method of making and harvesting ice cubes that includes providing a refrigerator with an ice maker having an ice mold. The ice mold includes a plurality of ice cube forming mold sections with upward facing openings. The ice mold further includes an upward facing surface. A rotatable member including fingers in alignment with the ice cube forming mold sections is provided. The rotatable member also has a cam projection. Water is provided to the ice cube forming mold sections, and heat is removed from the water to form ice cubes in the ice cube forming mold sections. An adhesion between the ice cubes and the ice cube forming mold sections is broken by rotating the rotatable member to bring the cam projection into contact with the upward facing surface of the ice mold to thereby flex the ice mold. The ice cubes are removed from the ice cube forming mold sections by continuing to rotate the rotatable member such that fingers pass through the ice cube forming mold sections. The rotatable member may have a second cam projection. The step of breaking the adhesion may include bringing the second cam projection into contact with the upward facing surface. The ice mold may be formed from a single piece of stamped aluminum. The cam projection may have a low friction surface such that the low friction surface slides freely across the upward facing surface of the ice mold. The ice mold sections are concavely curved from front-to-back and from side-to-side. The upward facing surface may have a front edge and rear edge such that rotating the rotatable member in a first direction moves the fingers generally toward the rear edge as they contact the ice cubes within the ice cube forming mold sections. An ice cube deflector is positioned generally above the upward facing surface proximate to the rear edge of the upward facing surface such that ice cubes dislodged from the ice cube forming mold sections are guided above the mold towards the front edge by the ice cube deflector as the rotatable member rotates in the first direction with the fingers in contact with the dislodged cubes. The cube deflector may have a plurality of concavely curved inner surfaces that generally match a curvature of the ice cubes. The cube deflector may have separator walls between the curved inner surfaces to break ice bridges between the cubes. The upward facing surface may have a front edge and a rear edge. The method may further include rotating the rotatable member in a first direction to dislodge and harvest ice cubes by moving the fingers toward the front edge as the fingers contact ice cubes until the ice cubes are deflected downwardly over the front edge by an ice cube deflector spaced apart from and above the upward facing surface between the front edge and the axis. After deflecting the ice cubes over the front edge, the rotatable

member may be rotated in a second direction opposite from the first direction until the fingers have passed completely through the ice cube forming mold sections moving in the second direction before again providing water to the ice cube forming mold sections.

[0010] The present invention will be described by way of example with reference to the accompanying drawings, in which:-

Figure 1 is a perspective view of a refrigerator according to the present invention.

Figure 2 is a perspective view of the refrigerator of Figure 1 with the fresh food compartment doors open.

Figure 3 is a perspective view of an icemaking module according to one embodiment of the present invention.

Figure 4 is a partial cross-section view of an ice making module according to one embodiment of the present invention.

Figures 5a-d are cross-section views of the ice mold from the ice making module of Figure 4 as the ice rake moves through a harvest cycle.

Figure 6 is a detail view of an alternative embodiment of a low profile ice making module according to the present invention wherein ice cubes are harvested from the mold without passing over the top of the mold after being dislodged from the mold.

Figure 7 is a partial cross section view of the ice making module from Figure 6.

[0011] A bottom mount refrigerator 10 is shown in Figures 1 and 2. The refrigerator 10 includes a cabinet 11 that encloses fresh food compartment 12 and a freezer compartment below the fresh food compartment 12. Doors 16 are provided for the refrigerator compartment or fresh food compartment 12 and a door 18 is provided for the freezer compartment. The freezer door 18 may take the form of a drawer, as shown in the drawings, or may be a conventional hinged design. One of the fresh food compartment doors 16 includes an ice dispenser 20, which may also include a water dispenser. While the embodiment shown is a bottom mount refrigerator 10 with the freezer compartment below the fresh food compartment 12, it should be appreciated that the present invention is not so limited and can be used beneficially in side-by-side refrigerators as well as top-mount refrigerators with the freezer compartment above the fresh food compartment.

[0012] An icemaking compartment 22 is provided in the fresh food compartment 12. The icemaking compartment 22 is shown to be in one of the upper corners of the fresh food, compartment 12, but other locations are also within the scope of this invention. For example, the icemaking compartment could be provided on the freezer door 18 or on a fresh food compartment door 16. In the embodiment shown, the icemaking compartment 22 is insulated to prevent the cold air of the icemaking com-

partment 22 from passing into the refrigerator compartment. An opening 24 is provided at the front of the ice-making compartment 22 that aligns with chute 19 which leads to an ice storage compartment 26 on one of the doors 16. An ice bin (not shown) is provided within the ice storage compartment 26 to store the ice until it is dispensed. It should be appreciated that while the embodiment described herein has a separate ice making compartment 22 provided in the fresh food compartment 12, the present invention is not limited to such an arrangement and would be suitable for use in a variety of arrangements, including, without limitation, locating the icemaker in the freezer compartment, or on any of the freezer or fresh food doors.

[0013] As seen in Figures 3 and 4, an ice making module 28 is provided within the ice making compartment 22. The ice making module 28 includes an ice mold 30, a cover 32, an ice rake 34, a deflector 36, and a stripper 37. While not shown in the drawings, the ice mold 30 is provided in close proximity to a supply of water that can be provided to the ice mold 30 to form ice cubes. Also not shown is an ice bin that is provided generally below and in communication with the ice mold 30 to store the ice cubes after they are harvested until the cubes are dispensed. The ice bin is provided in the ice storage compartment 26 in the embodiment shown, but may be provided within the ice making compartment or freezer compartment if desired.

[0014] Figures 5a-d show a partial cross-section view of an ice mold 30 according to one embodiment of the present invention. The ice mold 30 is formed from a single stamped piece of thin aluminum. The ice mold 30 includes a plurality of mold sections 46 that extend downwardly below an upper surface 42 of the ice mold 30. The ice mold sections 46 are concavely curved front-to-back and side-to-side. The overall shape of the ice mold sections 46 is similar to a section of a symmetrical egg shell. The ice mold sections 46 serve as ice cube forming compartments when filled with water. A heater, such as a wire heater 48, may be provided around the periphery, or preferably along the bottom surface, of the ice mold 30. Because the stamped aluminum is thin, there is very little thermal mass that needs to be heated to raise the temperature of the mold 30 when the heater 48 is activated. Alternatively, the present invention may eliminate the need for a heater.

[0015] Returning to Figure 3, the cover 32 protects and hides from view several components of the ice making module 28, including a motor, wiring, and control elements (not shown). The cover 32 may include tabs 40, or other conventional structures, for mounting the ice making module 28 within the refrigerator 10. The ice rake 34 has a shaft 38 that is operably connected to the motor and extends from the motor housing 32 above the ice mold 30. In operation, the motor can cause the ice rake 34 to rotate about an axis 44 that is generally parallel to and above an upper surface 42 of the ice mold 30. The ice rake 34 includes a plurality of fingers 50 that extend

generally radially outwardly from the ice rake shaft 38. As will be described in more detail below, the fingers 50 act as ejectors that expel ice cubes from the mold 30 during harvest.

[0016] The ice rake 34 further includes at least one cam projection 52 extended from the shaft 38. The cam projection 52 includes a cam surface 54 that is spaced a greater distance from the axis 44 than the distance between the axis 44 and the upper surface 42. Therefore, as the ice rake 34 is rotated, the cam surface 54 contacts and presses against the upper surface of the mold 30, causing the mold 30 to flex downwardly. In the embodiment shown, a single cam projection 52 is provided about midway along the length of the shaft 38. In addition to, or in place of, that centrally-located cam projection 52, additional cam projections (not shown) may be provided near either end of the shaft 38. If more than one cam projection is provided, the cam projections may be angularly aligned with each other to contact the ice mold upper surface 42 at substantially the same time, or may be angularly offset from each other to contact the mold surface 42 sequentially to create an even greater twisting force on the mold 30. The cam projections 52 should be axially aligned on the shaft 38 so as to contact the upper surface 42 of the mold outside of or between the ice mold sections 46 so as not to crush the ice cubes. Preferably the cam surface 54 will be smooth and low friction such that it will slide freely across the upper surface 42 of the ice mold 30 without causing significant wear to the ice mold 30 or the cam surface 42. The cam projection 52 may be formed from a low friction material such as low friction plastic or metal.

[0017] In operation, the ice mold sections 46 are filled with water. Weirs or low areas may be provided between the ice mold sections 46 to facilitate filling the separate ice mold sections 46 with water from a single source. The mold 30 and liquid water are chilled to remove heat from the water until the water freezes into ice. The heat may be removed by cold air from an evaporator, direct contact with a refrigerant line or evaporator, a secondary coolant loop, thermoelectric devices, or other known or unknown mechanisms. Temperature sensors (not shown) may be operably connected to the ice mold 30 to sense when the mold 30 is sufficiently cold to assure that the water has formed solid ice cubes. Once the ice cubes have formed within the mold sections 46 they can be harvested.

[0018] As shown in Figure 5a, the ice rake 34 is in a parked position ready to begin a harvest operation. To harvest the formed ice cubes 60, the motor is activated causing the rake 34 to rotate in the direction shown. As shown in Figure 5b, this rotation brings the cam surface 54 into contact with the upper surface 42 of the ice mold 30, which in turn causes the ice mold 30 to flex downwardly at the cam surface 54 as the cam surface 54 travels across the upper surface 42. This flexing action of the ice mold 30 fractures the bonds between the ice cubes 60 and the ice mold sections 46, thereby loosening

the cubes 60 from the mold 30. Optionally, the heater 48 may be activated to begin melting the ice cubes at the interface between the ice cubes and the ice mold sections 46 prior to rotating the rake 34.

[0019] As seen in Figure 5c, as the rake 34 continues to rotate, the fingers 50 are brought into contact with the ice cubes 60. Because the ice cubes 60 have been loosened from their respective mold sections 46 by the flexing action of the mold 30 caused by the cam surface 54 pressing against the upper surface 42 of the mold 30, the fingers 50 can easily dislodge the ice cubes 60 from the mold sections 46, driving the cubes 60 against the ice cube deflectors 36 that serve to guide the ice cubes 60 around and over the mold 30 as the rake 34 continues to rotate. The cube deflectors 36 each have a rounded inner surface 56 that generally matches the curvature of the ice cubes 60. Furthermore, the cube deflectors 36 include separator walls 58 between them that tend to break any ice bridges between the individual cubes 60. The cube deflectors 36 also serve as splash guards to prevent liquid water from splashing out of the ice making module 28. This splash guard function can be especially important in instances where the ice making module 28 is mounted on a door 16 where sloshing is likely to occur.

[0020] As seen in Figure 5d, as the rake 34 continues to rotate, the ice cubes 60 will drop on to the stripper 37 and then fall towards the ice bin (not shown) for storage until they are dispensed or otherwise removed from the ice bin. The stripper 37 prevents the ice cubes from falling back onto the ice mold 30 where they might interfere with the formation or harvesting of additional ice cubes. The stripper 37 also serves a spill prevention feature by blocking the space on that side of the ice mold 30, except where openings are provided to permit the fingers 50 and cam projection 52 to pass through.

[0021] Rotation of the ice rake 34 is stopped with the ice rake 34 in a parked position of Figure 5a with the ice rake fingers 50 clear of the ice mold sections 46 and the cam projection 52 poised to contact the upper surface 42 of the ice mold 30. Preferably the entire cycle from park to harvest to park position can be accomplished in a single 360 degree rotation of the ice rake 34. Alternatively, it may be necessary to rotate the rake 34 more than 360 degrees by passing the fingers 50 through the mold sections 46 twice to first harvest the ice cubes and then return the rake 34 to a the parked position. With the rake 34 returned to the parked position, the ice mold sections 46 may again be filled with water to start another cycle of ice making and harvesting.

[0022] Figures 6 and 7 show an alternative design for a low profile ice making module 128 according to one embodiment of the present invention. The ice making module 128 includes an ice mold 130, a cover 132, an ice rake 134, and a deflector 136. The alternative design of Figures 6 and 7 eliminates the need for a stripper. The ice making module 128 operates similarly to the ice making module 28 described above, except for the following differences. During harvest, the cam projection 152 con-

tacts and flexes the mold 130 to at least partially loosen the ice cubes 60 from the mold sections 146. In the embodiment shown, two cam projections 152 are provided--one near each end of the rake 134. As the fingers 150 dislodge the ice cubes 60 from the mold sections 146, the cubes 60 contact the bottom portion of the deflector 136 and are guided downwardly and off the front side of the mold 130 toward the ice bin (not shown). Therefore, rather than passing back over the top of the ice mold 130 and falling on the back side of the mold 130, the ice cubes 60 just drop off the front side of the ice mold 130. The rake 134 does not need to move more than 180 degrees during the harvesting process. Therefore, to return the rake 134 to the parked position, the motor can optionally be reversed such that the fingers 150 pass back through the mold sections 146 towards the parked position. This results in an overall lower height of the module 128 because the rake 134 does not need to be rotated significantly above the axis of rotation. This alternative design eliminates the need for the stripper, more quickly moves the ice cubes to the ice bin, and results in an overall lower profile for the module. It should be appreciated that the many of the advantages of this lower profile embodiment could be achieved without use of the cam projection 152, which optionally may be omitted from the design.

[0023] The invention has been shown and described above with reference to the preferred embodiments. It is understood that many modifications, substitutions, and additions may be made that are within the intended scope of the invention. The invention is only limited by the claims that follow.

Claims

1. A refrigerator comprising:

- a cabinet;
- a door for providing access to the cabinet;
- an ice maker mounted within the cabinet or on the door;
- the ice maker having an ice mold including a plurality of ice cube forming mold sections with upward facing openings, the ice mold including an upward facing surface;
- a supply of water provided to the ice cube forming mold sections;
- a rotatable member rotatable about an axis spaced apart from the upward facing surface of the ice mold by a first distance, the rotatable member including fingers in alignment with the ice cube forming mold sections such that rotation of the rotatable member about the axis causes the fingers to contact and thereby dislodge and harvest ice cubes from the ice cube forming mold sections; and
- a cam projection extending from the rotatable member to a second distance from the axis,

- the second distance being greater than the first distance such that rotation of the rotatable member causes the cam projection to contact the upward facing surface of the ice mold to thereby flex the ice mold and at least partially break a bond between the ice cubes and the ice cube forming mold sections to facilitate harvesting of the ice cubes by the fingers.
2. The refrigerator of claim 1, wherein the ice mold comprises a single piece of stamped aluminum.
 3. The refrigerator of claim 1 or 2, further comprising a second cam projection extending from the rotatable member to a third distance from the axis, the third distance being greater than the first distance, wherein optionally the third distance is equal to the second distance.
 4. The refrigerator of any preceding claim, wherein the cam projection has a low friction surface such that the low friction surface slides freely across the upward facing surface of the ice mold.
 5. The refrigerator of any preceding claim, wherein the ice cube forming mold sections are concavely curved from front-to-back and from side-to-side.
 6. The refrigerator of any preceding claim, wherein the upward facing surface has a front edge and rear edge, and wherein when the rotatable member is rotated in a first direction to dislodge and harvest ice cubes, the fingers move generally in a direction toward the rear edge as they contact the ice cubes within the ice cube forming mold sections, the refrigerator further comprising an ice cube deflector positioned generally above the upward facing surface, the ice cube deflector positioned proximate the rear edge of the upward facing surface such that ice cubes dislodged from the ice cube forming mold sections are guided over the mold towards the front edge by the deflector as the rotatable member rotates with the fingers in contact with the dislodged cubes.
 7. The refrigerator of claim 6, wherein:

the cube deflector has a plurality of concavely curved inner surfaces that generally match a curvature of the ice cubes; and/or

the cube deflector includes separator walls between the curved inner surfaces to break ice bridges between the cubes.
 8. The refrigerator of any of claims 1 to 5, wherein the upward facing surface has a front edge and a rear edge, and wherein when the rotatable member is rotated in a first direction to dislodge and harvest ice cubes, the fingers move in a direction toward the front edge as they contact ice cubes within the ice cube forming mold sections, the refrigerator further comprising an ice cube deflector positioned generally spaced apart from and above the upward facing surface between the front edge and the axis such that ice cubes dislodged from the ice cube forming mold sections are deflected downwardly over the front edge.
 9. A method of making and harvesting ice cubes, the method comprising:

providing a refrigerator with an ice maker including an ice mold within the refrigerator, the ice mold including a plurality of ice cube forming mold sections with upward facing openings, the ice mold further including an upward facing surface;

providing a rotatable member including fingers in alignment with the ice cube forming mold sections, the rotatable member further having a cam projection;

providing water to the ice cube forming mold sections;

removing heat from the water within the ice cube forming mold sections to form ice cubes in the ice cube forming mold sections;

breaking an adhesion between the ice cubes and the ice cube forming mold sections by rotating the rotatable member to bring the cam projection into contact with the upward facing surface of the ice mold to thereby flex the ice mold; and

removing the ice cubes from the ice cube forming mold sections by continuing to rotate the rotatable member such that the fingers pass through the ice cube forming mold sections to thereby remove the ice cubes.
 10. The method of claim 9, wherein the rotatable member further comprises a second cam projection, and wherein breaking the adhesion further comprises bringing the second cam projection into contact with the upward facing surface.
 11. The method of claim 9 or 10, wherein the ice mold comprises a single piece of stamped aluminum.
 12. The method of any of claims 9 to 11, wherein:

the cam projection has a low friction surface such that the low friction surface slides freely across the upward facing surface of the ice mold; and/or

the ice mold sections are concavely curved from front-to-back and from side-to-side.
 13. The method of any of claims 9 to 12, wherein the

upward facing surface has a front edge and rear edge, and wherein rotating the rotatable member in a first direction moves the fingers generally toward the rear edge as they contact the ice cubes within the ice cube forming mold sections, and further wherein an ice cube deflector is positioned generally above the upward facing surface proximate to the rear edge of the upward facing surface such that ice cubes dislodged from the ice cube forming mold sections are guided above the mold towards the front edge by the deflector as the rotatable member rotates in the first direction with the fingers in contact with the dislodged cubes.

14. The method of claim 13, wherein the cube deflector has a plurality of concavely curved inner surfaces that generally match a curvature of the ice cubes, wherein optionally the cube deflector includes separator walls between the curved inner surfaces that break ice bridges between the cubes.
15. The method of any of claims 9 to 12, wherein the upward facing surface has a front edge and a rear edge, the method further comprising: rotating the rotatable member in a first direction to dislodge and harvest ice cubes by moving the fingers toward the front edge as the fingers contact ice cubes until the ice cubes are deflected downwardly over the front edge by an ice cube deflector spaced apart from and above the upward facing surface between the front edge and the axis, optionally further comprising after deflecting the ice cubes over the front edge, rotating the rotatable member in a second direction opposite from the first direction until the fingers have passed completely through the ice cube forming mold sections moving in the second direction before again providing water to the ice cube forming mold sections.

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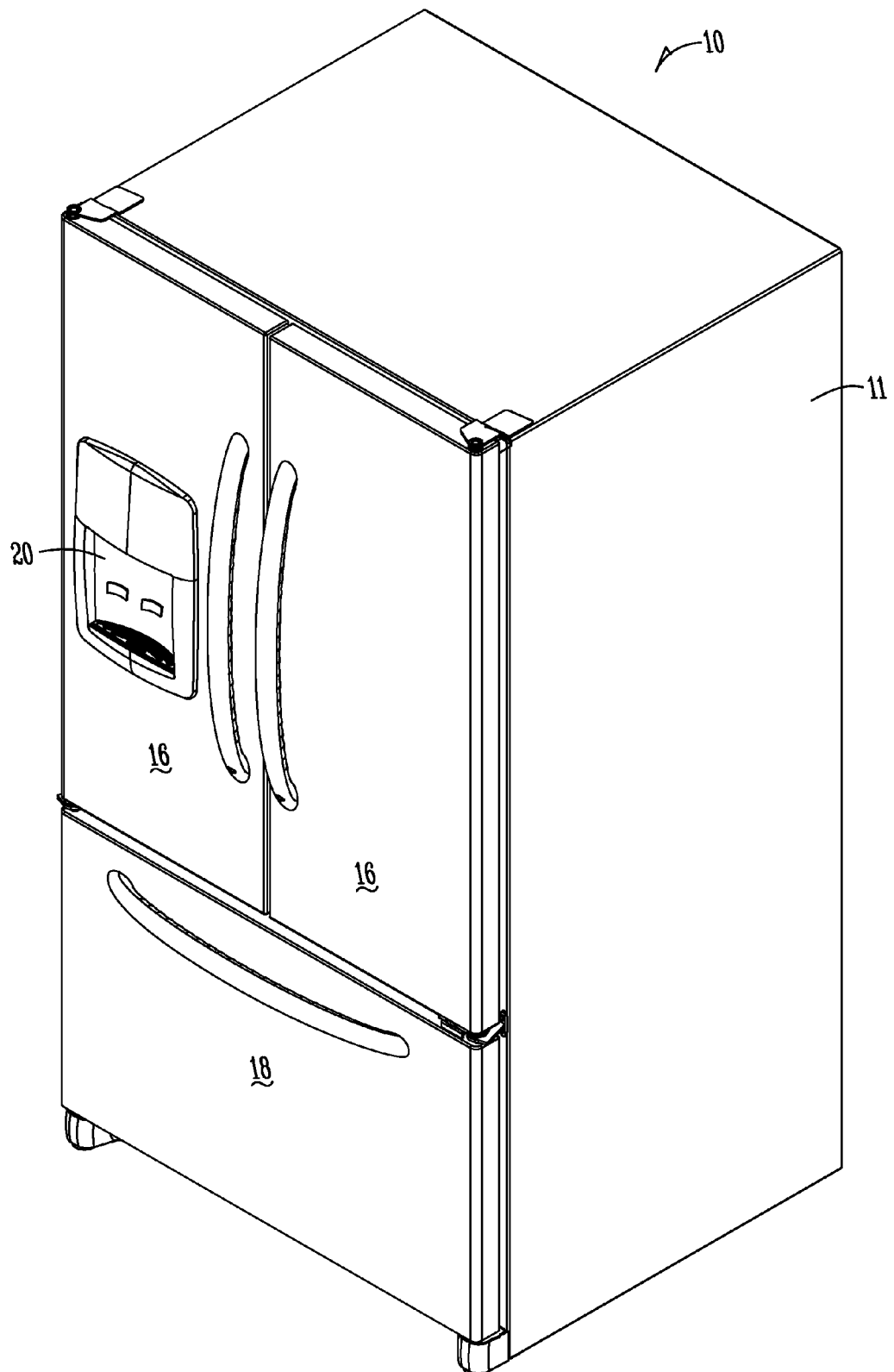


Fig. 1

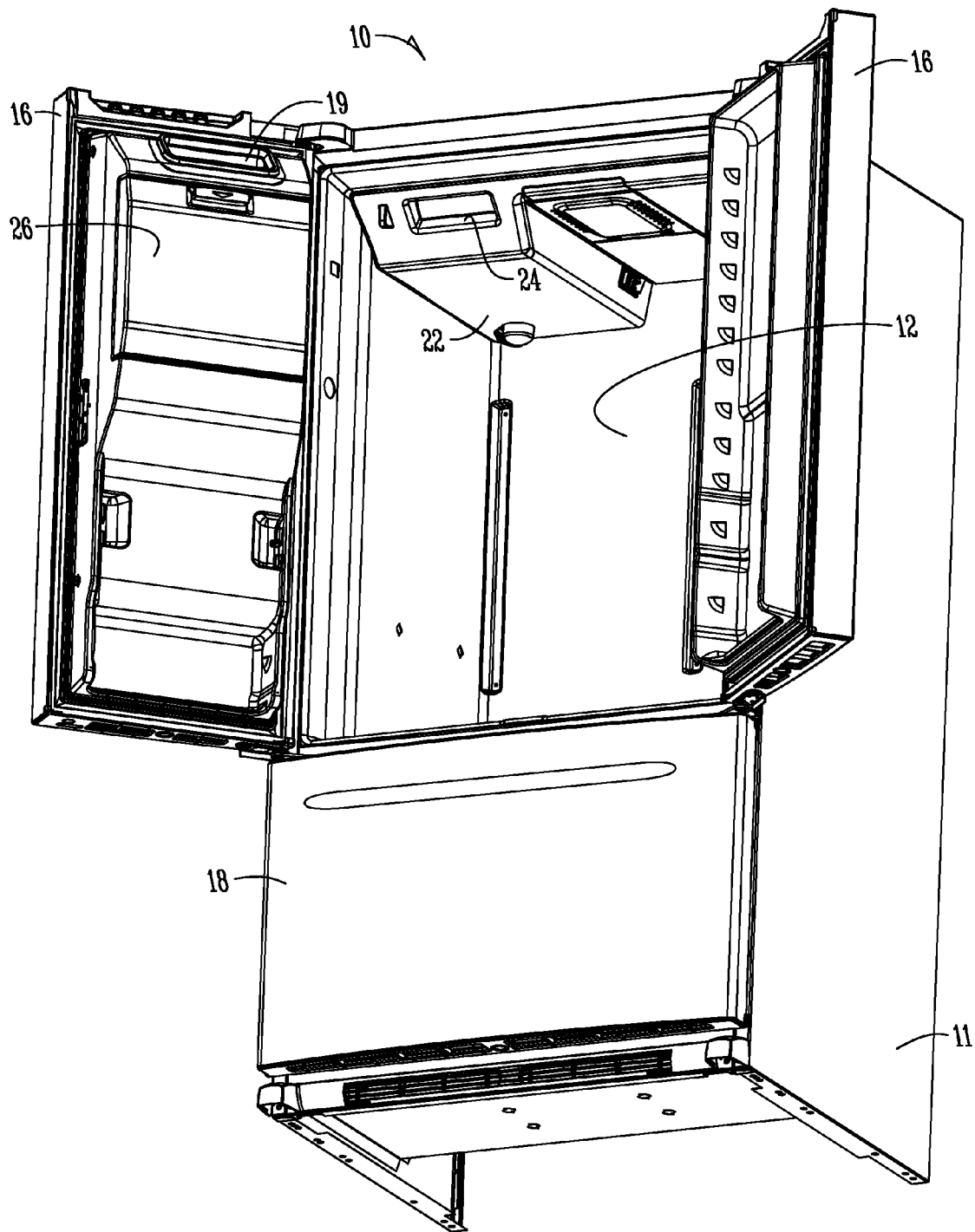


Fig. 2

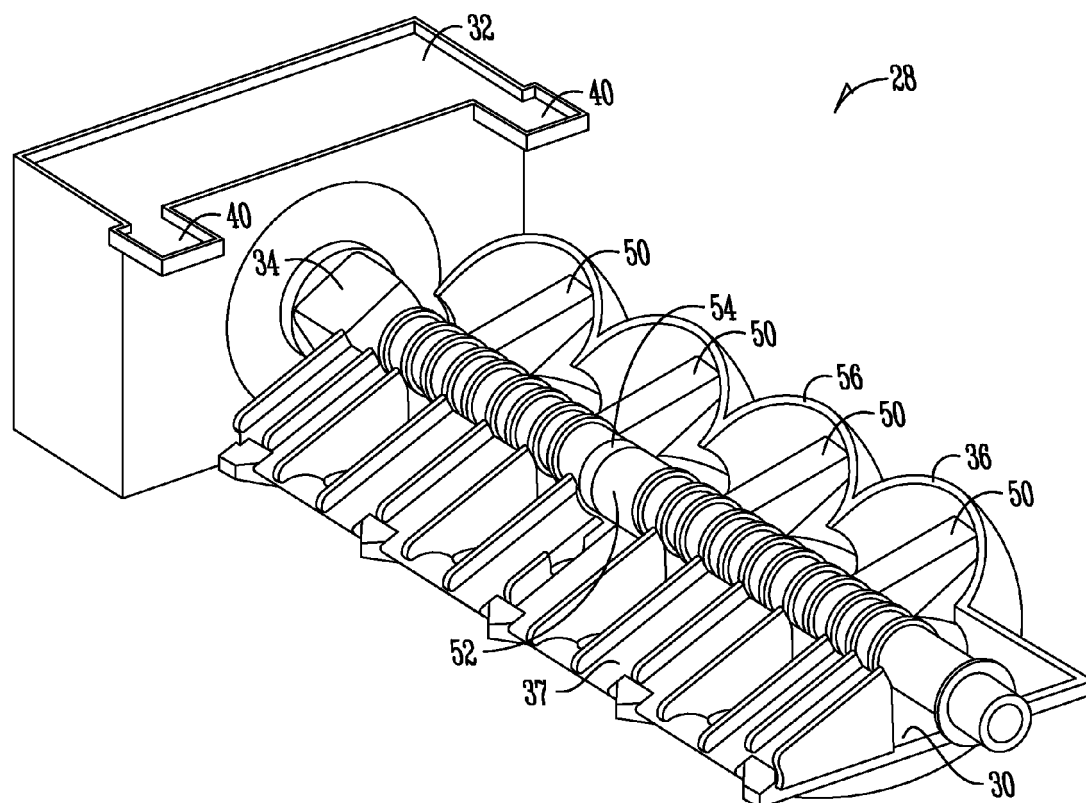


Fig. 3

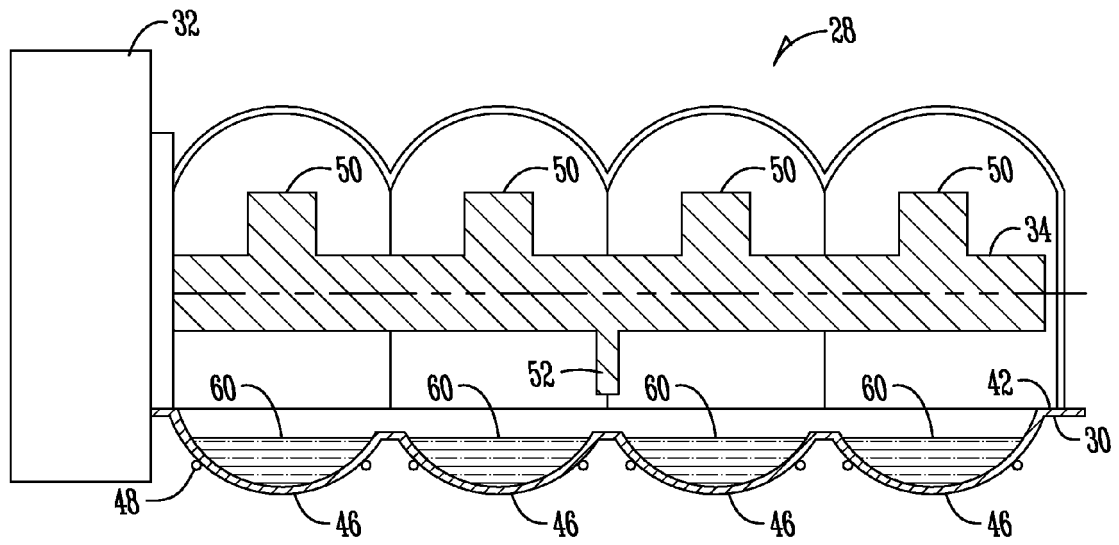


Fig. 4

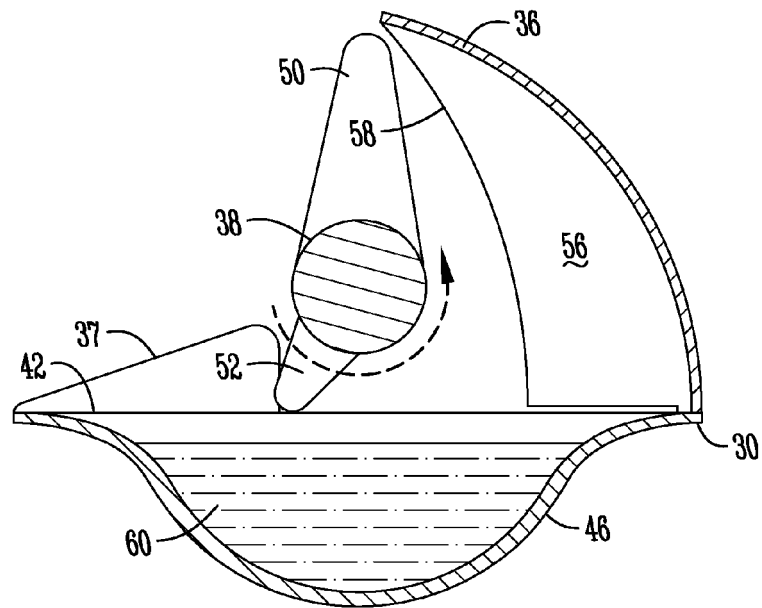


Fig. 5a

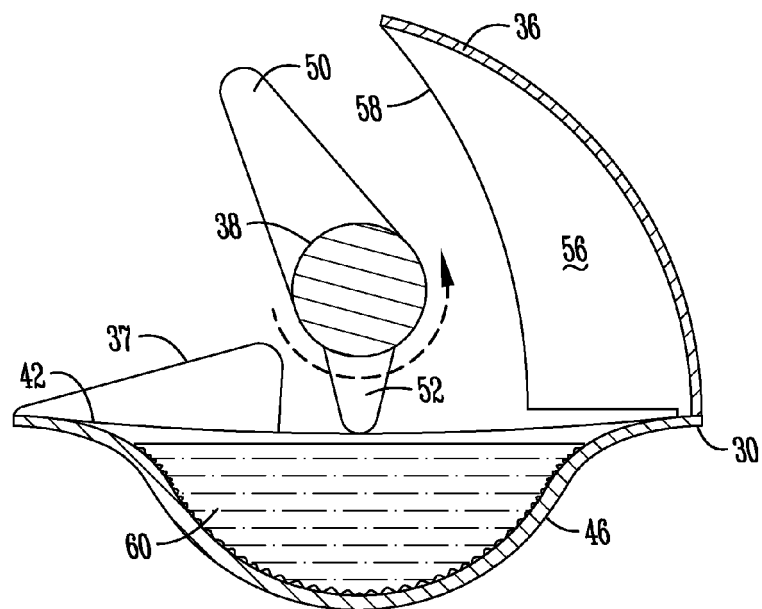


Fig. 5b

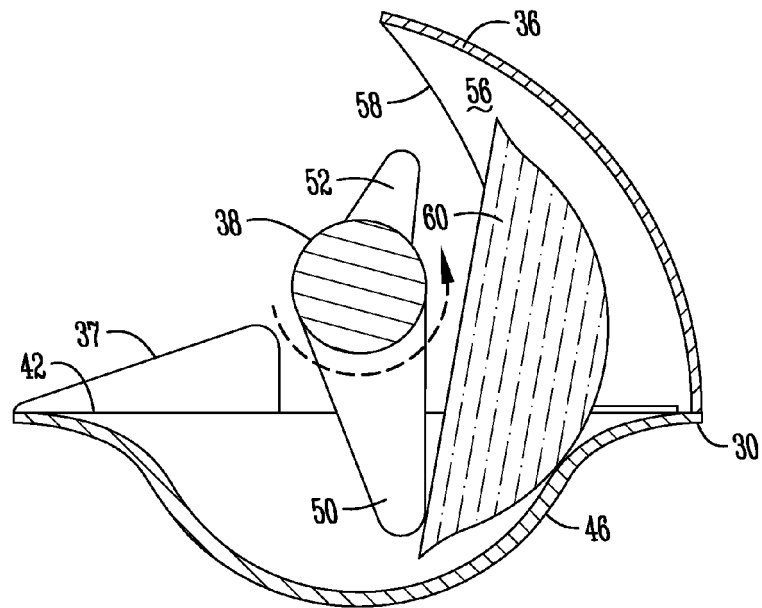


Fig. 5c

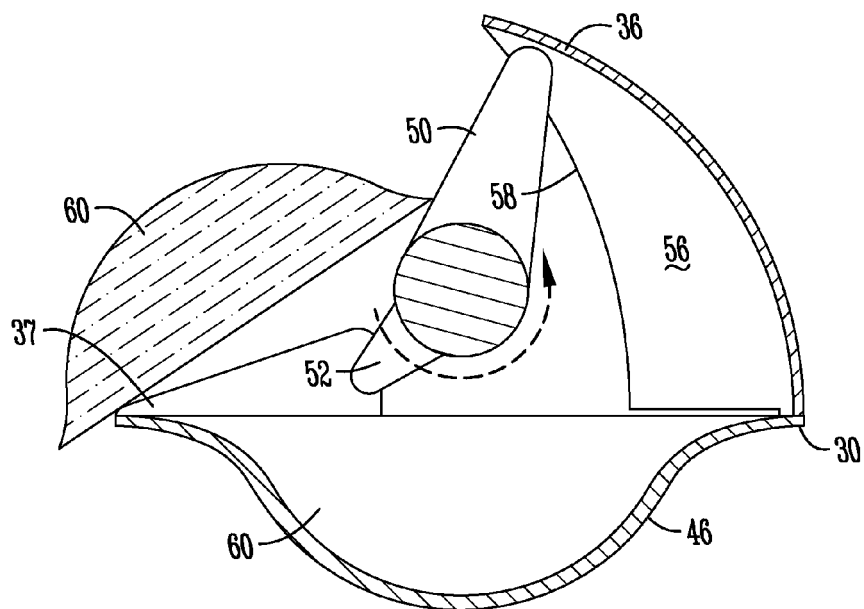


Fig. 5d

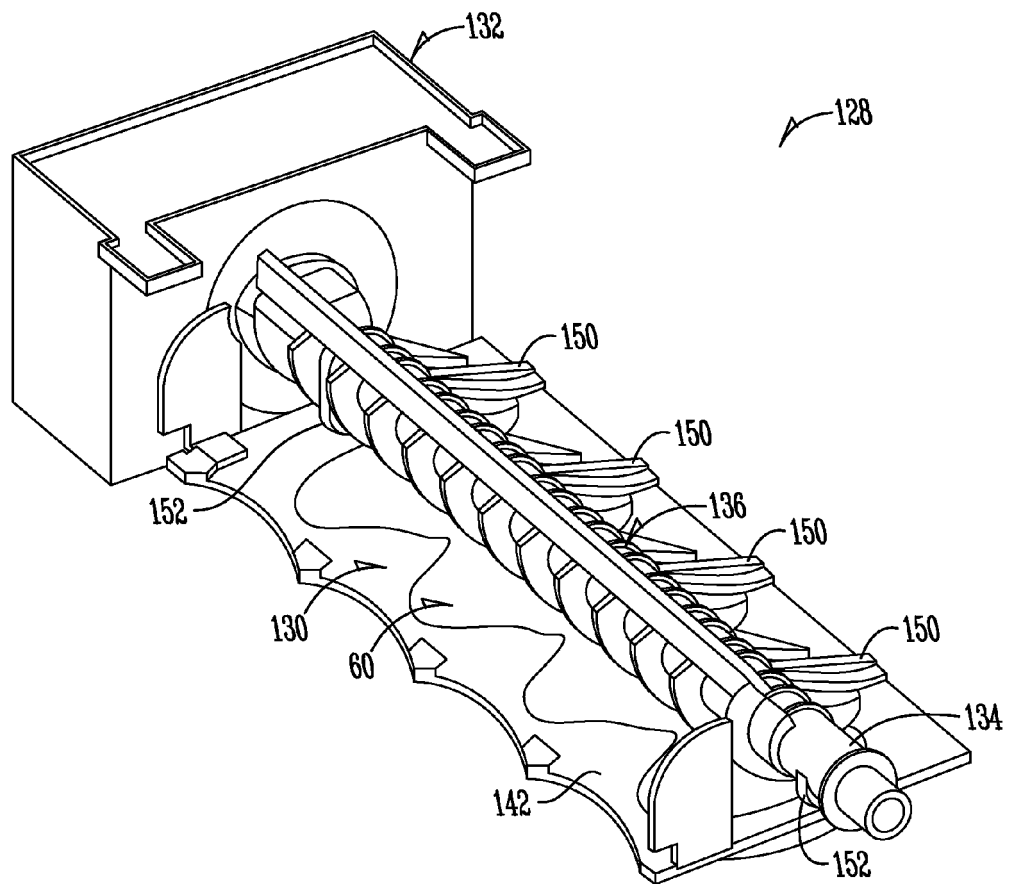


Fig. 6

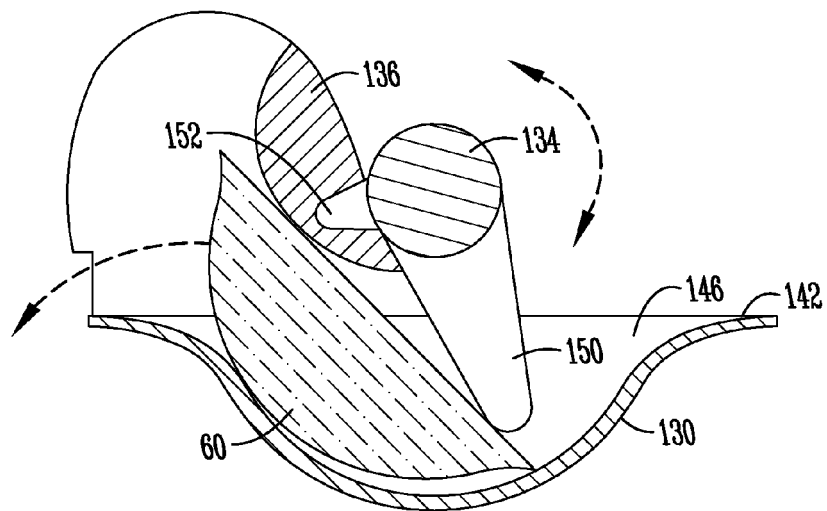


Fig. 7