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(54) **Systems and methods for ultrasound-based atomizer for humidity control in refrigerators**

(57) A system and method is provided for monitoring the humidity inside a refrigerator and increasing the humidity when desired. In an embodiment, the humidifier is an ultrasonic atomizer that receives supply water from a removable tank that is refilled by a consumer. An adaptive control system monitors the humidity level inside the refrigerator and actuates the ultrasonic atomizer when an increase in humidity is desired.

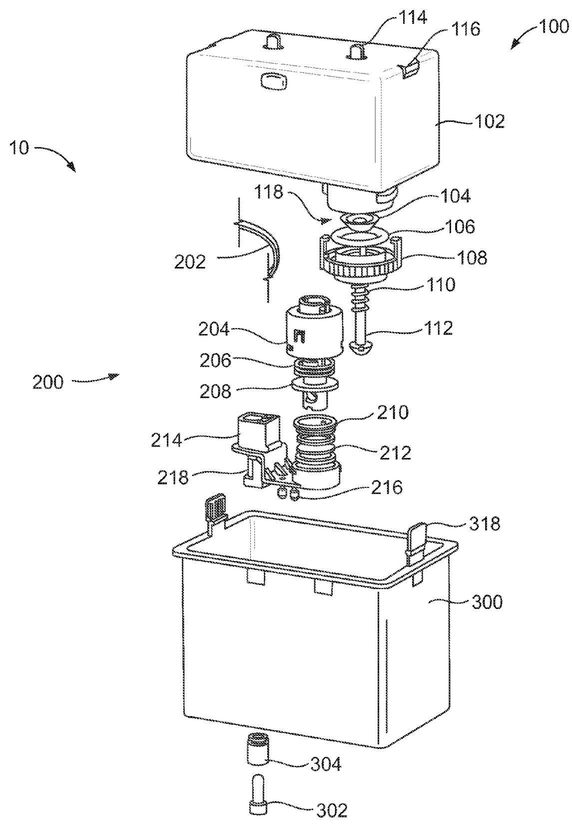


FIG. 1

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## Description

**[0001]** The present invention generally relates to a refrigerator. More particularly, the present invention relates to a refrigerator with an improved system for keeping food fresh.

**[0002]** In this regard, it has been determined that some refrigerated foods remain fresh and attractive to the consumer when the foods are exposed to water or moisture on a regular basis. However, the interior of the refrigeration compartment of a refrigerator is typically quite dry.

**[0003]** Moreover, it is often the case that additional moisture is undesirable in prior art refrigerators because it may make the cooling process more energy-intensive. Also, even when not directly designed to remove water or moisture, many refrigerators tend to minimize moisture purely as a by-product of their operation.

**[0004]** One or more of the embodiments of the presently described technology provide a humidification system for the interior of a refrigerator. In an embodiment, the humidification system includes an ultrasonic atomizer providing humidity to the refrigeration compartment of the refrigerator. The ultrasonic atomizer is controlled by an adaptive control system and receives its supply water from a removable tank that is refilled by a consumer.

A first aspect of the invention provides system for providing humidity control in a refrigeration product, said system including: a refrigeration product, wherein said refrigeration product includes a refrigeration compartment that is refrigerated; and a humidifier operatively coupled to said refrigeration compartment so that the output of said humidifier is introduced into said refrigeration compartment.

A second aspect of the invention provides a humidification system for the interior of a refrigeration compartment, said system including: a humidifier, wherein the output of said humidifier is introduced into the interior of said refrigeration compartment.

A third aspect of the invention provides a method for controlling humidity in a refrigeration product, said method including: refrigerating the interior of a refrigeration compartment of said refrigeration product; and positioning a humidifier so that output of said humidifier is introduced into said refrigeration compartment.

In any of the above aspects the humidifier may be an atomizer, e.g. ultrasound-based, such as a microfilm ultrasound water atomizer. The humidifier may be positioned to direct at least a portion of the output into at least one of a vegetable bin and a fruit bin located in said refrigeration compartment. The refrigeration product may include a removable liquid container for supplying liquid to said humidifier. The humidifier may be controlled to be operated intermittently. The refrigerator may be a food refrigerator, e.g. a domestic refrigerator.

**[0005]** The invention will be further described by way of example with reference to the accompanying drawings, in which:

**[0006]** Figure 1 illustrates an atomization unit formed in accordance with an embodiment of the present technology.

**[0007]** Figure 2 illustrates a refrigerator to which the atomization unit of Figure 1 may be added to or removed from, with the atomization unit in place in the refrigerator.

**[0008]** Figure 3 illustrates a refrigerator to which the atomization unit of Figure 1 may be added to or removed from, with the atomization unit being removed from the refrigerator.

**[0009]** Figure 4 illustrates an exploded perspective view of a water tank assembly formed in accordance with an embodiment of the present technology.

**[0010]** Figure 5 illustrates an exploded perspective view of a water delivery assembly formed in accordance with an embodiment of the present technology.

**[0011]** Figure 6 illustrates a perspective view of a docking station formed in accordance with an embodiment of the present technology.

**[0012]** Figure 7 illustrates a sectional view of the atomization unit of Figure 1 as the water tank assembly is being inserted into the docking station.

**[0013]** Figure 8 illustrates a sectional view of the atomization unit of Figure 1 with the water tank assembly securely positioned in the docking station.

**[0014]** Figure 9 illustrates an atomizer unit formed in accordance with an embodiment of the present technology in position in a refrigerator.

**[0015]** Figure 10 illustrates a perspective view of the atomizer unit of Figure 9.

**[0016]** Figure 11 illustrates a perspective view of a water tank assembly being slid into position into a docking station of the atomizer unit of Figure 9.

**[0017]** Figure 12 illustrates a schematic view of a main wick with auxiliary wicks formed in accordance with an embodiment of the present technology.

**[0018]** Figure 13 illustrates a humidity control system for improving the available humidity and/or moisture in the refrigeration compartment of a refrigerator.

**[0019]** Figure 14 illustrates another embodiment of the humidity control system of Figure 13.

**[0020]** Figure 15 illustrates another embodiment of the humidity control systems of Figures 13 and 14.

**[0021]** One characteristic of no-frost refrigerators is the high dehumidification rate of the freezer and fresh food compartments promoted by the relatively high air flow rate of cold air. For some types of foodstuff such as leafy vegetables that leads to considerable degradation in weight and quality due to water loss. The problem is somewhat reduced by providing a bin/drawer where air flow and, consequently, the number of air changes can be controlled by the consumer in the refrigeration compartment. This solution transfers the burden of humidity control to the foodstuff itself since it is the only water vapor source available. The current solution may also prevent water saturation in the storage container (crisper) from taking place but again does not completely eliminate the water loss from the foodstuff. There's also an opportunity for improvement as far as the perceived quality is concerned where the benefits can be clearly communicated to the consumer. The proposed solution addresses the problems of dehumidification and lack of visual appeal.

**[0022]** More specifically, an ultrasound based water atomizer and its application and integration in the refrigerator may improve the amount of available humidity and/or moisture in the refrigeration compartment. This is turn may help the foodstuffs in the refrigeration compartment stay free longer and have greater visual appeal.

**[0023]** More broadly, Figure 13 illustrates a humidity control system for improving the available humidity and/or moisture in the refrigeration compartment of a refrigerator. As shown in Figure 13, the humidity control system includes five segments: a location segment 1310, a control segment 1320, a core technology segment 1330, a power options segment 1340, and a water source segment 1350. Each of the five segments includes multiple options that are further discussed below. Additionally, the humidity control system is primarily intended for no-frost refrigeration products, but may be useful in other products as well.

**[0024]** With regard to the location segment 1310, the location of the emission of the moisture may be in either or both of two locations, the refrigeration compartment, or the bin, such as a vegetable, fruit, and/or produce bin in a refrigerator.

**[0025]** With regard to the control segment 1320, the control may include a feedback sensor for determining humidity, an adaptive sensor (for example, based on defrost cycle timings or number of door openings), and time-based humidity emission, or an evaporation fan dependent control system.

**[0026]** Additionally, any of the following systems may be employed: first, predetermined or user selected time schedules. In this embodiment, humidity sensors may not even be required.

**[0027]** Second, Adaptive control where the system determines how much moisture and when to add it to the refrigeration compartments to be humidity-controlled based on at least one of door opening, compressor run time, the frequency and length of defrost, etc. In this embodiment, a humidify sensor may also not be required.

**[0028]** Third, Closed loop control based on the actual humidity. In this embodiment, the humidity is preferably measured and used to initiate the humidifier or atomizer.

**[0029]** With regard to the core technology segment 1330, the method for emitting the moisture may be any of an ultrasound atomizer or another type of atomizer, a wick material, and/or a nozzle spray.

**[0030]** With regard to the power options segment 1340, power may be provided to the control segment 1320 and or the core technology segment 1330 using any of AC power, DC power, a battery, or power may not even be required in some cases.

**[0031]** Finally, with regard to the water source segment 1350, the source for the water to be emitted may be either the by-product water of the defrost operation and/or external water supplied by the consumer. For example, as further described below, the consumer may fill a water tank, hook up a water supply, or add a water bottle.

**[0032]** Returning again to Figure 13, there is also shown an segment selection 1375 that describes a specific embodiment of the humidity control system of Figure 13. For example, as shown in Figure 13, the segment selection 1375 has selected the bin of the location segment 1310, the feedback sensor of the control segment 1320, the ultrasound atomizer of the core technology segment 1330, the DC power unit of the power options segment 1340, and the defrost water of the water source segment 1350.

**[0033]** Thus, the segment selection 1375 describes a specific humidity control system that provides humidity to the bin of the refrigerator, uses a feedback sensor to measure humidity, supplies additional humidity using an ultrasound atomizer, powers the ultrasound atomizer and/or the feedback sensor using DC power, and supplies water from the output of the defrost process to the ultrasound atomizer for emission.

**[0034]** In this fashion, it can be seen that Figure 13 describes one hundred ninety-two (192) embodiments of the humidity control system because here are two options for the location segment 1310, four options for the control segment 1320, three options for the core technology segment 1330, four options for the power options segment 1340 and two options for the water source segment 1350.

**[0035]** Figure 14 illustrates another embodiment of the humidity control system of Figure 13. As shown in Figure 14, the segment selector 1475 indicates a humidity control system located in the refrigerator compartment, using time-based control, supplying humidity using the ultrasonic atomizer, receiving DC power at the ultrasonic atomizer and/or the time-based control, and receiving water from an external source supplied by a consumer.

**[0036]** Figure 15 illustrates another embodiment of the humidity control systems of Figures 13 and 14. As shown in Figure 15, the segment selector 1575 indicates a humidity control system located in the refrigerator compartment, using an adaptive control system, supplying humidity using an ultrasonic atomizer, receiving DC power at the ultrasonic atomizer and/or adaptive control system, and receiving water from the output of the defrost process for emission by the ultrasonic atomizer.

**[0037]** Additionally, in the core technology segment the proposed humidification technology may be based on the use of a microfilm ultrasound water atomizer. This atomizer may humidify the targeted compartment by generating a mist of water. The low wattage aspect of the technology is preferable so that its integration with the refrigerator has few implications on the refrigerator's design. Additionally, the humidification technology may be either integrated into the refrigerator at manufacture or may be retrofitable.

**[0038]** Additionally, in the location segment, the atomizer may be placed anywhere in the refrigerator compartment. However, if the desired location is inside a bin/drawer, it is preferable to use a reliable humidity sensor (for example, robust to water saturation) that may precisely control the desired amount of water addition without promoting saturation in the bin. The advantage of having the atomizer placed outside the bin is its robustness to water saturation due to a much larger number of air changes that the refrigerator compartment experiences when compared to a bin/drawer. As a result, there is a lesser need of a precise humidity feedback control system. However, the impact in number of defrosts may be increased.

**[0039]** With regard to the control segment, several options are available to control humidity. Some options are strongly linked to the location where the atomizer may be placed as mentioned previously. Humidity sensors are recommended for a more precise humidity control such as when the atomizer is located in a small space (such as a bin or drawer). Conversely, if the atomizer is installed in the refrigerator compartment, the number of options are much higher. Adaptive humidity control based upon past defrost cycles, time-based operation based upon consumer settings and mechanical activation are the examples for humidity control.

**[0040]** Figures 1-12 illustrate examples of atomizers for use in the humidity control system described above.

**[0041]** Figure 1 illustrates an atomization unit 10 formed in accordance with an embodiment of the present disclosure. The illustrated atomization unit 10 is a modular design that is configured and adapted to be added to or removed from a refrigerator as a unit. The atomization unit 10 comprises a water tank assembly 100, a water delivery assembly 200, and a docking station 300. In the illustrated embodiment, the docking station 300 is adapted to securely receive the water tank assembly 100 and the water delivery assembly 200. In turn, the docking station 300 may be securely mounted in a refrigerator.

**[0042]** Figures 2 and 3 illustrate a refrigerator 20 to which the atomization unit 10 may be added to or removed from. In Figure 2, the atomization unit 10 is shown in place, in an assembled condition, in the refrigerator 20. In Figure 3, the atomization unit 10 is illustrated as being removed from the refrigerator 20. The atomization unit 10 may be removed from the refrigerator 20, for example, for service, maintenance, or replacement. In certain embodiments, the atomization unit 10 may be removed from the refrigerator 20 to be refilled with a fluid, such as water. In other embodiments, the atomization unit 10 may be re-fillable without removal from the refrigerator, such as, for example, by plumbing provided within the refrigerator 20, or by a user pouring water into the atomization unit 10, or, as another example, by the attachment of a replaceable bottle or other filling device to the atomization unit 10. The atomizer unit 10 may have a footprint of, for example, about 75 millimeters by about 120 millimeters. The relatively small footprint of the atomizer unit 10 and/or the modularity of the atomizer unit 10 also allow for easier retrofitting to a refrigerator not previously designed for use with an atomizer unit to accept and use the atomizer unit 10.

**[0043]** For the illustrated embodiment, the refrigerator 20 includes a freezer compartment 30 located at a generally higher elevation, a refrigeration compartment 40 located at a generally intermediate level, and a refrigeration/humidification compartment 50 located at a generally lower level. The atomization unit 10 is securable at an intermediate position between the refrigeration compartment 40 and the refrigeration/humidification compartment 50, and disperses a spray of fluid generally downwardly into the refrigeration/humidification compartment 50. In such an arrangement, for example, the atomization unit may be supplied with water from a defrosting process in a compartment located at a higher level, the water being gravity fed to the atomization unit 10. Other refrigeration arrangements may be employed in other embodiments. As just one example, an atomization unit may be located proximate a side wall of a refrigeration compartment.

**[0044]** Additionally or alternatively, the refrigerator compartment and atomization unit may be configured and adapted so that some subcompartments of a larger compartment are supplied with atomized fluid and some are not, or further that subcompartments may be supplied with atomized fluid at different rates or amounts. Such subcompartments may be defined, for example, by bins, trays, and/or shelves dispersed throughout a compartment. The various compartments may be differently sized and/or arranged in other embodiments. As just one example, a refrigerator formed in accordance with another embodiment may not comprise a separate refrigerator/humidification compartment, but may instead comprise a freezer unit and a refrigerator unit arranged in a side-by-side fashion, with an atomization unit providing humidification to all or part of the refrigeration unit.

**[0045]** Returning to Figure 1, as also indicated above, the atomization unit 10 comprises a water tank assembly 100, a water delivery assembly 200, and a docking station 300. Figure 4 illustrates an exploded perspective view of the water tank assembly 100. The water tank assembly 100 includes a water tank 102, a poppet valve seal 104, an o-ring 106, a water tank cap 108, a poppet valve spring 110, a poppet valve 112, ears 114, and tabs 116.

**[0046]** The water tank 102 is configured and adapted to hold a volume of fluid. The water tank 102 is an example of a primary fluid reservoir or main supply fluid tank. As such, the water tank 102 should be constructed to be water tight, especially around its sides and bottom, to prevent leakage. The water tank 102 comprises one or more locations for the controlled entry and/or exit of fluid. Further, in the illustrated embodiment, the water tank 102 is configured to be airtight when the opening 118 is closed to the entry of air, for example, by being shut by a valve or submersed below a liquid level. The illustrated water tank 102 comprises an opening 118 located proximate the bottom of the water tank 102, which is sized and adapted to accept the water tank cap 108 and related components to allow for the controlled dispensing of water from the water tank 102. The water tank 102 may be inverted, with the water tank cap 108 removed, to be manually filled with water. In other embodiments, for example, the water tank 102, may be re-filled manually through a separate or additional cap accessible when the atomizer unit 10 is in place in the refrigerator, by a plumbing feed from water from another portion of the refrigerator or an external supply, and/or by a replaceably attachable supply such as a bottle. In other embodiments, for example, a replaceable supply such as a bottle may act as a supply of water without the use of a separate primary water tank.

**[0047]** In the illustrated embodiment, the ears 114 are located proximate to an external top surface of the water tank 102, and provide a convenient access point for handling the atomizer unit 10 during installation to and removal from the refrigerator 20. The ears 114 also provide a convenient access point for removing and/or installing the water tank 102 to the docking assembly 300. The tabs 116 are configured to help guide the water tank 102 into place into the docking station 300, and are configured to help secure the water tank 102 in place in the docking station 300.

**[0048]** As also previously mentioned, the water tank assembly 100 includes a poppet valve seal 104, an o-ring 106, a water tank cap 108, a poppet valve spring 110, and a poppet valve 112. The water tank cap 108 is sized and configured to cooperate with the opening 118 of the water tank 102 to allow fluid flow when the poppet valve 112 is open, and to prevent fluid flow when the poppet valve 112 is closed. The poppet valve seal 104, o-ring 106, water tank cap 108, and poppet valve spring 110 cooperate to prevent fluid flow when the poppet valve 112 is in a closed position. For example, the seals and o-ring are configured to help provide a waterproof barrier. The poppet valve spring 110 is configured to urge the poppet valve 112 in a closed position, and the poppet valve seal 104 is mounted to the poppet valve 112 so that the poppet valve seal 104 moves with the poppet valve 112.

**[0049]** In the illustrated embodiment, the poppet valve seal 104 is generally funnel shaped and configured to prevent flow through the water tank cap 108 when the poppet valve 112 is in a closed position. The funnel shape helps properly seat the poppet valve seal 104 with the assistance of downward pressure provided by a water column above it, when the poppet valve 112 is in a closed position. As shown in Figs. 1 and 4, the poppet valve spring 110 is configured to bias the poppet valve 112 downward, thus drawing the poppet valve seal 104 down over an opening in the water tank cap 108.

**[0050]** The poppet valve 112 is opened by pressing upward on the poppet valve 112 against the urging of the poppet valve spring 110, thereby moving the poppet valve seal 104 (which is mounted to the poppet valve 112) upward and away from the opening in the water tank cap 108, thereby allowing fluid flow. Thus, when fluid flow is desired, the poppet valve 112 may be urged against the poppet valve spring 110 to an open position to allow fluid flow through the water tank cap 108. Once fluid flow is desired to be stopped, the poppet valve 112 may be returned to a closed position, where the poppet valve spring 110 will help close it and maintain it in place. In other embodiments, different valve arrangements and/or cap opening/closing arrangements and/or fluid flow mechanisms may be employed.

**[0051]** Figure 5 illustrates an exploded perspective view of the water delivery assembly 200. In the illustrated embodiment, the water delivery assembly includes a wick 202, a wick holder 204, a wick spring 206, a wick plunger 208, a piezo compression ring 210, a piezo cell 212, a piezo casing 214, and light emitting diodes (LEDs) 216. The water delivery assembly 200 in the illustrated embodiment is modular, and may be assembled and removed from and/or installed into the docking station 300 as a unit.

**[0052]** The wick 202 is configured to be a flexible member with sufficient absorbency to be able to deliver fluid from a reservoir to the piezo cell 212. The wick 202, for example, may be constructed of a cotton material, such as material from Pepperell Braiding Co., which can range in size, for example, from about 1/16 inch to about ½ inch and may be capable of drawing water up to about 8 inches. The wick holder 204, wick spring 206, and wick plunger 208 are configured and adapted to maintain one end of the wick 202 in proximity to the piezo cell 212, so that the wick 202 may act as a fluid conduit to the piezo cell 212. The wick holder 204 and/or other components provide an example of a wick guide.

**[0053]** The wick 202 is positioned such that one end of the wick 202 is in fluid communication with a source of fluid, and the other end is proximate to the piezo cell 212, so that the fluid is provided from a source of fluid to the piezo cell 212 via the wick 202. In certain embodiments, the wick is securely attached to the piezo cell, or element. In other embodiments, the wick is not securely attached to the piezo cell, but is positioned close enough to the piezo cell to provide water or other fluid. For example, the piezo casing may define a piezo reservoir that is supplied by the wick and maintains a volume of water proximate to the piezo cell.

**[0054]** The piezo casing 214 and piezo compression ring 210 cooperate to help maintain the piezo cell 212 in a desired position. The piezo casing 214 also includes a female docking pin 218 adapted to help secure the water delivery assembly 200 in place in the docking assembly 300. The piezo cell 212 is a relatively thin, perforated disk that, when stimulated vibrates, whereby fluid from a top surface of the piezo cell 212 is drawn through the perforations and distributed in an atomized spray from a bottom surface of the piezo cell 212. For example, the piezo cell 212 may be about 20 millimeters in diameter and between about 0.65 and about 0.83 millimeters thick. The perforations may be sized, for example, from about 8 to about 12 microns. The piezo cell 212 may have an activating frequency of about 110 Kilohertz, and may provide a misting rate of greater than about 10 cubic centimeters per hour. Perforations above about 12 microns may increase the possibility of leakage, while perforations under about 6 microns may contribute to clogging, thereby shortening the effective life. This atomized fluid may then be used to provide moisture in an easily accepted form to foodstuffs in an appropriate compartment that is supplied with an atomizer.

**[0055]** The wick holder 204 and related components cooperate with the piezo casing 214 and related components to form a modular unit that may be handled as a unit, and helps maintain the piezo cell 212 in proper position. For example, the wick plunger 208 may urge against the piezo compression ring 210 to help maintain the piezo cell 212 in place as well as to help prevent any leakage from the water delivery assembly 200. The wick holder 204 may be snappably and removable received by the piezo casing 214. The LEDs 216 light to provide information regarding the status and/or function of the piezo cell 212.

**[0056]** The piezo cell 212 is an example of an atomizer that may be used to provide a fine spray of fluid. Such a fine spray of fluid, such as water, may be beneficial in a refrigerator application, as certain foodstuffs advantageously absorb the water provided in such a fine spray in a more effective manner compared to certain other methods of providing water to foodstuffs. The humidity provided by the atomizer, for example, improve preservation of vegetables and other fresh foods, helps maintain the color of green vegetables longer and aid nutrition retention, and improves savings due to avoiding waste of vegetables.

**[0057]** As shown in Figure 1, the docking station 300 includes a male docking pin 302 and grommet 304 configured to cooperate with the female docking pin 218 to secure the water delivery unit 200 in place. The grommet 304 helps maintain water-tightness through the opening of the docking station 300 that accepts the male docking pin 302 and grommet 304. Docking station 300 also includes snaps 318 that cooperate with the ears 114 of the water tank 102 to help guide, place, and secure the water tank 102 to the docking station 300. With the water tank assembly 100 and water delivery assembly 200 in place in the docking station 300, the assembled components form a modular assembly that can be conveniently attached to and removed from the refrigerator 20. The modular design of the entire unit as well as various modular sub-assemblies also simplifies repairs and maintenance, as well as easing the process of retrofitting the unit to a refrigerator not originally designed to accommodate such a unit.

**[0058]** Figure 6 illustrates a perspective view of a docking station 300. The docking station 300 of the illustrated embodiment includes side walls 330 that extend from a base 340 to define an open volume. The docking station 300 is configured to accept the water delivery assembly 200 and the water tank assembly 100. In the illustrated embodiment, the docking station 300 is molded as a single piece. The docking station 300 comprises a water delivery assembly mounting hole 306, a valve projection 308, a switch projection 310, a reservoir wall 312, a docking station reservoir 314, ribs 316, snaps 318, a piezo opening 320, and mounting features 322, 324.

**[0059]** The water delivery assembly mounting hole 306 is configured to cooperate with the female docking pin 218, male docking pin 302, and grommet 304 to help secure the water delivery assembly 200 in place in the docking station 300. Additionally, the illustrated embodiment includes mounting features 322, 324 to help guide, located, and/or secure the water delivery assembly 200 in place in the docking station 300. As shown in Figure 6, mounting features 322 comprise raised surfaces and mounting features 324 comprise holes in the base 340 of the docking station 300. Further, the docking station 300 is configured to allow wiring for power supply and control to be connected to the water delivery assembly 200.

**[0060]** The valve projection 308 extends from the base 340 of the docking station 300, and is positioned and configured to press against the bottom of the poppet valve 112 when the water tank assembly 100 is lowered into place in the docking station 300. The atomization unit 10 is configured so that, when the water tank assembly 100 is securely positioned in place in the docking unit 300, the poppet valve 112 is urged upward by contact with the valve projection 308 into an open position thereby allowing fluid flow. In alternative arrangements, for example, the docking station reservoir 300 (or other reservoir with which a wick is in fluid communication) may be provided with water from a source other than a water tank, such as via municipally provided water via plumbing into the refrigerator, or water obtained from a defrosting process elsewhere in the refrigerator.

**[0061]** The switch projection 310 extends upward from the base 340 of the docking station 300. The switch projection 310 cooperates with a reed switch (not shown) to indicate the position of the water tank 102, for example, to indicate whether or not the water tank 102 is in its secure, assembled position within the docking station 300.

**[0062]** The reservoir wall 312 is a generally vertical wall that extends upward from the base 340, and together with portions of the base 340 and side walls 330 defines a docking station reservoir 314. The docking station reservoir 314 is an example of a secondary reservoir that accepts fluid from a primary reservoir or main supply, such as a water tank, and from which fluid is provided to an atomizer via the wick 202. In the illustrated embodiment, the docking station reservoir 314 is integrally formed with the docking station 300.

**[0063]** In other embodiments, a secondary reservoir that is not integrally formed with a docking station may also be employed. The reservoir wall 312 extends from the base 340 to a height that is low enough to not interfere with the placement of the water tank 102 in the docking assembly 300, but high enough to retain water in the docking station reservoir 314 without water spilling over the top of the reservoir wall 312. As will be appreciated further below, the reservoir wall 312 in the illustrated embodiment extends to a height such that its top is located at an elevation higher than the opening through the water tank cap 108 when the water tank 102 is in its secured, assembled position in the docking station 300.

**[0064]** The ribs 316 extend upward from the base 340 of the docking station and are configured to provide support to the water tank 102 when the water tank 102 is placed in the docking station 300. The ribs 316 also provide a positive stop to help prevent the water tank 102 from being pressed too deeply into the docking station 300 and damaging portions of the water delivery assembly 200.

**[0065]** The snaps 318 extend upward from the sides of the docking unit 300. The snaps are configured to be resiliently biasable, and to cooperate with the tabs 116 of the water tank 102 to secure the water tank 102 in place to the docking station 300.

**[0066]** The piezo opening 320 extends through the base 340 and is configured to provide an opening for the piezo cell 212, so that an atomized spray from the piezo cell 212 may be delivered to a desired location in a refrigerator.

**[0067]** The assembly of the atomization unit 10 may be accomplished as discussed below. Figure 7 illustrates a sectional view of the atomization unit 10 as the water tank assembly 100 is being inserted into the docking station 300, and Figure 8 illustrates a sectional view of the atomization unit 10 with the water tank assembly 100 securely positioned in the docking station 300. The water delivery system 200 may be assembled, positioned, and secured in place to the docking station 300, with one of the wick 202 proximate the piezo cell 212, and the other end of the wick 202 positioned in the docking station reservoir 314 where the wick 202 will be in fluid communication with a liquid supply to provide liquid to the piezo cell 212. The docking station 300 may then be securely positioned in the refrigerator 20, and all necessary connections made to provide power and/or control to the water delivery system 200. As an alternative, the water tank assembly 100 may be positioned in the docking station 300 before the docking station 300 is positioned in the refrigerator 20.

**[0068]** Before installing the water tank assembly 100, the water tank 102 may be filled with water. To fill, the water tank 102 is inverted so that the opening faces upward, and the water tank cap 108 and related components are removed from the water tank 102, providing access to the opening. A desired amount of water is then poured into the water tank 102, and the water tank cap 108 and related components are re-positioned on the water tank 102. With the water tank cap 108 securely fastened to the water tank 102 and the poppet valve spring 110 urging the poppet valve 112 into a closed position, the opening is closed and the water tank 102 is sealed, so that it may transferred without spillage.

**[0069]** The water tank 102 is then oriented for installation, with the water tank cap 108 oriented downward and aligned over the valve projection 308. As shown in Figure 7, the water tank assembly 100 is then lowered in place into the docking station 300. Eventually, as the water tank assembly 100 is lowered, the poppet valve 112 will come into contact with the valve projection 308 to initiate opening of the poppet valve 112. Also, during the lowering, the tabs 116 of the water tank 102 encounter the snaps 318 of the docking station 300, and as the water tank 102 is further lowered, the tabs 116 press against the snaps 318, resiliently biasing the snaps 318 outwardly. For example, the tabs 116 may comprise sloped surfaces to assist in biasing the snaps 318 outwardly. As the water tank reaches its final, secured position, the tabs 116 pass beyond the snaps 318, allowing the snaps 318 to resiliently snap back into their original position, helping secure the water tank 102 in place.

**[0070]** At the same time, as the water tank 102 reaches its final, secured position, the poppet valve 112 is moved into its open position by its contact with the valve projection 308. With the poppet valve 112 in its open position, liquid flows from the water tank 102 through the opening in the water tank cap 108 into the docking station reservoir 314. Thus, the poppet valve 112 is an example of a secondary reservoir supply valve. The liquid continues to flow and fill the docking station reservoir 314 until the liquid rises to a level high enough to cover the opening in the water tank cap 108, such that the opening is not exposed to atmospheric pressure but is instead surrounded by liquid. At this point, atmospheric pressure acting on the top of the liquid in the docking station reservoir 314 is sufficient to prevent any further flow into the docking station reservoir 314. Thus, the atomization unit 10 is configured to provide a maximum, controlled height of fluid in the docking station reservoir 314.

**[0071]** As liquid is removed from the docking station reservoir via the wick 202 (which delivers liquid to the piezo cell 212 from where it is atomized into at least a portion of a refrigerator) water from the water tank 102 will replenish the docking station reservoir 314 to maintain the water level in the docking station reservoir 314 at a height sufficient to shield the opening in the water tank cap 108 from atmospheric pressure. The atomization unit 10 may be configured to maintain the level of water in the docking station reservoir 314 below a certain height to prevent water at too high of a pressure from being delivered to the piezo cell 212. For example, certain piezo cells do not function properly when exposed to water pressure caused by a head of about 3 inches.

**[0072]** Thus, in certain embodiments, the atomization unit 10 is configured so that the level of water in the docking station reservoir 314 is maintained at a level below about 3 inches. In other embodiments, for example, the opening and closing of a valve from the water tank may be controlled by sensors and switches based on the level of water in the secondary reservoir. For example, the valve may be opened when the level of water falls below a certain height, and closed when the level reaches a second height. In other embodiments, sensors may send signals to control the flow of water into the docking station reservoir 314 from an external supply via plumbing into the refrigerator.

**[0073]** With the atomizer unit 10 in place, an atomized spray may now be provided to a desired portion or portions of a refrigerator. The atomizer unit 10 defines a fluid flow path from the water tank 102, through the water tank cap 108 and into the docking station reservoir 314, and from the docking station reservoir 314 to the piezo cell 212 via the wick 202. The piezo cell 212 then may deliver an atomized spray.

**[0074]** Figure 9 illustrates another embodiment of an atomizer unit 500 in position in a refrigerator 510. As shown in Figure 9, the atomizer unit 500, when positioned in the refrigerator 510, is positioned proximate a side wall of the refrigerator 510. While differing in some respects from the atomizer unit 10, the atomizer unit 500 may also have certain similar components to the atomizer unit 10, and may function in a generally similar manner to above discussed embodiments. As also shown in Figure 9, the refrigerator 510 includes a control unit 515. The control unit 515 may be used to control the times at which the atomizer is turned on and off, and may optionally provide a user interface for adjusting the operating settings of the atomizer.

**[0075]** Figure 10 illustrates a perspective view of the atomizer unit 500. The atomizer unit 500 includes a water delivery assembly 520, a water tank assembly 530, a docking station 540, and a piezo cover 545 that snaps into place on the docking station 540. Figure 11 illustrates a perspective view of the water tank assembly 530 being slid into position into the docking station 540.

**[0076]** As seen in Figs. 9-11, the atomized spray from the atomizer unit 500 is dispersed at an angle from the vertical and not straight down. Also, the water tank assembly 530 includes a sliding face 550 that cooperates with the docking station 540 so that the water tank assembly 530 is slid at an angle into the docking station 540, and a locking projection 555 that helps secure the water tank assembly 530 in its final installed position.. The water tank assembly 530 includes a cap assembly 560 that includes a valve allowing it to be open and closed. Water from the water tank assembly 530 is delivered to a reservoir in the docking station 540 from where water is delivered to the water delivery assembly via a flexible wick.

**[0077]** Various flexible wicks may be used in conjunction with different embodiments of the presently claimed and described technology. For example, in some embodiments the wick may be used to deliver fluid to an atomizer at an elevation a limited distance above the water reservoir. As will be appreciated by those skilled in the art, a wick may be used to draw a fluid upward a given distance based on, for example, the wick material and fluid being drawn.

**[0078]** Figure 12 illustrates a view of a wick 600 formed in accordance with an embodiment of the presently claimed and described technology. The wick 600 may be used in a refrigeration system for providing fluid to a plurality of atomizers dispersed in different locations of a refrigerator. Such an arrangement can be used to provide atomization to separately located discrete portions of a refrigerator, and/or different amounts of atomization to different portions of a refrigerator, and/or atomization to different portions of a refrigerator at different times based upon, for example, different localized conditions. The wick includes a main wick 610 and auxiliary wicks 620, 630, and 640. Each of the auxiliary wicks 620, 630, and 640 provide liquid to atomizaters 650, 660, and 670, respectively. The atomizers 650, 660, 670 provide an atomized spray to compartments 680, 690, 700, respectively of the refrigerator.

**[0079]** Thus, each of the auxiliary wicks provides an example of a compartment wick, and the atomizers provide examples of compartment atomizers that are configured to deliver liquid to one of a plurality of compartments in a refrigerator. As one example, different numbers of auxiliary wicks may be used in other embodiments. As further examples, a primary wick may branch off to different locations in a refrigerator and there may be wicks that branch off from auxiliary wicks as well. In other embodiments, more than one wick and/or atomizer may provide fluid to a compartment.

**[0080]** In the illustrated embodiment, the main wick 610 includes a source end 612. The source end 612 is in fluid communication with a water source. Water is drawn from the source proximate the source end 612 through the main wick 610 to the auxiliary wicks 620, 630, and 640. Each of the auxiliary wicks 620, 630, and 640 include a terminal end 622, 632, and 642, respectively. Atomizers are located proximate to each of the terminal ends 622, 632, and 642. Water is provided to the atomizers from the source through the main wick from the source end 612 to the various auxiliary wicks, and then to the terminal ends of the auxiliary wicks, which provide the water to the atomizers, which may comprise, for example, piezo cells. In another embodiment, the main wick may also proceed to a terminal end that provides water to a piezo cell. Use of such a main wick and auxiliary wicks as discussed, for example, in connection with embodiments described above, allows water from a single source to be provided to different portions of a refrigerator, providing added flexibility and adjustability in water delivery.

**[0081]** As can be gathered from the foregoing, certain embodiments of the present technology thus can provide, for example, a modular assembly and/or sub-assemblies for the atomization of water in a refrigerator. Such a modular unit or units improves ease and cost of maintenance, assembly, and/or replacement. Further, certain embodiments of the present technology provide improved flexibility with respect to the location of water supply for an atomizer, and/or location of an atomizer or atomizers within a refrigerator. For example, multiple atomizers may be used that are supplied from a single water source, and/or atomizers can be positioned both above and below a water source. Atomizers can also be positioned at various remote distances from a water source, with water delivered via a wick. Use of multiple atomizers may allow discrete portions of a refrigerator to receive an atomized spray, as well as allow different portions to receive an atomized spray at different times and/or in different amounts.

As discussed above, the atomization unit 10 may be used to raise the moisture or humidity level in the interior of the refrigeration compartment of a refrigerator, for example. Further, a variable and/or user-controllable humidity level may be desirable. In this regard, it has been determined that a highly accurate estimate of moisture or humidity level may be obtained by analyzing one or more measured variables from the interior of the refrigeration compartment, as further discussed below. Further, because a value for the humidity level is available, a user may set a desired humidity level and the atomization unit 10 may be operated in a fashion to approximate the desired humidity level selected by the user.

**[0082]** Further, the humidifier and/or atomizer mentioned above may be switched on and off or otherwise controlled. Additionally, the humidifier and/or atomizer and/or its control system may be operated intermittently

**[0083]** While particular elements, embodiments, and applications of the present technology have been shown and described, it is understood that the invention is not limited thereto because modifications may be made by those skilled in the art within the scope of the invention as defined by the appended claims.

## Claims

**1.** A system for providing humidity control in a refrigeration product, said system including:

> a refrigeration product, wherein said refrigeration product includes a refrigeration compartment that is refrigerated; and
> a humidifier operatively coupled to said refrigeration compartment so that the output of said humidifier is introduced into said refrigeration compartment.

**2.** The system of claim 1 wherein said humidifier is an atomizer.

**3.** The system of claim 2 wherein said atomizer is ultrasound-based.

**4.** The system of claim 3 wherein said atomizer is a microfilm ultrasound water atomizer.

**5.** The system of claim 1, 2, 3 or 4, wherein said humidifier is positioned to direct at least a portion of the output into at least one of a vegetable bin and a fruit bin located in said refrigeration compartment.

**6.** The system of claim 1, 2, 3, 4 or 5, wherein said refrigeration product includes a removable liquid container for supplying liquid to said humidifier.

**7.** A method for controlling humidity in a refrigeration product, said method including:

> refrigerating the interior of a refrigeration compartment of said refrigeration product; and
> positioning a humidifier so that output of said humidifier is introduced into said refrigeration compartment.

**8.** The method of claim 7 wherein said humidifier is an atomizer.

**9.** The method of claim 8 wherein said atomizer is ultrasound-based.

**10.** The method of claim 9 wherein said atomizer is a microfilm ultrasound water atomizer.

**11.** The method of claim 7, 8, 9 or 10 wherein said humidifier is positioned to direct at least a portion of the output into at least one of a vegetable bin and a fruit bin located in said refrigeration compartment.

**12.** The method of claim 7, 8, 9, 10 or 11, wherein said refrigeration product includes a removable liquid container for supplying liquid to said humidifier.

**13.** The method of any one of claims 7 to 12 wherein said humidifier is operated intermittently.

**14.** A humidification system for the interior of a refrigeration compartment, said system including:

> a humidifier, wherein the output of said humidifier is introduced into the interior of said refrigeration compartment.

**15.** The system of any one of claims 1 to 6 or 14 wherein said humidifier is operated intermittently.

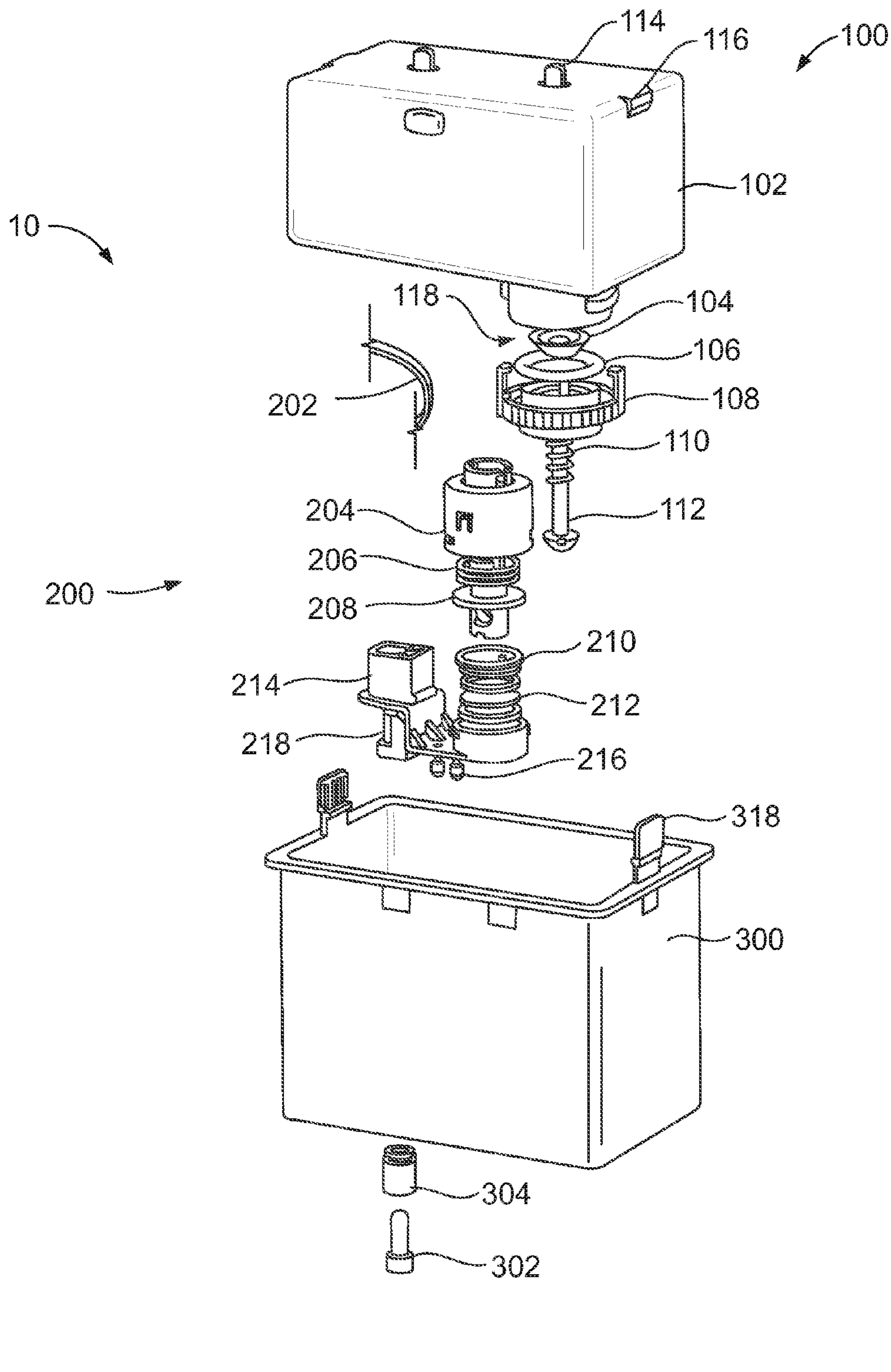
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**FIG. 1**

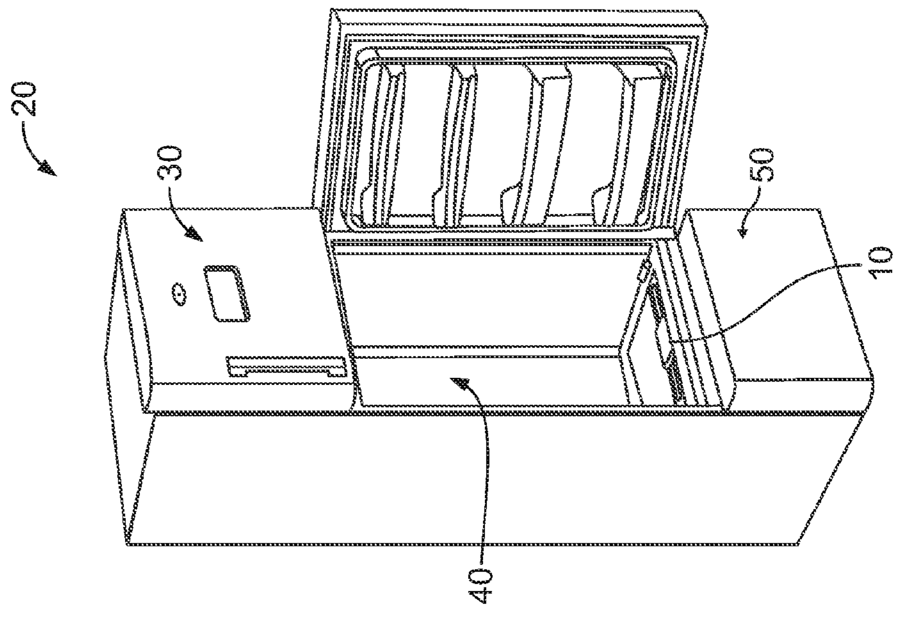
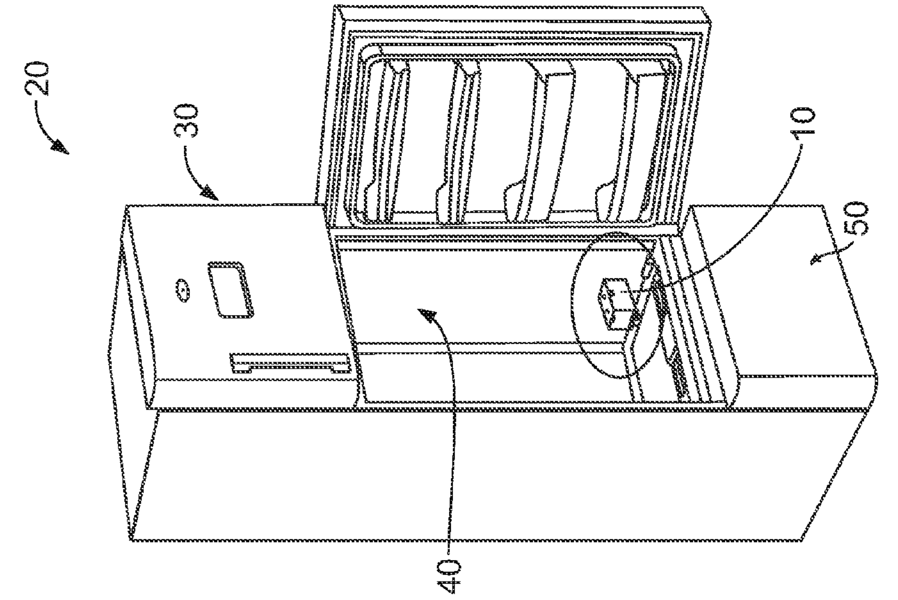



FIG. 2

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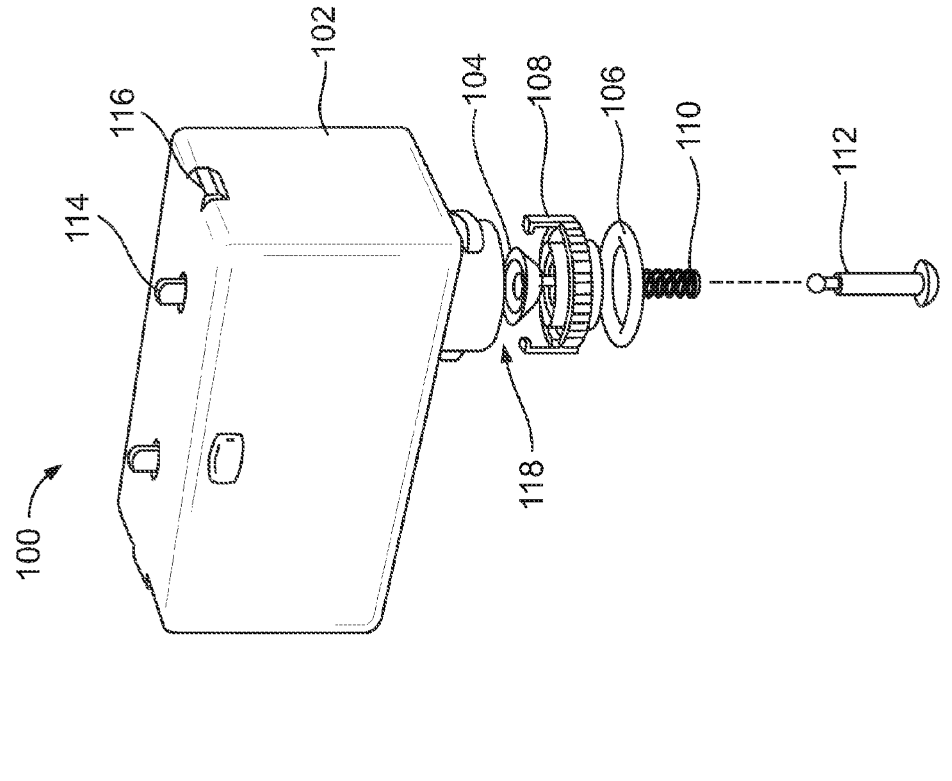
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FIG. 4

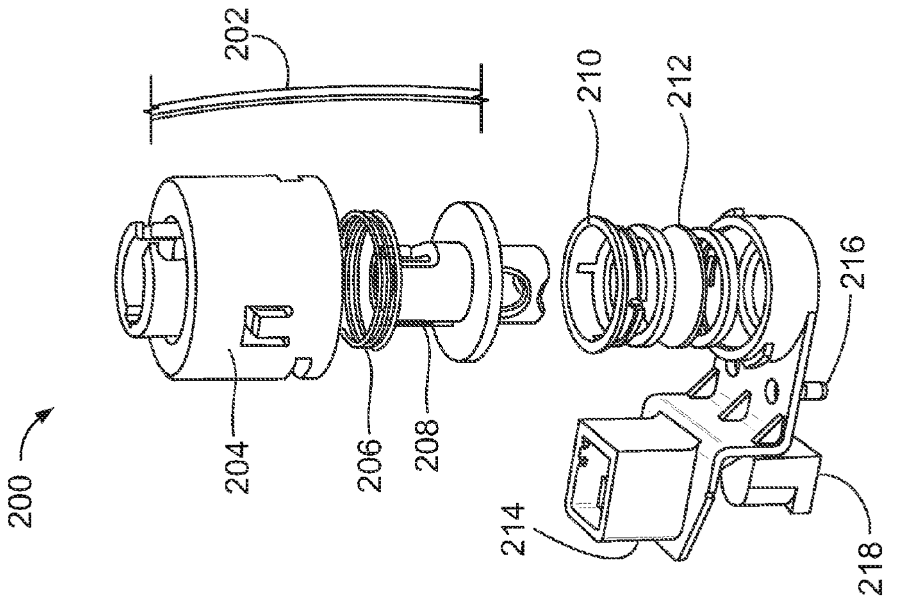
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FIG. 5

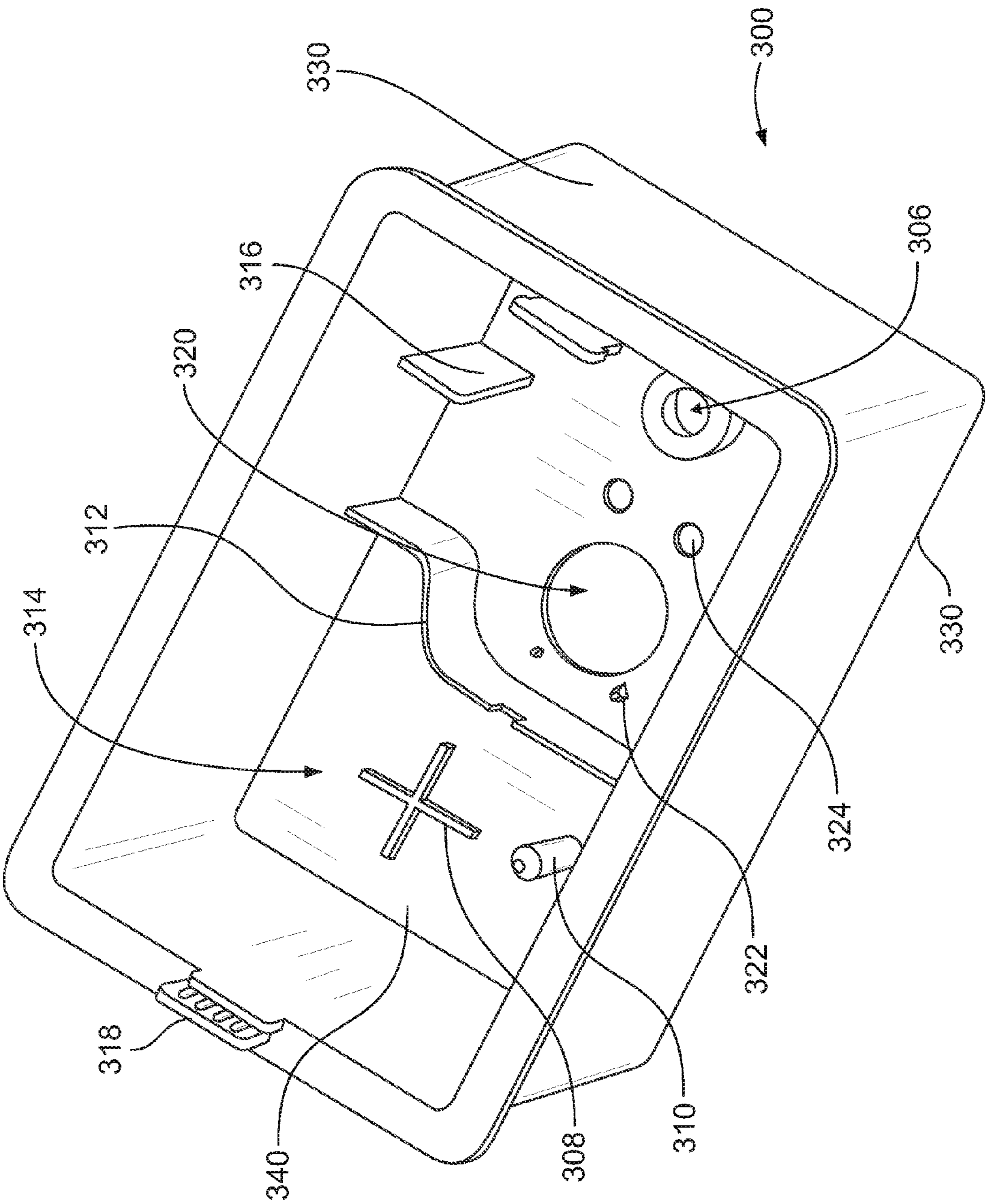


FIG. 6

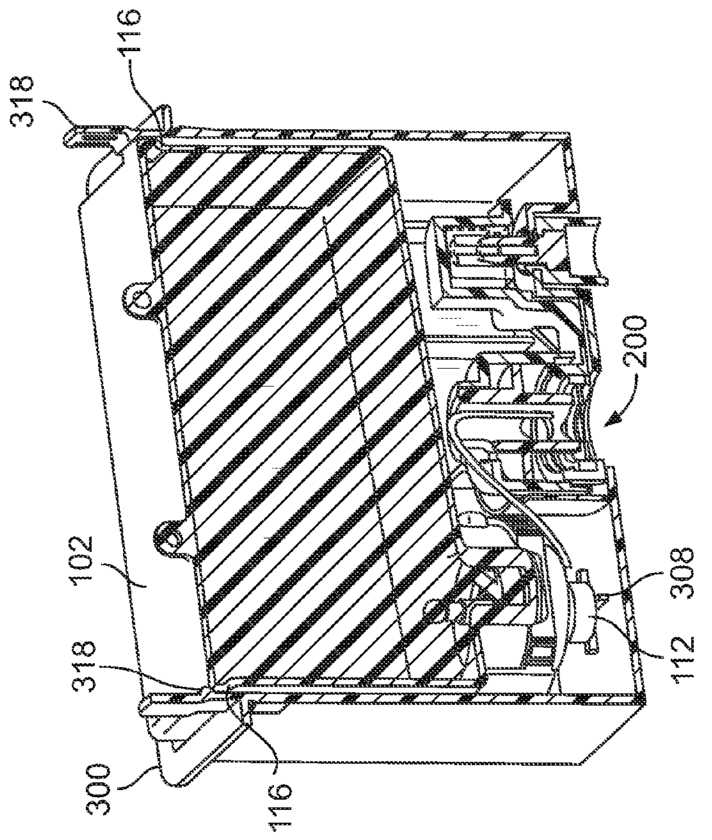
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FIG. 8

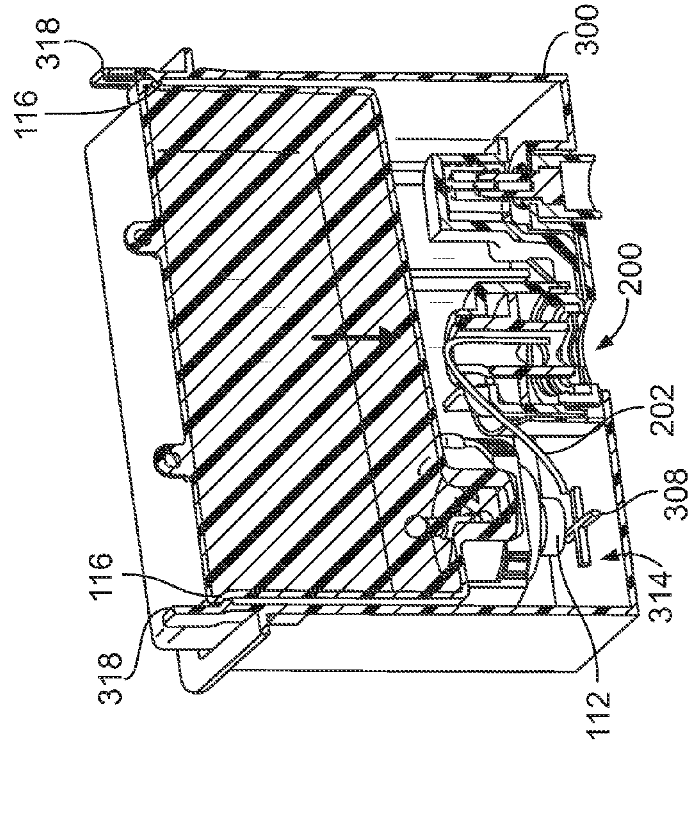
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FIG. 7

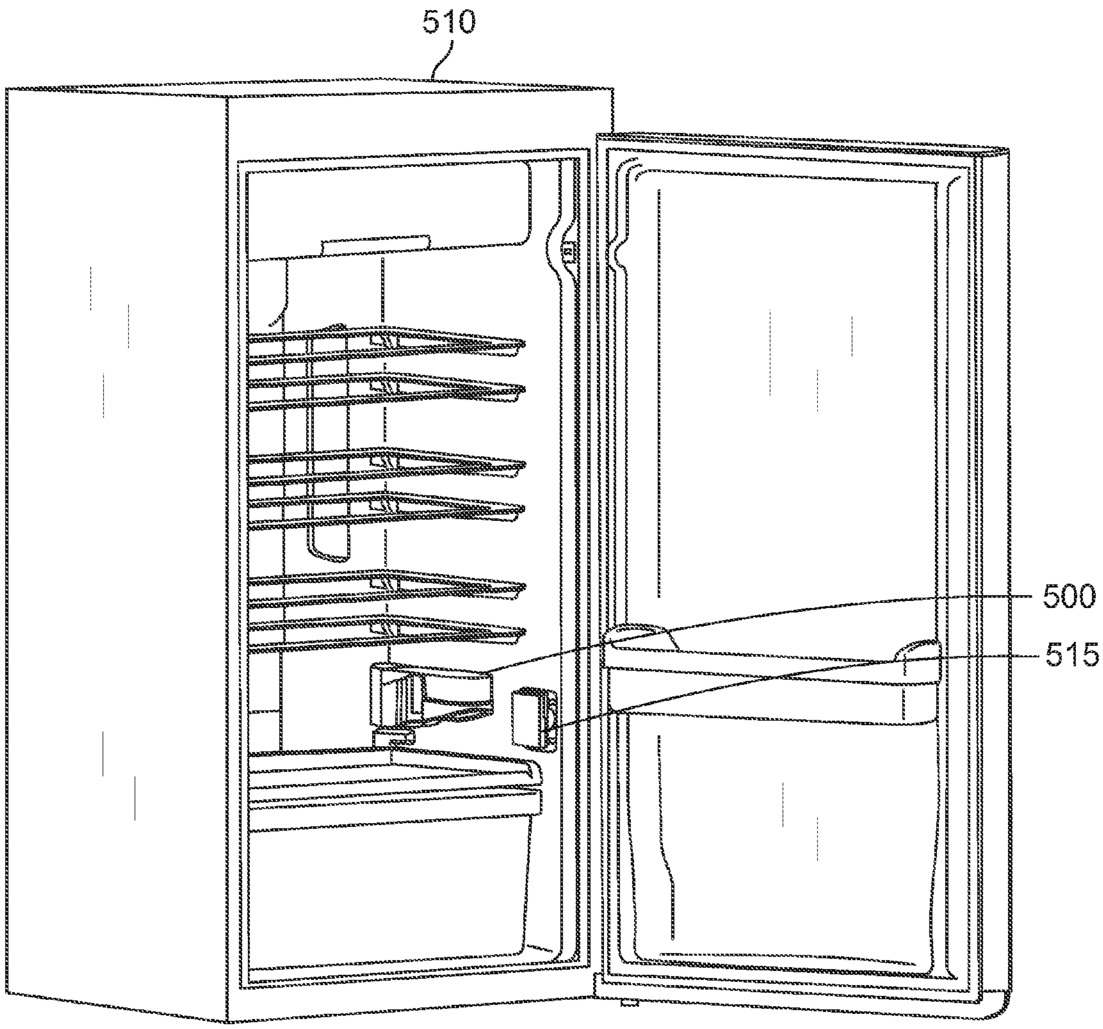



FIG. 9

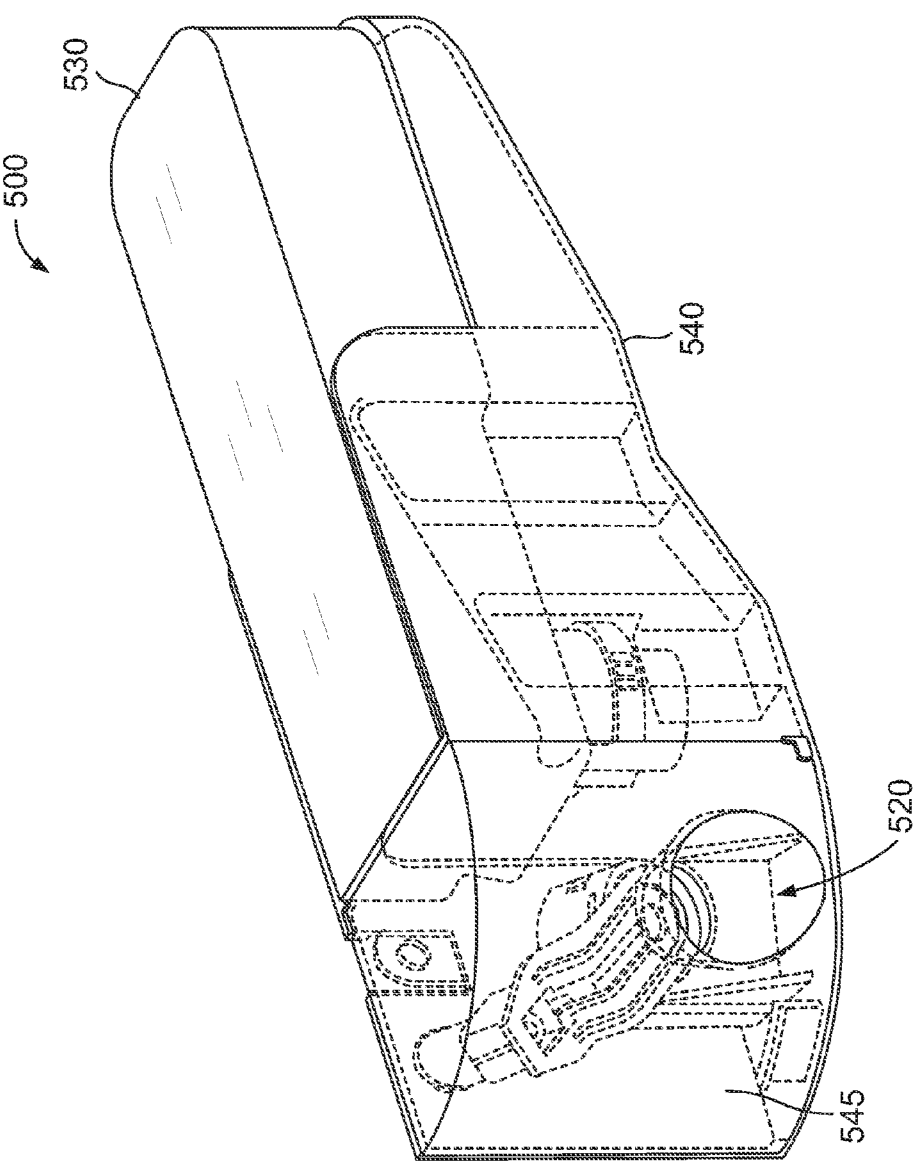



FIG. 10

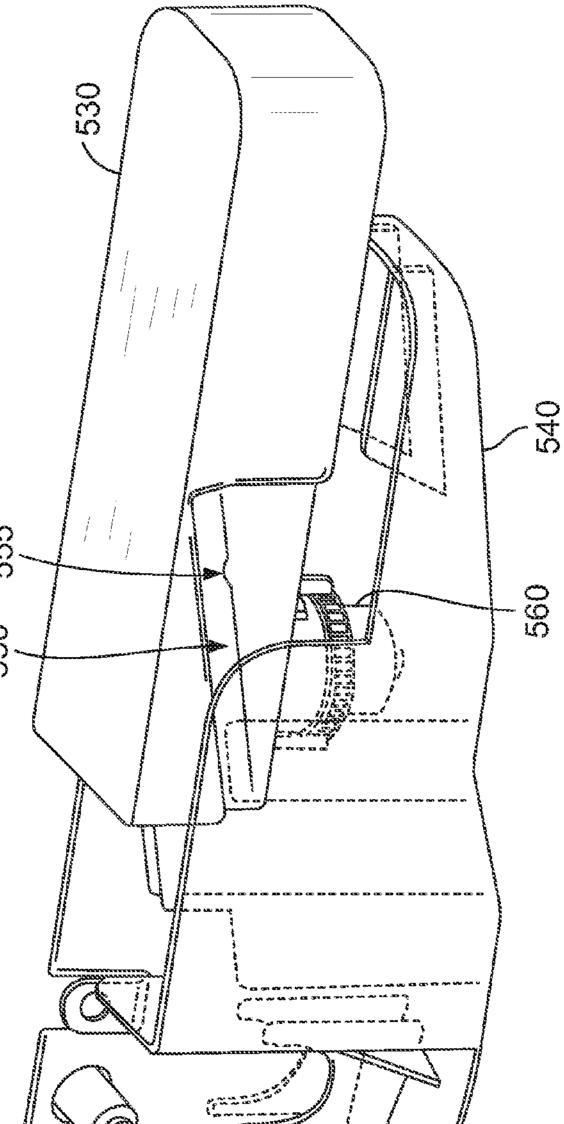



FIG. 11

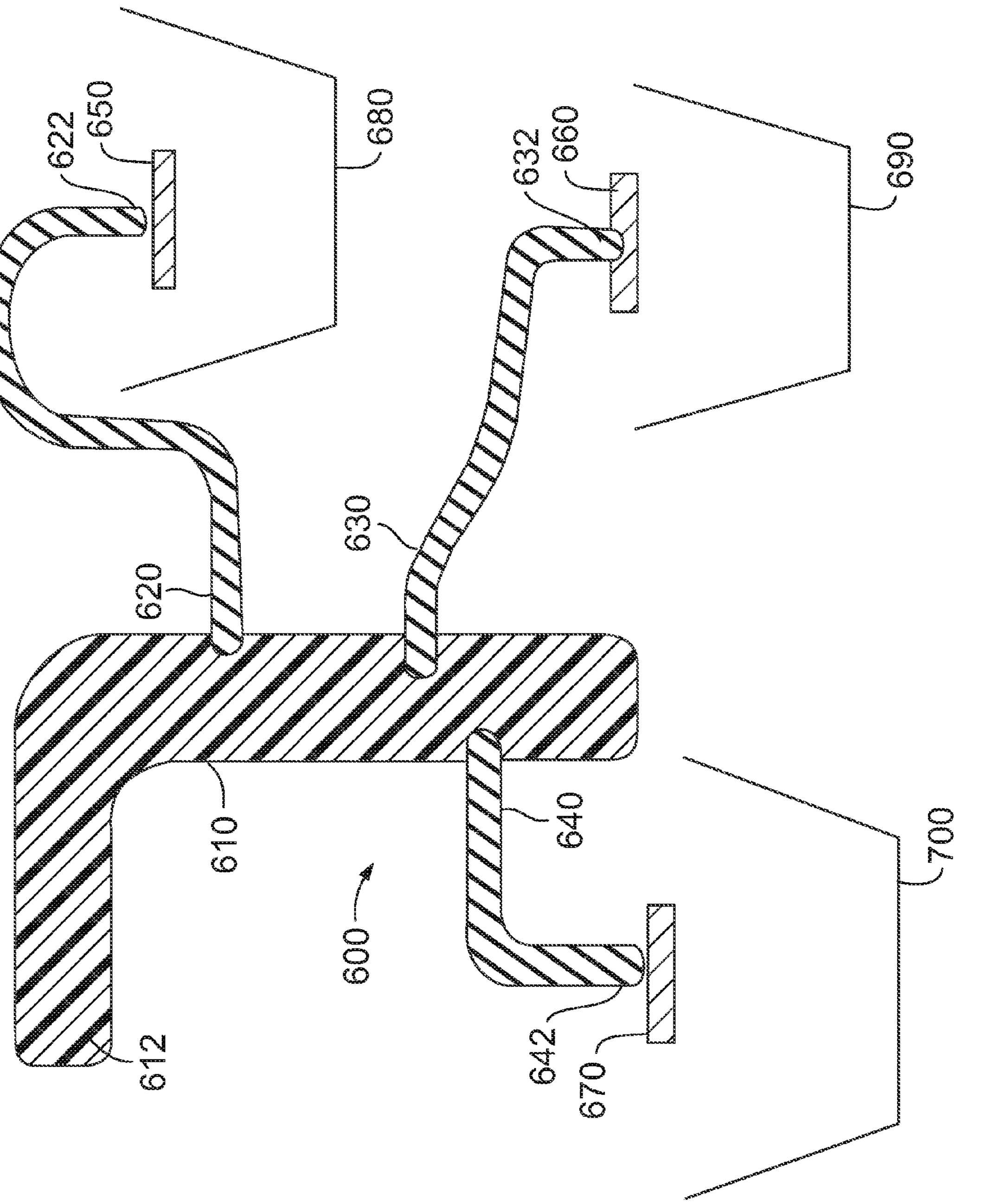
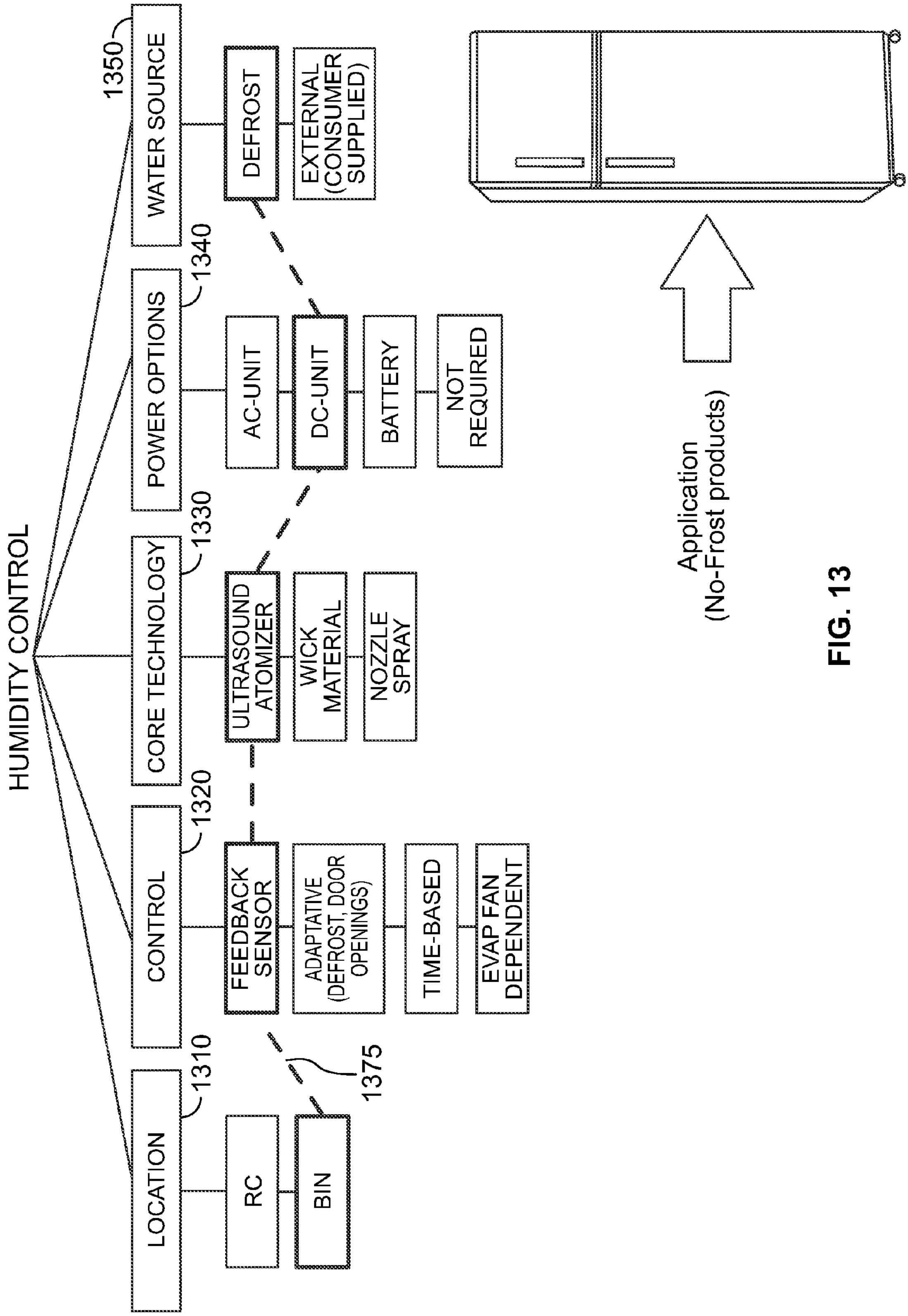



FIG. 12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RC
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CONTROL
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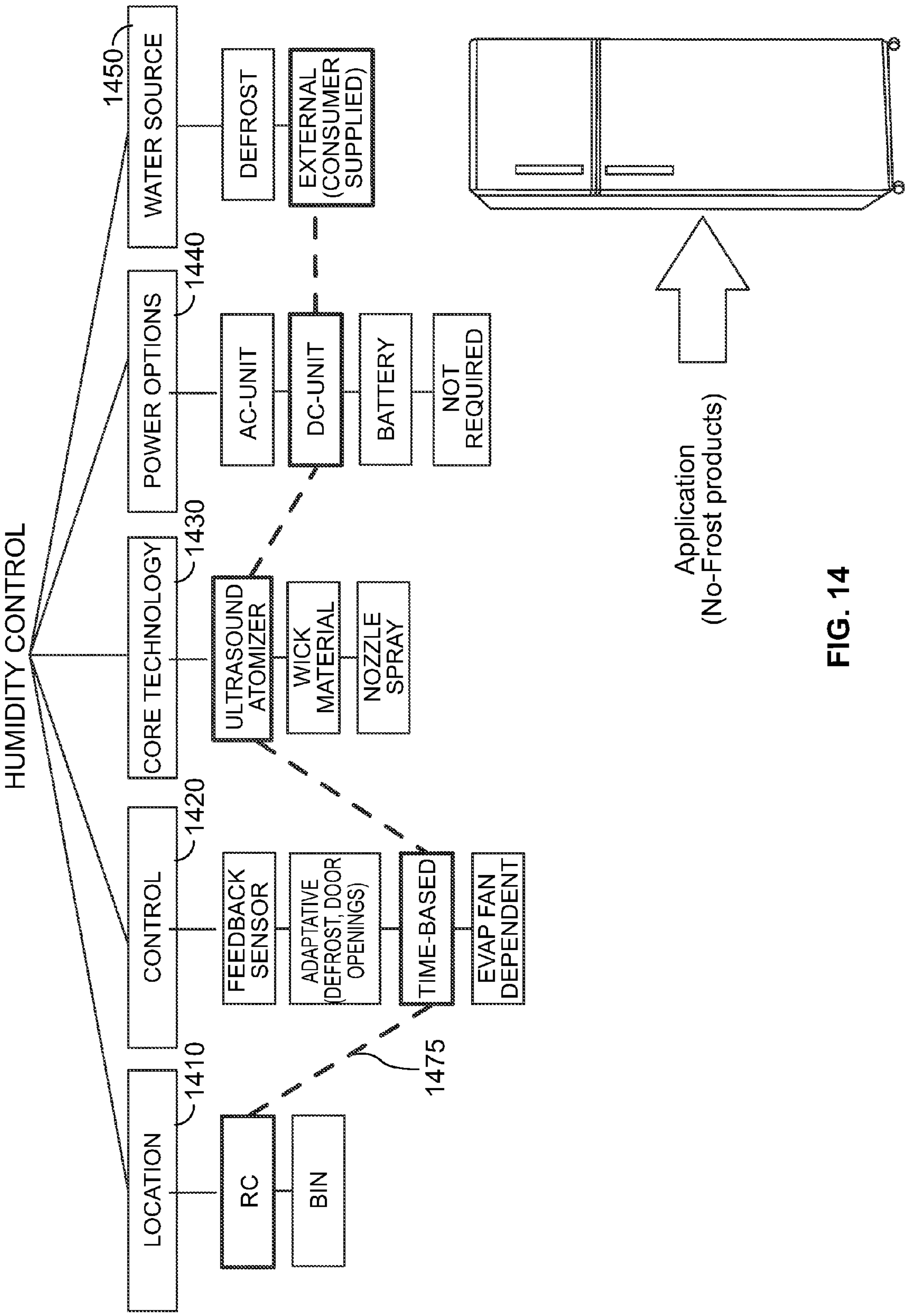
FEEDBACK SENSOR
ADAPTATIVE (DEFROST, DOOR OPENINGS)
TIME-BASED
EVAP FAN DEPENDENT
CORE TECHNOLOGY
1330
ULTRASOUND ATOMIZER
WICK MATERIAL
NOZZLE SPRAY
POWER OPTIONS
1340
AC-UNIT
DC-UNIT
BATTERY
NOT REQUIRED
WATER SOURCE
1350
DEFROST
EXTERNAL (CONSUMER SUPPLIED)
Application
(No-Frost products)

FIG. 13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CONTROL
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ADAPTATIVE (DEFROST, DOOR OPENINGS)
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EVAP FAN DEPENDENT
CORE TECHNOLOGY
1430
ULTRASOUND ATOMIZER
WICK MATERIAL
NOZZLE SPRAY
POWER OPTIONS
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AC-UNIT
DC-UNIT
BATTERY
NOT REQUIRED
WATER SOURCE
1450
DEFROST
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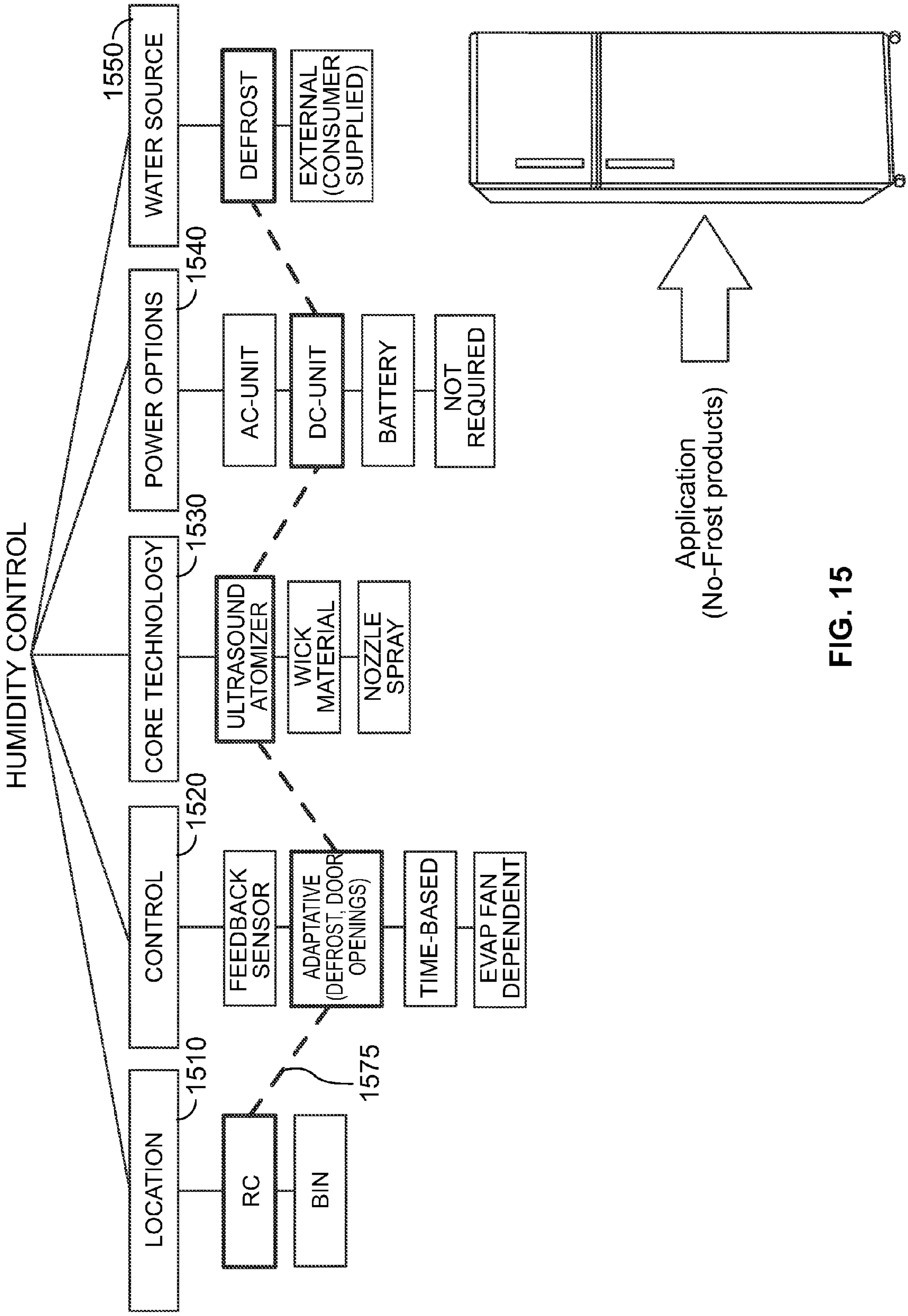
1475
Application (No-Frost products)

FIG. 14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CORE TECHNOLOGY
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ULTRASOUND ATOMIZER
WICK MATERIAL
NOZZLE SPRAY
POWER OPTIONS
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AC-UNIT
DC-UNIT
BATTERY
NOT REQUIRED
WATER SOURCE
1550
DEFROST
EXTERNAL (CONSUMER SUPPLIED)
1575
Application (No-Frost products)

FIG. 15