

FIG. 1

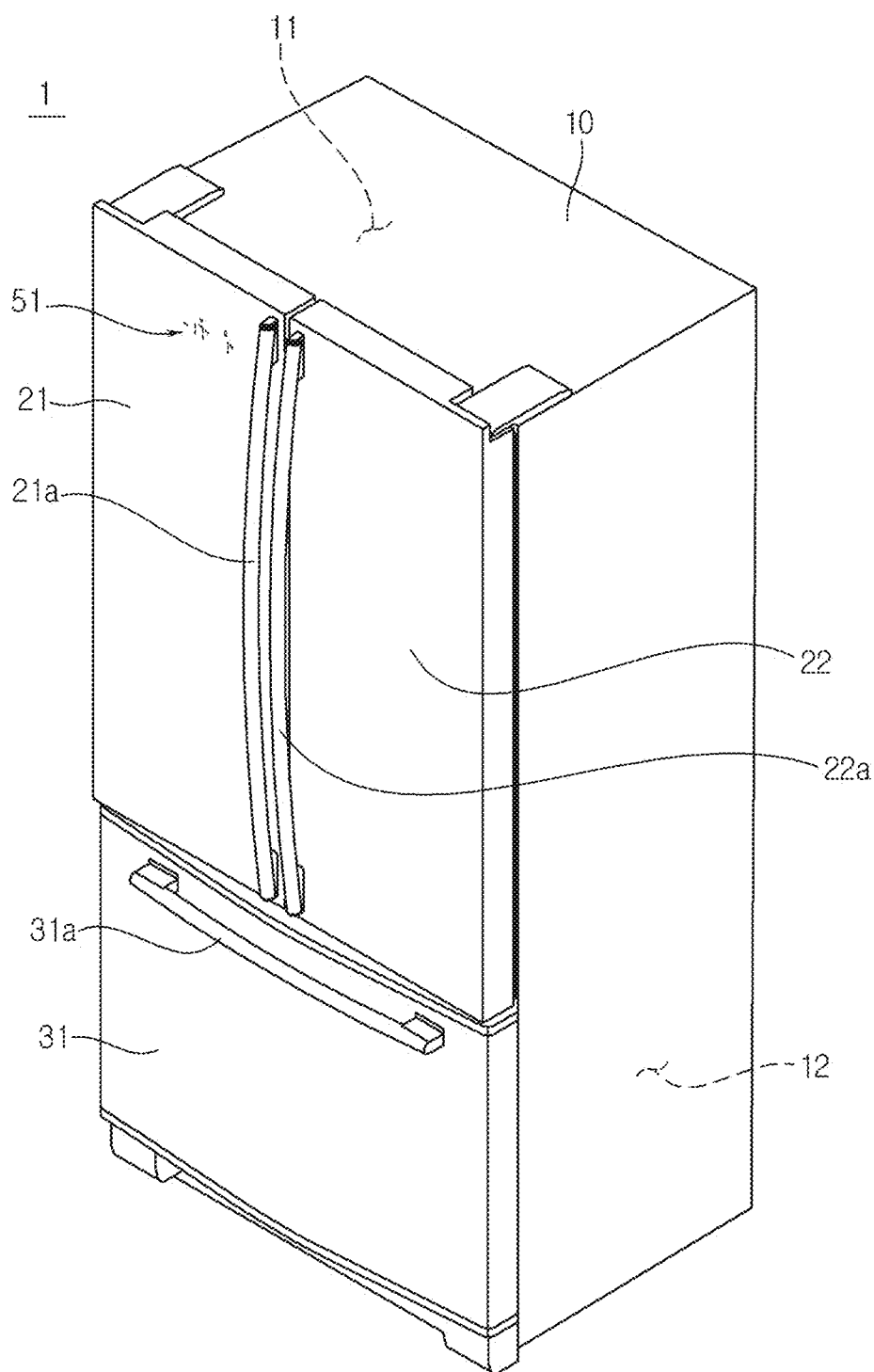


FIG. 2

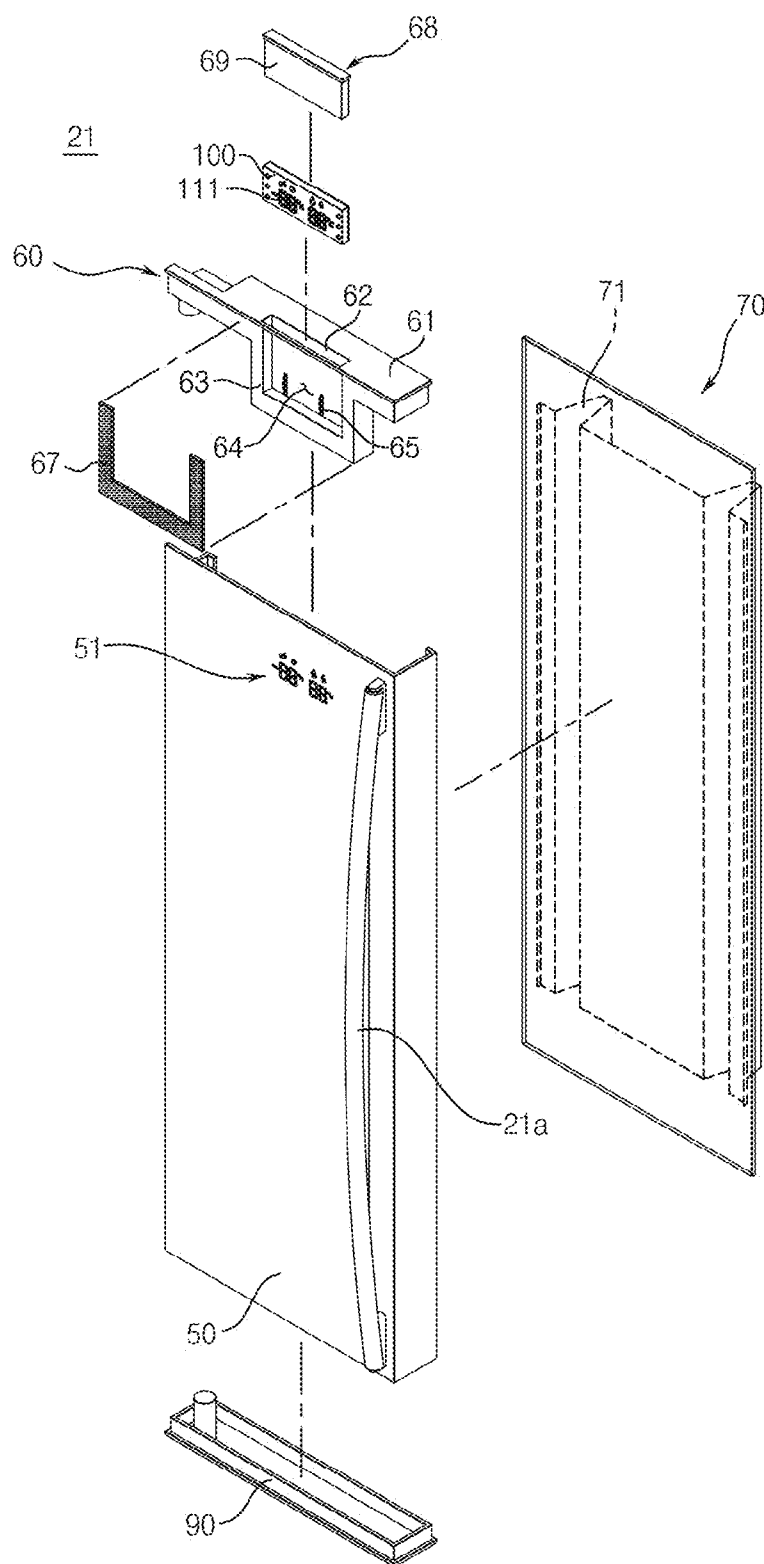


FIG. 3

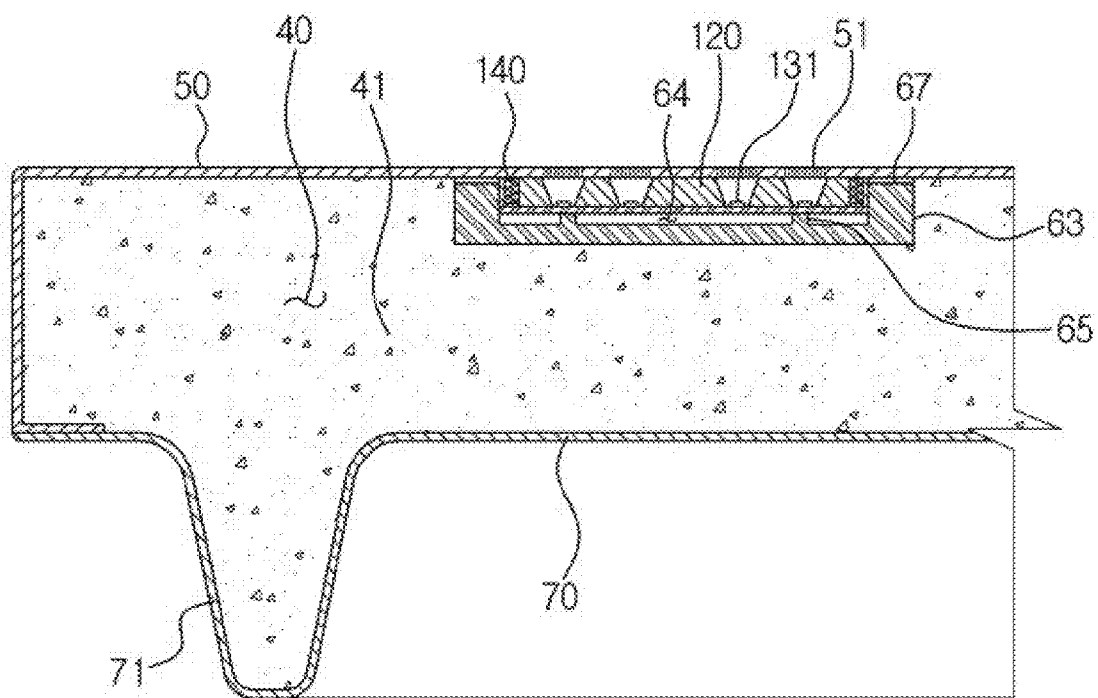


FIG. 4

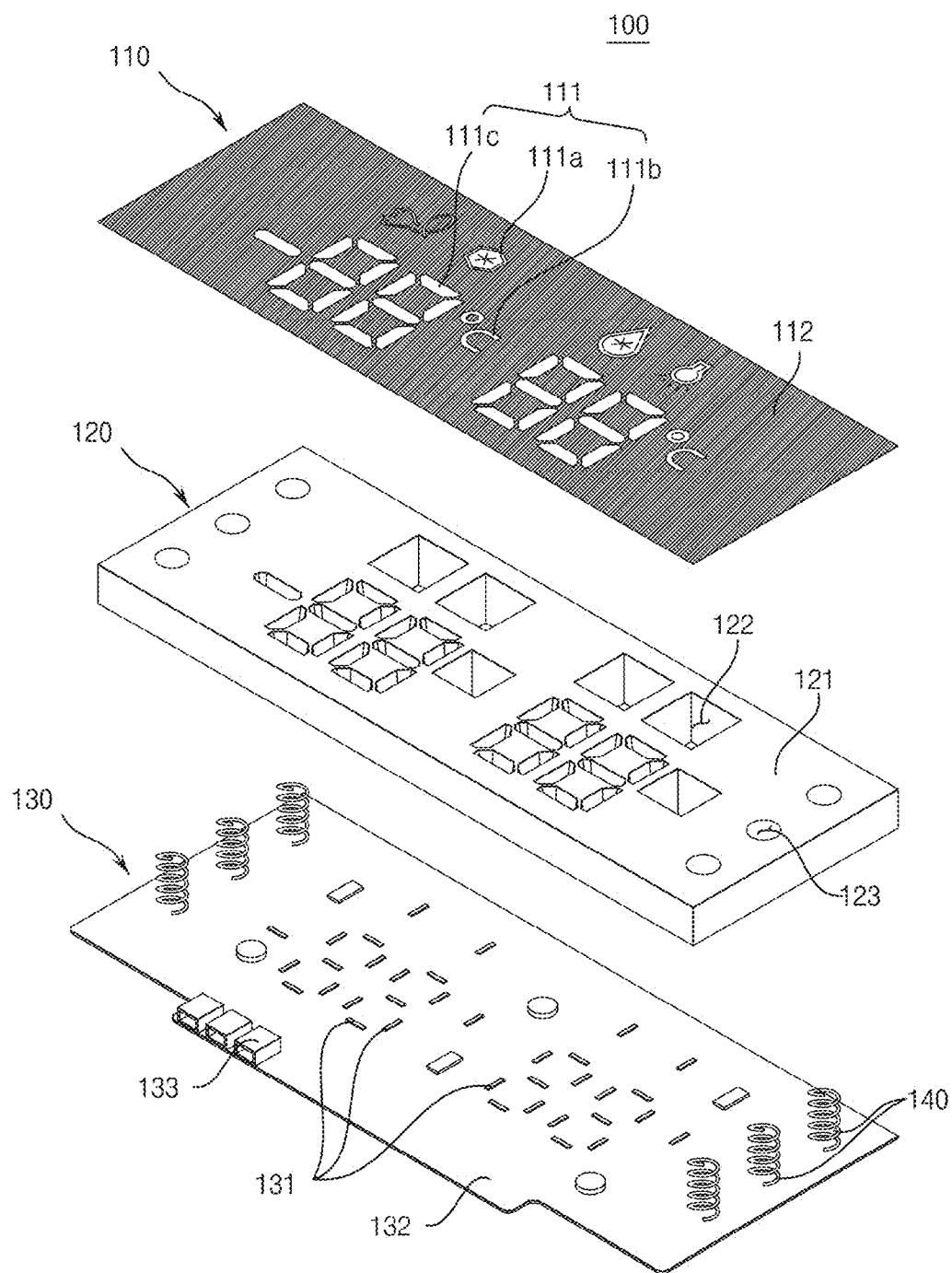


FIG. 5

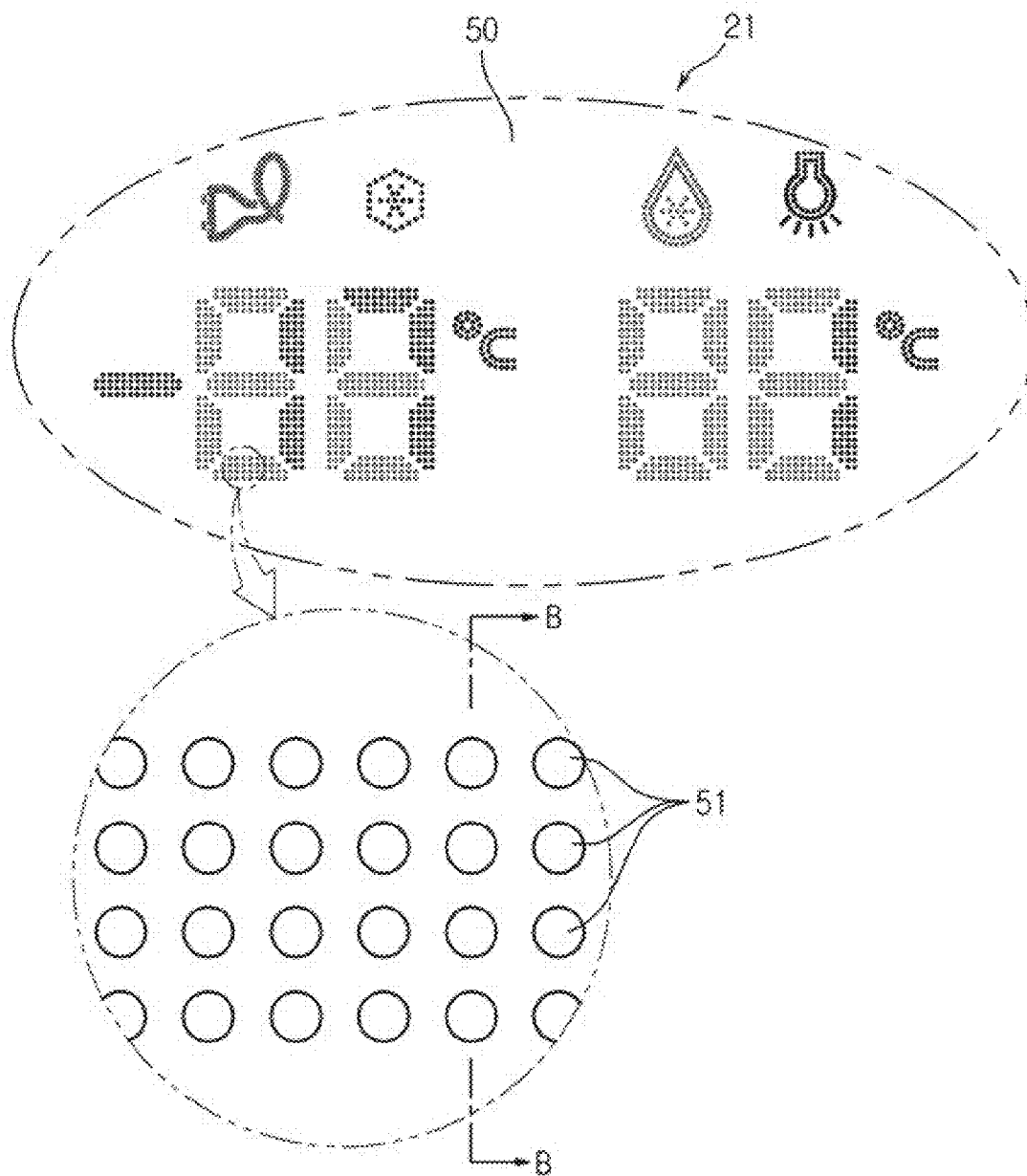


FIG. 6

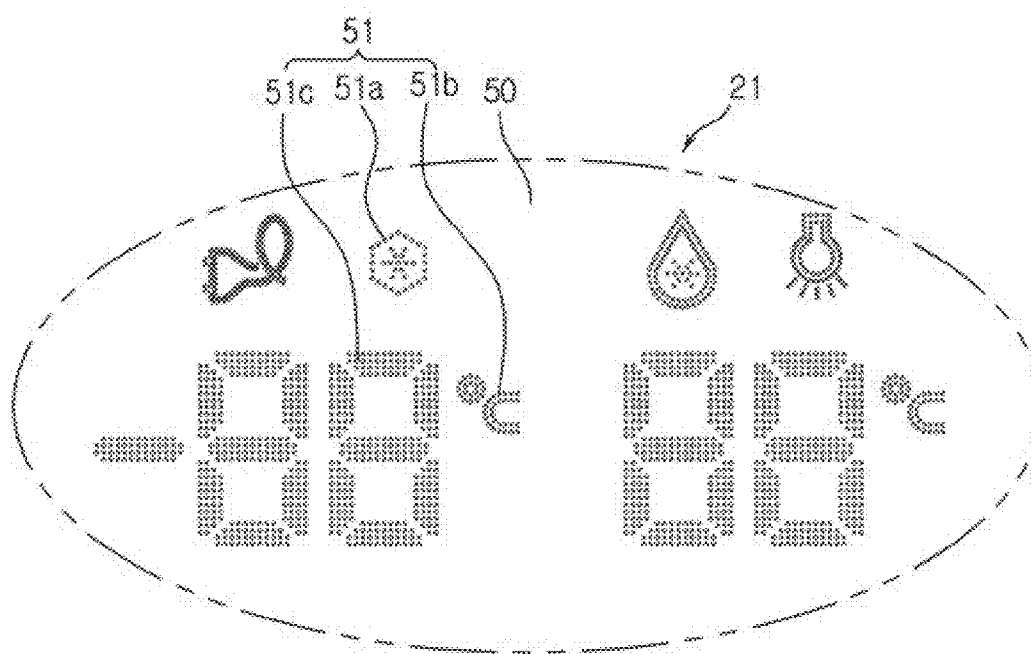


FIG. 7

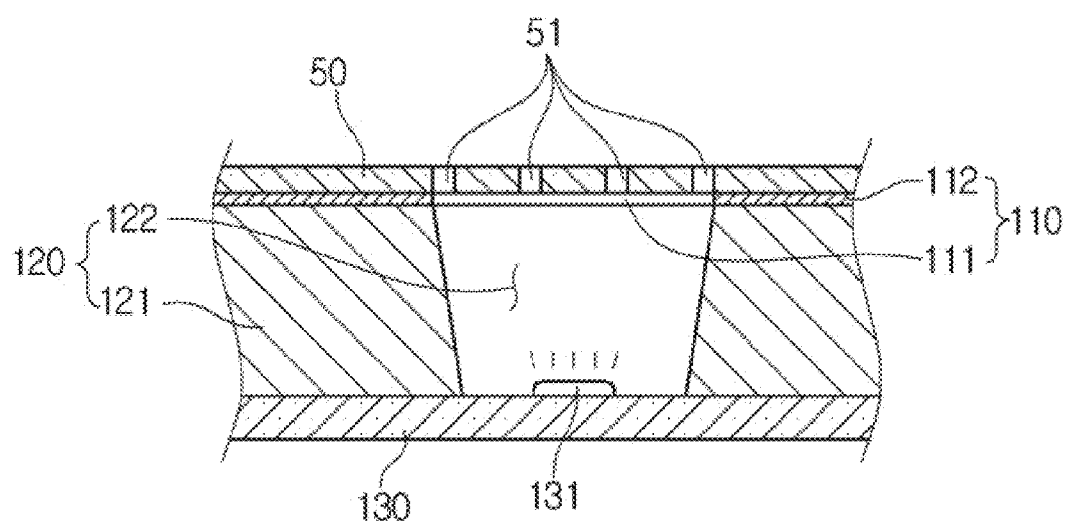
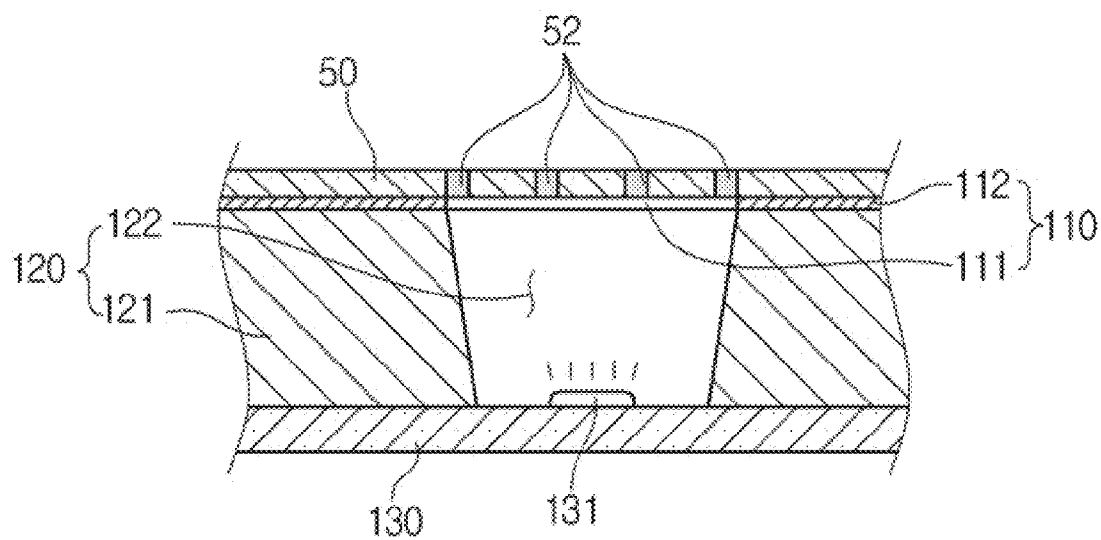


FIG. 8



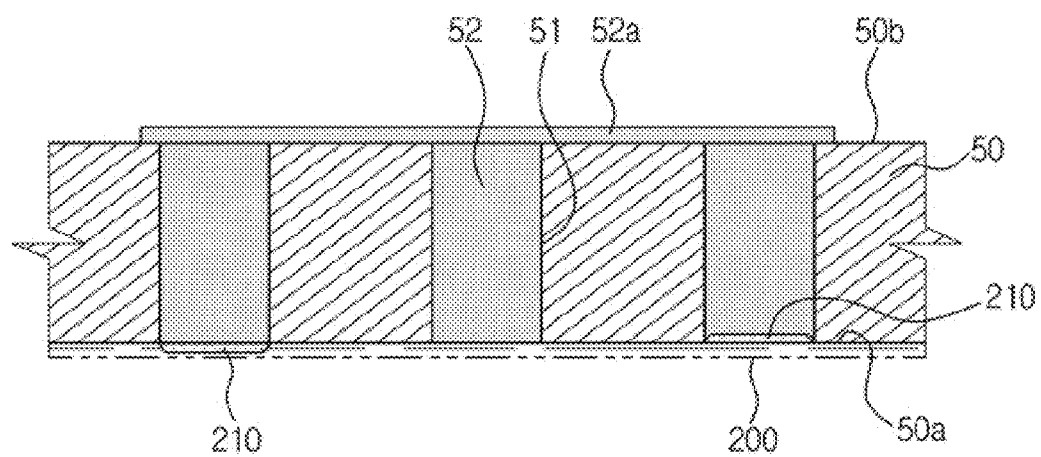


FIG. 10

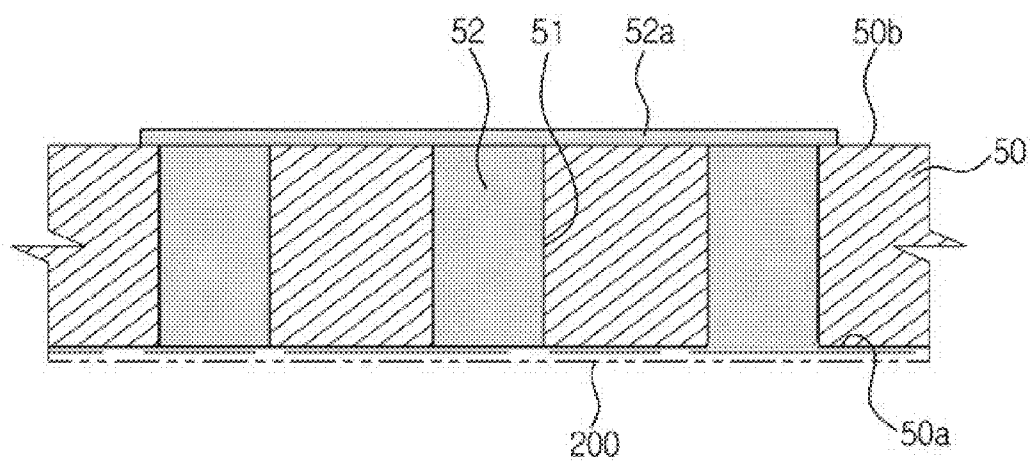


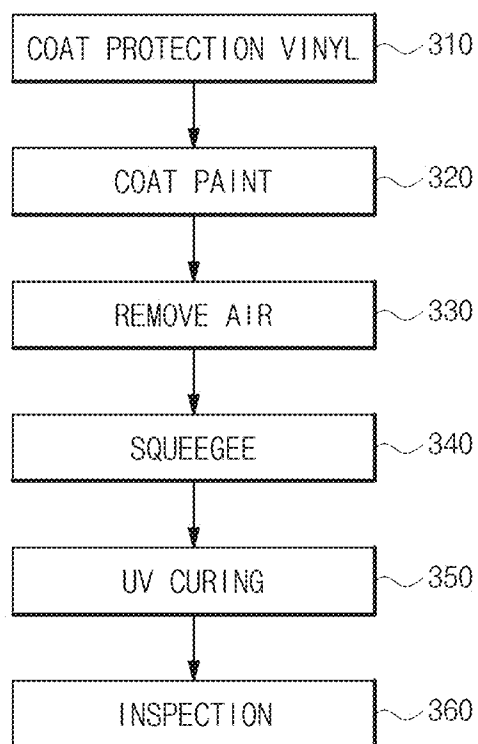
FIG. 11

FIG. 12

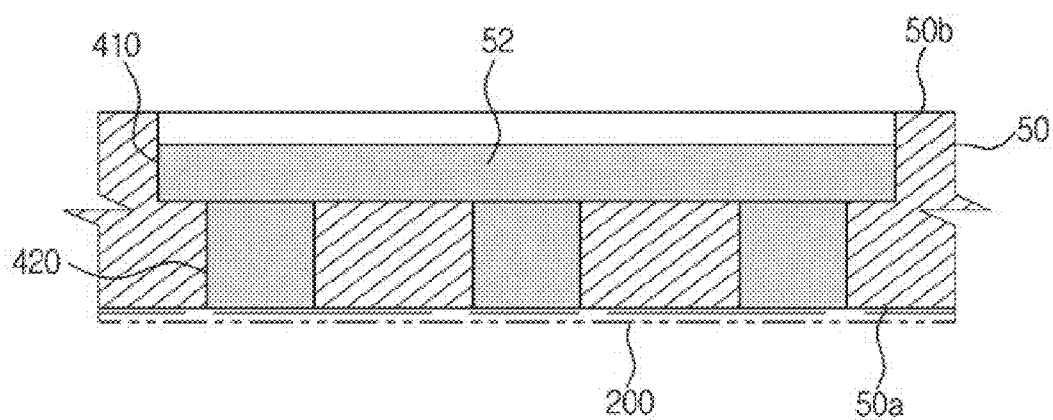


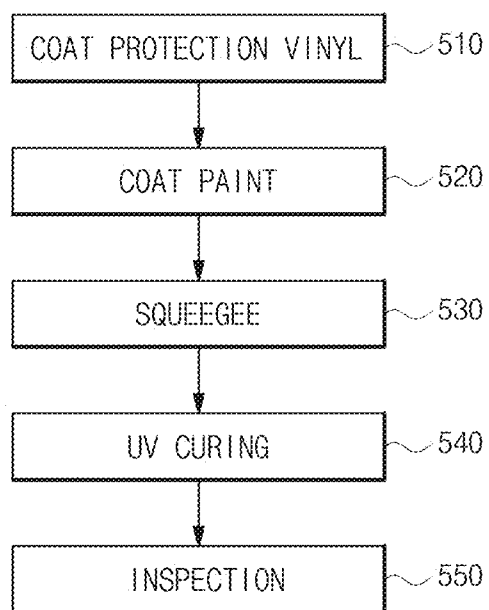
FIG. 13

FIG. 14

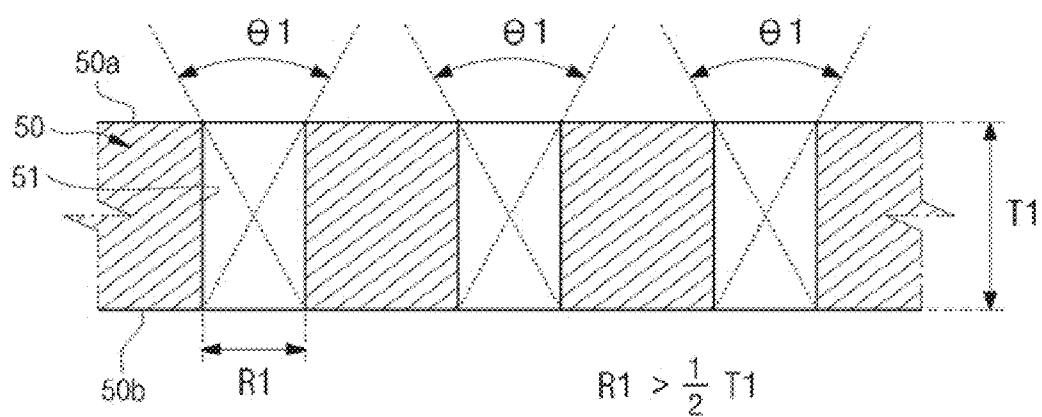
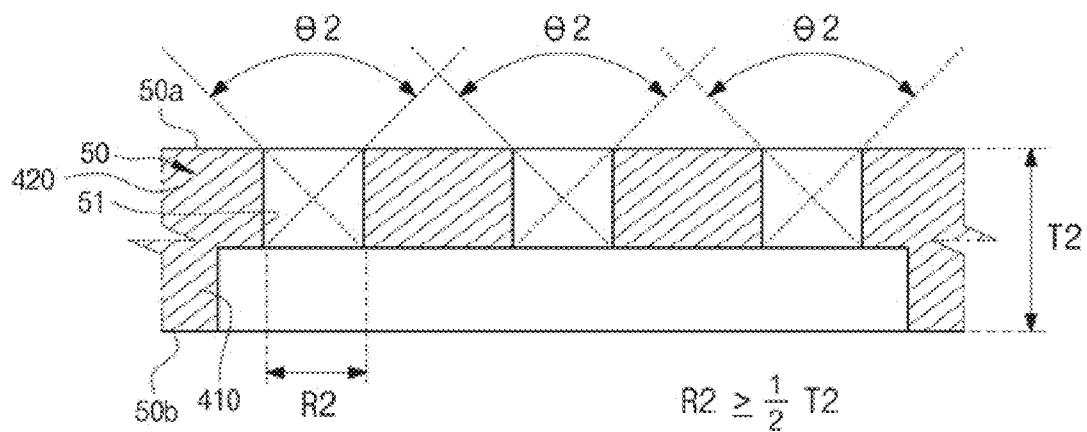


FIG. 15



REFRIGERATOR AND MANUFACTURING METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority benefit of Korean Patent Application No. 10-2014-0001655, filed on Jan. 7, 2014 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND

[0002] 1. Field

[0003] The following description relates to a refrigerator having a display unit provided at a door.

[0004] 2. Description of the Related Art

[0005] In general, a refrigerator is a home appliance which includes a storage chamber configured to store food and a cold air supplying device configured to supply cold air to the storage chamber, which keeps food fresh. The storage chamber is opened and closed by a door, and a display unit configured to display operation information of the refrigerator or to receive operation commands of the refrigerator is provided at the door.

[0006] There is a refrigerator in which the display unit may be hidden in the door in order to improve an exterior appearance thereof. At this time, a front plate of the door is formed of a tempered glass material or a transparent resin material, such that the information displayed on the display unit may be viewed through the front plate.

SUMMARY

[0007] Therefore, it is an aspect of the present disclosure to provide a door of a refrigerator, which has a front plate thereof formed of a steel plate and in which a display unit is hidden.

[0008] It is an aspect of the present disclosure to provide a door of a refrigerator, in which information displayed on the display unit may be normally viewed through through-holes formed in the front plate, even when the refrigerator is viewed obliquely.

[0009] It is an aspect of the present disclosure to provide a method of manufacturing a door of a refrigerator, which may prevent generation of unfilled portions and bubbles when filling the through-holes with a filler member.

[0010] Additional aspects of the disclosure will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the disclosure.

[0011] In accordance with an aspect of the present disclosure, a refrigerator includes a main body, a storage chamber formed in the main body, and a door configured to open and close the storage chamber, wherein the door includes a front plate configured to form a front surface and side surfaces of the door, a rear plate coupled to a rear portion of the front plate, an upper cap coupled to an upper portion of the front plate, a lower cap coupled to a lower portion of the front plate, a foaming space sealed by the front plate, the rear plate, the upper cap, and the lower cap, an insulation material foamed into the foaming space, and a display unit including a display part having a desired shape to be turned on and off, and disposed at a rear side of the front plate, and through-holes having a diameter larger than a half of a thickness of the front plate and a shape corresponding to a shape of the display part of the display unit are formed in the front plate.

[0012] The display unit may include a printed circuit board on which at least one LED emitting light is mounted, a guide part configured to guide the light of the at least one LED, and a cover sheet attached to a front surface of the guide part and having the display part.

[0013] The diameter of each through-hole may be from approximately 0.1 mm to approximately 0.5 mm.

[0014] The thickness of the front plate may be approximately 0.6 mm or less.

[0015] The front plate may include a half-cut portion formed by half-cutting, and a through-hole portion in which the through-holes are formed.

[0016] When the front plate is half-cut, the diameter of each through hole may be formed to be larger than or the same as the half of the thickness of the front plate.

[0017] The door may further include a supporting member configured to support the display unit.

[0018] The door may further include a guide member configured to press the display unit to a front side so that the display unit is in close contact with the front plate.

[0019] The door may further include a sealing member provided between the front plate and the supporting member to prevent an insulation foaming agent from permeating the display unit.

[0020] The door may further include a filler member filled in the through-holes to prevent foreign substances from permeating the through-holes.

[0021] The filler member may have a viscosity of 2000 centipoise (cP) or more.

[0022] In accordance with an aspect of the present disclosure, a method of manufacturing a refrigerator which includes a main body, a storage chamber, and a door configured to open and close the storage chamber and having a front plate formed of a steel plate includes forming through-holes having a diameter larger than a half of a thickness of the front plate in the front plate, and filling a filler member in the through-holes to prevent foreign substances from permeating the through-holes.

[0023] The forming of the through-holes having the diameter larger than the half of the thickness of the front plate in the front plate may include half-cutting the front plate to form a half-cut portion and a through-hole portion, and forming through-holes having a diameter larger than or the same as the half of the thickness of the front plate.

[0024] The filler member may have a viscosity of 2000 centipoise (cP) or more.

[0025] The filling of the filler member in the through-holes may include attaching a protection vinyl on a front surface of the front plate, and coating inner portions of the through-holes with the filler member through a rear surface of the front plate on which the protection vinyl is not attached.

[0026] The protection vinyl may be formed of a polyethylene material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] These and/or other aspects of the disclosure will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

[0028] FIG. 1 is a view of an exterior of a refrigerator in accordance with an embodiment of the present disclosure;

[0029] FIG. 2 is an exploded perspective view schematically illustrating the refrigerator of FIG. 1;

[0030] FIG. 3 is a cross-sectional view illustrating the refrigerator of FIG. 1;

[0031] FIG. 4 is a view illustrating a state in which a display unit of the refrigerator of FIG. 1 is disassembled;

[0032] FIG. 5 is an enlarged view illustrating the vicinity of through-holes of a front plate of the refrigerator of FIG. 1;

[0033] FIG. 6 is an enlarged view illustrating the vicinity of the through-holes of the front plate in a state in which the display unit of the refrigerator of FIG. 1 is turned off;

[0034] FIG. 7 is a cross-sectional view taken along a line B-B of FIG. 5;

[0035] FIG. 8 is a view illustrating a state in which the through-holes in FIG. 7 are filled with a filler member;

[0036] FIG. 9 is a view illustrating a state in which an error is generated while the through-holes are coated with the filler member in accordance with the embodiment of the present disclosure;

[0037] FIG. 10 is a view illustrating a state in which air is removed from the through-holes of FIG. 9 using a vacuum apparatus;

[0038] FIG. 11 is a flow chart illustrating a process of filling the through-holes with the filler member in accordance with an embodiment of the present disclosure;

[0039] FIG. 12 is a view illustrating a state in which the through-holes are coated with the filler member in accordance with the embodiment of the present disclosure;

[0040] FIG. 13 is a flow chart illustrating a process of filling the through-holes with the filler member in accordance with an embodiment of the present disclosure;

[0041] FIG. 14 is a view illustrating a relationship between a thickness of the front plate of the refrigerator and a size of each of the through-holes in accordance with the embodiment of the present disclosure; and

[0042] FIG. 15 is a view illustrating the relationship between the thickness of the front plate of the refrigerator and the size of each of the through-holes when the front plate of the refrigerator is half-cut in accordance with the embodiment of the present disclosure.

DETAILED DESCRIPTION

[0043] Reference will now be made in detail to the embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings.

[0044] FIG. 1 is a view of an exterior of a refrigerator in accordance with an embodiment of the present disclosure.

[0045] Referring to FIG. 1, a refrigerator 1 includes a main body 10, storage chambers 11 and 12 provided in the main body 10, and a cold air supplying device (not shown) configured to supply cold air to the storage chamber.

[0046] The storage chambers 11, 12 may be partitioned into an upper refrigerator chamber 11 and a lower freezer chamber 12. The refrigerator chamber 11 may store food at a temperature of approximately 0° C. The refrigerator chamber 11 has a front surface which is opened to put in or take out food. The opened front surface may be opened and closed by a pair of doors 21 and 22 rotatably coupled to the main body 10. The pair of doors 21 and 22 may have handles 21a and 22a.

[0047] The freezer chamber 12 may store food at a sub-zero temperature. The freezer chamber 12 has a front surface which is opened to put in or take out food. The opened front surface may be opened and closed by a door 31 disposed to be slidable forward and backward. The door 31 may have a handle 31a.

[0048] A plurality of through-holes 51 configured to display operation information of the refrigerator may be provided in one 21 of the doors 21 and 22. The through-holes 51 may at least partially brighten or darken to display a specific image and thus may display the operation information of the refrigerator. The configuration of the through-holes 51 will be described below.

[0049] Meanwhile, as described above, the embodiment of the present disclosure is an FDR type refrigerator. However, the spirit of the present disclosure is not restricted by a type of the refrigerator, and may be applied to all kinds of refrigerators.

[0050] FIG. 2 is an exploded perspective view schematically illustrating the refrigerator of FIG. 1. FIG. 3 is a cross-sectional view illustrating the refrigerator of FIG. 1.

[0051] Referring to FIGS. 2 and 3, the door 21 includes a front plate 50 configured to form a front surface and both sides surfaces of the door 21, a rear plate 70 configured to be coupled to a rear surface of the front plate 50 and to form a rear surface of the door 21, and an upper cap 60 and a lower cap 90 configured to seal upper and lower ends of an internal space defined between the front plate 50 and the rear plate 70.

[0052] The handle 21a may be provided at the front plate 50. The front plate 50 may be formed of a metallic material such as steel, aluminum, an alloy, PCM, and VCM, for example. The front plate 50 may be formed by bending a single plate to form the front and both side surfaces of the door 21.

[0053] The front plate 50 may provide high strength and a luxurious feel due to the nature of the metallic material, compared to a tempered glass plate or a resin plate. The front plate 50 may have an enhanced appearance through a characteristic surface treatment of the metallic material.

[0054] That is, a hair line process, a mirror polishing process, a bead blast process or the like may be performed on a surface of the front plate 50. At this time, only one of the processes may be performed on the front plate 50.

[0055] Alternatively, all of the processes may be performed on the front plate 50. That is, the front plate 50 may have all of hair line patterns, gloss, and beads. At this time, the mirror polishing process, the hair line process, and the bead blast process may be performed in turn.

[0056] The rear plate 70 may be vacuum-molded from a resin material. The rear plate 70 may have a dike 71 protruding rearward so that a door pocket may be installed.

[0057] The upper cap 60 and the lower cap 90 may be injection-molded from the resin material. The front plate 50, the rear plate 70, the upper cap 60, and the lower cap 90 may be temporarily assembled through a fitting structure or an adhesive tape, and then an insulation foaming agent may be injected and foamed in the internal space thereof.

[0058] That is, a foaming space 40 in which an insulation material 41 is foamed is formed between the front plate 50 and the rear plate 70. The insulation material 41 is for insulating the storage chamber 11, and urethane may be used for the insulation material 41. If the forming process of the insulation foaming agent in the foaming space 40 is completed, the front plate 50, the rear plate 70, the upper cap 60, and the lower cap 90 may be firmly coupled.

[0059] Meanwhile, a display unit 100 configured to display operation information of the refrigerator or receive operation commands of the refrigerator is provided in the door 22. The display unit 100 may be provided to be in close contact with the rear surface of the front plate 50.

[0060] The display unit 100 may be received and supported in the upper cap 60 coupled to an upper portion of the front plate 50. That is, the upper cap 60 of the door 22 may serve to support the display unit 100. However, the display unit 100 may be provided to be supported by a separate supporting member other than the upper cap 60.

[0061] The display unit 100 may be fixed so that a display part 111 is located at a position corresponding to the through-holes of the front plate 50.

[0062] The upper cap 60 includes a body part 63, and a receiving space 64 configured to be formed in the body part 63 so that a front surface thereof is opened to receive the display unit 100. That is, the receiving space 64 has a groove shape formed at the front side of the body part 63. Further, an insertion groove 62 is formed in an upper surface 61 of the upper cap 60 to insert the display unit 100 into the receiving space 64.

[0063] The front surface of the receiving space 64 is opened to allow light of the display part 111 of the display unit 100 to be emitted to the through holes 51 of the front plate 50.

[0064] A guide member 65 configured to press the display unit 100 frontward so that the display unit 100 is in close contact with the front plate 50 may be provided in the receiving space 64. The guide member 65 may protrude frontward from the body part 63. The guide member 65 may have an overall gentle curve to guide movement of the display unit 100 inserted downward from an upper side thereof. The guide member 65 may be configured as an elastic member having an elastic force.

[0065] When the insulation foaming agent is injected and foamed in the foaming space 40, the insulation foaming agent should not permeate the receiving space 64. To this end, the upper cap 60 is disposed so that the front surface of the body part 61 is in close contact with the rear surface of the front plate 50.

[0066] As the body part 61 of the upper cap 60 is in close contact with the rear surface of the front plate 50, the receiving space 64 defined in the body part 61 may be separately partitioned from the foaming space 40. That is, the top and bottom and left and right sides and the rear side of the receiving space 64 may be covered by the body part 61, and the front side thereof may be covered by the rear surface of the front plate 50.

[0067] A sealing member 67 may be provided at the front surface of the body part 61 to hermetically secure of the foaming space 40. The sealing member 67 may include an elastic material such as rubber. When the upper cap 60 is coupled to the upper portion of the front plate 50, the sealing member 67 may be in close contact with the rear surface of the front plate 50 and thus may hermetically seal the receiving space 64 as an independent space.

[0068] The upper cap 60 may further include a cover 68 configured to seal the insertion groove 62 after the display unit 100 is inserted into the receiving space 64. The cover 68 may have a pressing part 69 configured to press the display unit 100 and to prevent the display unit 100 from moving up and down.

[0069] In the embodiment, the receiving space 64 configured to receive the display unit 100 and the body part 63 configured to separately partition the receiving space 64 from the foaming space 40 are integrally formed at the upper cap 60, but the present disclosure is not limited thereto. The

receiving space 64 and the body part 63 may be separately provided from the upper cap 60 and then fixedly coupled to the upper cap 60.

[0070] By such structure, the display unit 100 may be installed in the door 21, and the display unit 100 is prevented from being exposed to the outside of the door. However, when particular information is displayed through the display unit 100, the information may be displayed to the outside through the plurality of through-holes 51 of the front plate 50.

[0071] FIG. 4 is a view illustrating a state in which the display unit of the refrigerator of FIG. 1 is disassembled.

[0072] Referring to FIG. 4, the display unit 100 may include a cover sheet 110, a light source 130 configured to emit light, and a guide part 120 configured to guide the light emitted from the light source 130 to the display part 111.

[0073] The cover sheet 110 may include the display part configured to brighten or darken and thus to display the operation information of the refrigerator, and a counteraction part 112 configured to be maintained in a relatively dark state. The display part 111 may be formed of a transparent material or a fluorescent material, and the counteraction part 112 may be formed of an opaque material.

[0074] The cover sheet 110 may be separately provided from the guide part 120 and then adhered to one surface of the guide part 120.

[0075] The display part 111 may be configured with one of a pattern 111a, a character 111b, a numeral and a symbol indicating the operation information of the refrigerator, and one of segments 111c partially forming the pattern 111a, the character 111b, the numeral and the symbol, or the combination thereof. Therefore, when the light illuminates the cover sheet 110, the pattern 111a, the character 111b, the numeral, the symbol or the like brightens and thus the operation information of the refrigerator may be displayed.

[0076] The light source 130 may include LEDs 131 and a printed circuit board 132 on which the LEDs 131 are mounted, and a connector 133 to which a power source is connected. The plurality of LEDs 131 may be provided to be independently controlled.

[0077] The guide part 120 guides the light emitted from the LEDs 131 to the cover sheet 110. The guide part 120 includes a body part 121 formed of a material reflecting the light, and a guide hole 122 configured to pass through the body part 121. As illustrated in FIGS. 7 and 8, the guide hole 122 may be formed so that a size thereof is gradually increased from the LEDs 131 toward the cover sheet 110.

[0078] Meanwhile, the display unit 100 may further include an input part configured to receive the operation commands of the refrigerator. The input part may be configured in a capacitive touch sensing manner.

[0079] As an example, the input part may include a spring-shaped touch button 140, and a sensor (not shown) configured to measure a change in an electric charge according to the user's touch. The touch button 140 is mounted on the printed circuit board 132 to pass through a button hole 123 of the guide part 120 and then to be in contact with the cover sheet 110.

[0080] When a user touches a particular area of the front plate corresponding to a position of the touch button 140, the sensor may measure the change in the electric charge flowing through the touch button 140 and sense whether the user touches. The input part may employ various methods such as a resistive method, a dome switch method, and a proximity sensing method, for example.

[0081] Meanwhile, the display part **111** may be integrally formed with the guide part **120**. In this case, the cover sheet may not be separately provided at the display unit **100**.

[0082] FIG. **5** is an enlarged view illustrating the vicinity of through-holes of the front plate of the refrigerator of FIG. **1**. FIG. **6** is an enlarged view illustrating the vicinity of the through-holes of the front plate in a state in which the display unit of the refrigerator of FIG. **1** is turned off. FIG. **7** is a cross-sectional view taken along a line B-B of FIG. **5**. FIG. **8** is a view illustrating a state in which the through-holes in FIG. **7** are filled with a filler member.

[0083] Referring to FIGS. **5** to **8**, when the particular information is displayed on the display unit hidden in the door **21**, the information may be displayed through the plurality of through-holes **51** formed in the front plate **50** of the door **21**, as illustrated in FIG. **5**.

[0084] Each of the through-holes **51** formed in the front plate **50** may have a diameter of approximately 0.1 mm to approximately 0.5 mm, and a gap between the through-holes **51** may be approximately 0.3 mm to approximately 1.5 mm. The through-holes **51** may be observed by the user's naked eye. At this time, it is assumed that a thickness of the front plate **50** is approximately 0.6 mm.

[0085] The through-holes **51** may be formed through an etching process or a laser drilling process. When the size of the through-hole **51** is within a range of approximately 0.3 mm to approximately 0.4 mm, an etching process having high accuracy may be suitable.

[0086] When the size of the through-hole **51** is approximately 0.2 mm or less, the laser drilling process may be used, even though slight thermal deformation or burrs may be generated. Meanwhile, in the case of a relatively small shape, if the size of the through-hole **51** is great, discrimination thereof is reduced, and thus the through-hole **51** may have a size of approximately 0.2 mm or less.

[0087] As an example, in FIG. **3**, the size of each through-hole **51c** corresponding to the segments **111c** partially forming the numeral may be within a range of approximately 0.3 mm to approximately 0.4 mm, and the size of each through-hole **51a** and **51b** corresponding to the small pattern **111a** and the small character **111b** may be approximately 0.2 mm or less. The through-holes **51** are formed in a predetermined area corresponding to the display part **111** of the display unit **100**.

[0088] That is, the through-holes **51** may be arranged to form shapes of the segments **51c** or the like of the pattern **51a**, the character **51b**, and the numeral corresponding to the segments **111c** or the like of the pattern **111a**, the character **111b**, and the numeral of the display part **111**. Therefore, when the LEDs **131** emit light, and the pattern, the character, the numeral, the symbol, or the like is displayed on the display unit **100**, the particular pattern, character, numeral, symbol, or the like may be displayed on the front plate **50** of the door.

[0089] As illustrated in FIG. **7**, as a result, the light emitted from the LEDs **131** of the printed circuit board **132** may pass sequentially through the guide hole **122** of the guide part **120**, the display part **111** of the cover sheet **110**, and the plurality of through-holes **51** of the front plate **50**, and then may be viewed by the user.

[0090] Meanwhile, as illustrated in FIG. **8**, the through-holes **51** may be filled with a filler member **52** to prevent foreign substances from being inserted into the through-holes **51** and thus to prevent the through-holes **51** from being clogged.

[0091] The filler member **52** may include the transparent material or the fluorescent material. The filler member **52** may be a silicone resin or a UV resin. The filler member **52** may be filled in the plurality of through-holes **51** through a manner of coating a silicone or UV paint on the front plate **50**.

[0092] FIG. **9** is a view illustrating a state in which an error is generated while the through-holes are coated with the filler member in accordance with the embodiment of the present disclosure. FIG. **10** is a view illustrating a state in which air is removed from the through-holes of FIG. **9** using a vacuum apparatus. FIG. **11** is a flow chart illustrating an entire process of filling the through-holes with the filler member in accordance with an embodiment of the present disclosure.

[0093] Referring to FIGS. **9** to **11**, a process of filling the through-holes with the filler member in accordance with the embodiment of the present disclosure will be described. Here, as an example, the UV paint is used for the filler member. Hereinafter, the filler member, the UV paint, and the paint all refer to the same thing.

[0094] As illustrated in FIG. **11**, the process of filling the through-holes with the filler member in accordance with the embodiment of the present disclosure includes operation **310** of coating with a protection vinyl, operation **320** of coating with a paint, operation **330** of removing air, squeegee operation **340** of squeezing overflowed filler member, operation **350** of curing the UV paint, and inspection operation **360**.

[0095] In operation **310** of coating with the protection vinyl, the protection vinyl **200** is coated to block one or both side openings of the through-holes **51**. In the embodiment, the protection vinyl **200** is coated on the front surface **50a** of the front plate **50**. However, the present disclosure is not limited thereto, and the protection vinyl **200** may be coated on the rear surface **50b** of the front plate **50**.

[0096] The protection vinyl **200** should be coated to be in close contact with the front surface **50a** of the front plate **50** and thus to prevent the paint **52** from leaking. When the process of filling the through-holes **51** with the paint **52** is completed, the protection vinyl **200** may be stripped away.

[0097] Polyethylene (PE), polyethylene terephthalate (PET), and oriented polypropylene (OPP) materials may be used for the protection vinyl **200**.

[0098] However, compared to the other materials, air generation in the through-holes **51** may be further reduced when the polyethylene material is used.

[0099] In operation **320** of coating with the paint, the UV paint is substantially coated in the through-holes **51**. Because the protection vinyl **200** is coated on the front surface **50a** of the front plate **50**, the paint is coated in the through-holes **51** through an entrance of each through-hole **51** which is formed at the rear surface **50b** of the front plate **50**.

[0100] The coating of the paint may be performed by immersing the front plate **50** in a container filled with the paint.

[0101] If possible, the paint may have a high viscosity. If the paint has a high viscosity, the through-holes **51** may be completely filled without any unfilled area. The paint may have a viscosity of approximately 2000 centipoise (cP) or more.

[0102] As illustrated in FIG. **9**, when the paint **52** is coated, during the process of coating all of the through-holes **51** with the paint, coating the paint **52** to the extent that it overflows from inner sides of the through-holes **51** may be unavoidable. That is, the paint may be slightly disposed on the rear surface **50b** of the front plate **50** during coating.

[0103] For convenience of explanation, a part of the paint 52 disposed on the rear surface 50b of the front plate 50 but not in the through-holes 51 is referred to as an overflowed portion 52a. As described later, the overflowed portion 52a is removed in the squeegee operation.

[0104] Meanwhile, as illustrated in FIG. 9, air 210 may be generated in the through-holes 51 while the paint 52 is coated. The air 210 prevents parts of the inner sides of the through-holes 51 from being coated with the paint. Further, the air 210 may push the paint to the protection vinyl 200. Therefore, a state in which the through-holes are filled with the paint 52 may be poor, and may affect an appearance of the display.

[0105] In order to prevent such a phenomenon, when the coating of the paint is completed, the process of removing the air 210 generated in the through-holes 51 is performed. The removing of the air may be achieved by removing the air 210 using a vacuum apparatus. A state in which the air 210 is removed is illustrated in FIG. 10.

[0106] Squeegee operation 340 is a leveling process in which the above-mentioned overflowed portion 52a of the paint 52 is removed. Squeegee operation 340 may be performed by squeezing the rear surface 50b of the front plate 50 using a rolling pin. As described later, the squeegee operation may not be needed according to the shapes of the through-holes.

[0107] In operation 350 of curing the UV paint, ultraviolet light is radiated to the completely coated UV paint to cure the UV paint.

[0108] In inspection operation 360, a state in which the UV paint is filled is finally inspected.

[0109] FIG. 12 is a view illustrating a state in which the through-holes are coated with the filler member in accordance with the embodiment of the present disclosure. FIG. 13 is a flow chart illustrating a process of filling the through-holes with the filler member in accordance with an embodiment of the present disclosure.

[0110] As described above, the squeegee operation may not be needed according to the shapes of the through-holes. As an example, as illustrated in FIG. 12, when the front plate 50 is half-etched and includes a half-cut portion 410 and a through-hole portion 420, the squeegee operation is not needed.

[0111] The coating of the paint 52 is performed to coat all of the through-hole portions 420 with the paint 52, but in the half-cut portion 410, a part is not coated with the paint 52. That is, when the front plate 50 is half-cut, the overflow of the paint 52 may not occur.

[0112] The filling of the paint may be performed through the same process as previously described except for the squeegee operation. That is, the operation of filling the through-holes with the filler member in accordance with an embodiment of the present disclosure may include operation 510 of coating with a protection vinyl, operation 520 of coating with paint, operation 530 of removing air, operation 540 of curing the UV paint, and inspection operation 550. Because these operations are the same as those in the previous embodiment, the description thereof will be omitted.

[0113] Through this filling method, the air in the through-holes is removed, and a sealing member may be filled in the through-holes without the overflow of the sealing member, and thus an appearance of the door may be enhanced.

[0114] The above-mentioned method of filling the sealing member 67 in the through-holes 51 is not applied only to the front plate 50 of the door of the refrigerator. This method may

also be applied when the sealing member is filled in the through-holes formed in general steel plates other than the door of the refrigerator.

[0115] FIG. 14 is a view illustrating a relationship between a thickness of the front plate of the refrigerator and a size of each of the through-holes in accordance with an embodiment of the present disclosure. FIG. 15 is a view illustrating the relationship between the thickness of the front plate of the refrigerator and the size of each of the through-holes when the front plate of the refrigerator is half-cut in accordance with an embodiment of the present disclosure.

[0116] With reference to FIGS. 14 and 15, a viewing angle of the display unit will be described. Because the display unit 100 of the refrigerator according to the embodiment of the present disclosure is provided to be hidden in the front plate 50, and exposed to the user through the through-holes 51 of the front plate 50, it is necessary to secure a sufficient viewing angle at which the user may read the information displayed on the display unit 100 easily even when viewing the refrigerator obliquely.

[0117] As illustrated in FIG. 14, the viewing angle $\theta 1$ is defined as an angle which is formed by straight lines connecting both ends of the diameter of the through hole 51 in the front surface 50a of the front plate 50 and both ends of the diameter of the through hole 51 in the rear surface 50b of the front plate 50.

[0118] The viewing angle $\theta 1$ may be minutely changed according to the materials of the front plate 50 and the filler member 52, and the machined state of the through-holes 51, i.e., the squareness of the front, or whether there are foreign substances after the machining process.

[0119] However, it is assumed that the viewing angle $\theta 1$ is determined by a thickness T1 of the front plate 50 and a size R1 of the through hole 51.

[0120] The viewing angle $\theta 1$ may be in inverse proportion to the thickness T1 of the front plate 50, and in proportion to the size R1 of the through hole 51.

[0121] If the thickness T1 of the front plate 50 and the size R1 of the through hole 51 are equal, the viewing angle $\theta 1$ may be 90° , if the size R1 of the through hole 51 is smaller than the thickness T1 of the front plate 50, the viewing angle $\theta 1$ may be an acute angle, and if the size R1 of the through hole 51 is larger than the thickness T1 of the front plate 50, the viewing angle $\theta 1$ may be an obtuse angle.

[0122] In a service environment in which the user uses the refrigerator in the kitchen or the like, the suitability of the view angle according to the thickness of the front plate 50 of the door of the refrigerator and the size of the through-hole 51 thereof may be determined as shown in the following Table 1.

TABLE 1

When the front plate is not half-cut						
Thickness of front plate (T1, mm)	0.6			0.3	0.2	
Diameter of through-hole (R1, mm)	0.1	0.3	0.4	0.5	0.3	0.2
Suitability of viewing angle ($\theta 1$)	unsuitable	unsuitable	suitable	suitable	suitable	suitable

[0123] As shown in Table 1, it may be understood that, when the thickness T1 of the front plate is 0.6 mm, the diameter R1 of the through-hole should be more than 0.3 mm to have the suitable viewing angle $\theta 1$. It may also be understood that, when the thickness T1 of the front plate is 0.3 mm and 0.2 mm, the diameter R1 of the through-hole should be 0.3 mm and 0.2 mm to have the suitable viewing angle $\theta 1$.

[0124] According to the above-mentioned results, the relationship between the diameter R1 of the through-hole and the thickness T1 of the front plate for securing the sufficient viewing angle $\theta 1$ will be defined as the following equation.

$$R1 > T1/2 \quad (\text{Equation 1})$$

[0125] However, when the front plate 50 is half-cut, the relationships among the viewing angle, the diameter of the through-hole and the thickness of the front plate may be changed.

[0126] As illustrated in FIG. 15 and Table 2 below, in the case in which the front plate 50 is half-cut and includes a half-cut portion 410 and a through-hole portion 420, when a thickness T2 of the front plate is 0.6 mm and a diameter R2 of the through-hole is 0.3 mm, a suitable viewing angle $\theta 2$ is provided. Here, the half-cutting means that a half of the thickness T2 of the front plate 50 is cut.

[0127] That is, when the front plate 50 is not half-cut, if the thickness T1 of the front plate is 0.6 mm and the diameter R1 of the through-hole is 0.3 mm, the viewing angle $\theta 1$ is not sufficient. However, when the front plate 50 is half-cut, if the thickness T2 of the front plate is 0.6 mm and the diameter R2 of the through-hole is 0.3 mm, the viewing angle $\theta 2$ is sufficient.

[0128] In the following Table 2, because it is difficult to perform the half-cutting when the thickness T2 of the front plate is 0.1 mm, the suitability of the viewing angle may not be determined. In other cases, because the sufficient viewing angle may be secured without performing the half-cutting as shown in Table 1, and thus the half-cutting is not needed, it should be noted that the suitability of the viewing angle is not determined.

TABLE 2

When the front plate is half-cut						
Thickness of front plate (T2, mm)	0.1	0.3	0.4	0.5	0.3	0.2
Diameter of through-hole (R2, mm)	0.1	0.3	0.4	0.5	0.3	0.2
Suitability of viewing angle ($\theta 2$)	—	Suitable	—	—	—	—

[0129] According to the above-mentioned results, when the front plate is half-cut, the relationship between the diameter R2 of the through-hole and the thickness T2 of the front plate for securing the sufficient viewing angle $\theta 2$ will be defined as the following equation.

$$R2 \geq T2/2 \quad (\text{Equation 2})$$

[0130] That is, in the case in which the front plate is half-cut, when the diameter R2 of the through-hole is greater than or equal to half the thickness of the front plate, a sufficient viewing angle may be secured.

[0131] According to embodiments of the present disclosure, the front plate of the refrigerator is formed of the steel plate, the display unit is hidden in the door, and information displayed on the display unit may be seen through the through-holes formed in the front plate. Therefore, an appearance of an exterior of the refrigerator may be improved.

[0132] Also, it is possible to minimize the diameters of the through-holes and to secure a sufficient viewing angle at which the information displayed on the display unit in the door may be read easily through through-holes even if the display of the refrigerator is viewed obliquely.

[0133] Further, it is possible to prevent the generation of unfilled portions and bubbles when filling the through-holes with the filler member, and thereby to improve reliability.

[0134] Although a few embodiments of the present disclosure have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the disclosure, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. A refrigerator comprising:

a main body;

a storage chamber formed in the main body; and

a door configured to open and close the storage chamber, wherein the door comprises:

a front plate configured to form a front surface and side surfaces of the door;

a rear plate coupled to a rear portion of the front plate;

an upper cap coupled to an upper portion of the front plate;

a lower cap coupled to a lower portion of the front plate;

a foaming space defined by the front plate, the rear plate, the upper cap, and the lower cap;

an insulation material foamed into the foaming space; and

a display unit including a display part having a desired shape to be turned on and off, and disposed at a rear side of the front plate, and

a through-hole having a diameter larger than half of a thickness of the front plate is formed in the front plate.

2. The refrigerator according to claim 1, wherein the display unit comprises a printed circuit board on which a Light Emitting Diode (LED) is mounted, a guide part configured to guide the light of the LED, and a cover sheet attached to a front surface of the guide part and having the display part.

3. The refrigerator according to claim 1, wherein the diameter of the through-hole is 0.1 mm or more and 0.5 mm or less.

4. The refrigerator according to claim 1, wherein the thickness of the front plate is 0.6 mm or less.

5. The refrigerator according to claim 1, wherein the front plate comprises a half-cut portion formed by half-cutting, and a through-hole portion in which the through-hole is formed.

6. The refrigerator according to claim 5, wherein, when the front plate is half-cut, the diameter of the through hole is formed to be larger than or the same as the half of the thickness of the front plate.

7. The refrigerator according to claim 1, wherein the door further comprises a supporting member configured to support the display unit.

8. The refrigerator according to claim 1, wherein the door further comprises a guide member configured to press the display unit to a front side so that the display unit is in close contact with the front plate.

9. The refrigerator according to claim **8**, wherein the door further comprises a sealing member provided between the front plate and the supporting member to prevent an insulation foaming agent from permeating the display unit.

10. The refrigerator according to claim **1**, wherein the door further comprises a filler member in the through-hole to prevent a foreign substance from permeating the through-hole.

11. The refrigerator according to claim **10**, wherein the filler member has a viscosity of 2000 centipoise (cP) or more.

12. A method of manufacturing a refrigerator which comprises a main body, a storage chamber, and a door configured to open and close the storage chamber and having a front plate formed of a steel plate, comprising:

forming a through-hole having a diameter larger than half of a thickness of the front plate in the front plate, and

filling a filler member in the through-hole to prevent a foreign substance from permeating the through-hole.

13. The method of manufacturing the refrigerator according to claim **12**, wherein the forming of the through-hole in the front plate comprises half-cutting the front plate to form a half-cut portion and a through-hole portion, and forming the through-hole having a diameter larger than or the same as the half of the thickness of the front plate in the through-hole portion.

14. The method of manufacturing the refrigerator according to claim **12**, wherein the filler member has a viscosity of 2000 centipoise (cP) or more.

15. The method of manufacturing the refrigerator according to claim **12**, wherein the filling of the filler member in the through-hole comprises attaching a protection vinyl on a front surface of the front plate, and coating an inner portion of the through-hole with the filler member through a rear surface of the front plate on which the protection vinyl is not attached.

16. The method of manufacturing the refrigerator according to claim **15**, wherein the protection vinyl is formed of a polyethylene material.

17. A display apparatus for a refrigerator, the display apparatus comprising:

a printed circuit board comprising a Light Emitting Diode (LED);

a display part;

a guide hole configured to guide the light of the LED to the display part; and

a front plate comprising a pattern of through-holes;

wherein each through-hole in the pattern of through-holes has a diameter greater than or equal to half of a thickness of the front plate, and

the pattern of through-holes has a location corresponding to the location of the guide hole for the LED.

18. The display apparatus according to claim **17**, wherein the front plate forms a front portion of a door of the refrigerator.

19. The display apparatus according to claim **17**, further comprising:

a filler member in each through-hole in the pattern of through-holes.

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