

Refrigerator

Field of the Invention

The invention relates to a refrigerator having a
5 door-opening device for a drawer door attached on a storage
container.

Background of the Invention

In recent years, storage volume of the refrigerator as
well as its height and width dimension is increasing with
10 increase of life style variations in respect of foods. This
makes increase in height, width and depth dimensions of flapper
doors for a fresh-food chamber, which have storage pockets in
inner face, as well as dimensions of drawer doors for a freezer
chamber and a vegetable chamber. Because increasing amount
15 of foods are stored and dimensions of the doors are large, opening
of doors requires increasing extent of manual force so that
the opening may have become tiresome for aged people or twiggy
women. Thus, some improvement for this had been desired.

For the fresh-food chamber that is the largest, there
20 has been adopted a pair of flapper doors in a French-door
arrangement, or a door-opening device that is turned on when
a user presses touch switch on outer face of the door, as to
actuate a solenoid to push out a pusher and to open the flapper
door by pushing inner face of the door from the refrigerator
25 casing. Such refrigerators have been on sale and got a

reputation as having easiness of door opening. Moreover, there has been proposed a refrigerator having door-opening devices for the lapper doors in a French-door arrangement. Please see JP-2003-083673A (Japan's patent application publication
5 No.2003-083673) for example. Each of the solenoids for the door-opening devices is provided with a plunger that is movable in front-rear direction and is connected with the pusher. The pusher moves forward along with the plunger when the solenoid is actuated in a state the flapper door is closed, as to push
10 and flap-wise open the flapper door.

The door-opening device for the flapper door usually has a stroke length of about 35mm as a result of conditioning or adjustment of a distance from a hinge axis of the door and of extent of pushing force. As for the drawer doors for the
15 vegetable and freezer chambers, the door-opening device has never been commercialized due to assumed difficulty in a mechanism for effecting straight forward moving of the drawer door instead of rotational moving of the flapper door.

When the door-opening device is to be used for the drawer
20 door on the freezer chamber, the solenoid is accommodated in the freezer chamber. Thus, when the solenoid is stuck with ice by cooled air in the chamber, the plunger would not fully move forward; and thus, opening of the door might be failed. Moreover, inside of the freezer chamber may become below of
25 atmospheric pressure as a result of rapid cooling of a warm

air introduced from atmosphere in the house. Thus, the drawer door will be too tightly pressed by a magnet force of magnetic door-sealing gasket and negative pressure. In such state, when the door-opening device is utilized as to repeatedly apply a pressing stress on the door-sealing gasket; then, the door-sealing gasket may be undergone a plastic deformation and thus sealing property may be damaged.

As for the drawer door, pushing-out distance of the door by the door-opening device is essentially same with the stroke length of door-opening device. Thus, the stroke length has to be far larger when to enable enough pushing out of the drawer door in an extent that stored goods in the storage container are to be taken out. Then, gravity center of an assembly consisting of the plunger and the pusher will be far distanced from the solenoid; and, due to weight imbalance in an extent to cause forwardly downward inclination, scraping and chipping on the plunger is caused. Thus, repeating of opening and closing the drawer door will cause insufficient sliding as well as abrasion and deterioration of the pusher. Resultantly, expected lifetime of the door-opening device will become too short.

In view of the above, it is aimed for a refrigerator to curb frosting on the solenoid even when the door-opening device is adopted for the freezer door in a drawer arrangement and to curb plastic deformation as a result of being repeatedly

pressed. In otherwise, it is aimed to curb abrasion due to the weight imbalance as to increase the expected life time and to improve easiness of use of the drawer door.

Brief Summary of the Invention

5 A refrigerator (1) of the invention comprises: an insulator casing (1) that is box-shaped and opened to frontward; a storage chamber (24) arranged in the insulator casing (1); a drawer door (36), which closes a front opening of the storage chamber (24) and which holds a container (53,54,55) at rear
10 side of the door (36) in a manner as able to be pulled out to forward by way of rails (34,35) that are arranged on side walls on the storage chamber (24); a solenoid casing (111), which is arranged within the storage chamber (24) and has a solenoid chamber (118); an electromagnetic solenoid (200), which is
15 arranged in the solenoid chamber (118) and has a plunger (134) that is movable in front-rear direction; an opening (102), which is formed on front wall of the solenoid chamber (118) and is opened in front-rear direction; a rod (144) that is arranged on the plunger (134) of the solenoid (200); a sealing element
20 (145), which is attached on the rod (144) from frontward as to hermetically close the opening (102) from its front side and is able to be deformed to allow moving in a front-rear direction, of the rod (144); and a pusher (154), which is interlocked with the rod (144) at outside of the solenoid chamber
25 (118), and which travels forward in conjunction with the plunger

(134) and the rod (144) to push out the drawer door (36) to forward from its closed-up position, if and when the solenoid (200) is actuated at a time the door (36) is closed.

Advantages of the Invention

5 When the solenoid coil (129) of the solenoid (200) is activated at a time the door (36) is in its closed-up position, the pusher (154) travels to forward in conjunction with the plunger (134) and the rod (144) to push out the door (36) to forward from its closed-up position. The rod (144) juts out
10 to outside of the solenoid chamber (118) through a tube-shaped element (120); and inside of the solenoid chamber (118) is hermetically closed by the solenoid cover (183) except for inside of the tube-shaped element (120); and inside of the tube-shaped element (120) is hermetically closed by the sealing element
15 (145) that is attached from frontward onto tube-shaped element (120) and in same time onto the rod (144). Thus, entering of moisture into the solenoid chamber (118) is curbed; and hence, ice formation in the solenoid (200) and resultant malfunction are curbed. Moreover, the sealing element (145) progressively
20 deforms in accordance with frontward or rearward moving of the rod (144); thus, curbed are rupture of the sealing element (145) and resultant deterioration of sealed-off state of the solenoid chamber (118).

Detailed Description of the Invention

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<First Embodiment>

As shown in Fig.1, an insulator casing 1 is formed of:
an outer casing 2, an inner casing 3 and insulator 4. The outer
and inner casings 2 and 3 are rectangular and long in vertical
direction and are opened on front side and formed of: a bottom
5 wall, a rear wall, a top wall, and right-hand and left-hand
side walls. All the walls of the outer casing 2 are formed
of steel plate while all the walls of the inner casing 3 are
formed of synthetic resin. At between each pair of
corresponding ones of the walls of the outer and inner casings
10 2 and 3, a space is formed as to be filled with the insulator
4. As shown in Fig.2, a bottom flange 5 is extended from bottom
wall of the outer casing 2 as to close front end of the space
between a pair of bottom walls; each of right-hand and left-hand
side flanges 6 and 7 is extended from a side wall of the outer
15 casing 2 as to close front end of the space between a pair of
side walls; and a top flange is extended from top wall of the
outer casing 2 as to close front end of the space between a
pair of top walls.

As shown in Fig.1, a horizontal insulator partitioner
20 wall 8 is arranged as fixed at inside of the insulator casing
1, for partitioning a space at inside of the inner casing into
a fresh-food compartment 9 on top side and a freezer compartment
20 on bottom side. The insulator partition wall 8 is formed
of a hollow casing filled with solid insulator such as styrene
25 foam. As shown in Fig.2, front opening of the fresh food

compartment 9 is closed by a pair of flapper doors 10 and 11 hinged on hinge shafts 12 and 13, in a French-door arrangement. As shown in Fig.1, rear wall of the fresh-food compartment 9 is attached with a cool-air duct 14 extending in vertical direction, which has an inlet port at bottom and an outlet port at top. On inside of the cool-air duct 14, a fan device 16 is attached, which is formed of a fan that is connected on rotation shaft of a fan motor. When the fan motor is on work, air in the fresh-food compartment 9 is sucked from the inlet port of the cool-air duct 14, sent upward and then sent out from the outlet port.

As shown in Fig.1, a machine room 17 is formed on bottom-rear part of the insulator casing 1, and is accommodated with a compressor 18 for refrigerant circuit. A fresh-food cooler 19 is connected to a refrigerant outlet port of the compressor 18 and is placed within the cool-air duct 14 as to cool the air flowing through the cool-air duct 14, so that cooled air is circulated in the fresh-food compartment 9 for cooling its inside space in a temperature range for preservation of fresh foods. As shown in Fig.2, a front plate 21 is arranged to bridge across front opening of the freezer compartment 20 in horizontal direction; and the freezer compartment 20 is partitioned to a freezer chamber 24 at bottom side, an icemaker chamber 25 at top-left side and an auxiliary freezer chamber 26 at top-right side, with respect to the front plate 21. As shown in Figs.3

and 5, the front plate 21 formed of magnetic material such as steel has an upper gasket seat 22 and lower gasket seat 23, which are arranged in vertical direction and are extended in horizontal direction. Rear face of the front plate 21 is
5 attached on a front frame bar 27 formed of synthetic resin as to close front opening of the front frame bar 27 that is extending in a horizontal direction and has an angled-C-shaped cross section as to form the front opening. On rear wall of the front frame bar 27, a rib plate 28 extending in horizontal direction
10 is formed as attached. The front plate 21 is screwed on front end of the rib plate 28 by screws 29 that penetrate the front plate 21.

As shown in Fig. 2, an icemaker door 30, an auxiliary-freezer door 32 and a freezer door 36 are attached
15 on the heat-insulator casing 1 as to respectively cover front sides of the icemaker chamber 25, the auxiliary-freezer chamber 26 and the freezer chamber 24; and each of these doors is in a drawer arrangement as to be pulled out and pushed in along with one or more container attached thereon, along a direct
20 line in front-rear direction, to open and close the respective chamber. As shown in Fig. 1, an ice box 31 is attached on the icemaker chamber 25 and receives ices that are automatically thrown out from an ice maker when the icemaker door 30 is shut. On the auxiliary-freezer door 32, a container for freezing
25 preservation of foods is attached. The auxiliary-freezer

chamber 26 may be a temperature-switchable chamber, in which temperature at inside is switchable among various values.

As shown in Fig.4, each of right-hand and left-hand side walls of the inner casing 3 has on the freezer chamber 24, a lower groove 33 that run along a direct line in a front-rear direction. A stationary rail is fixed in and along each of the lower groove 33. As shown in Fig. 2, a first movable rail 34 is attached on each of the stationary rails as to be movable in front-rear direction; and then, a second movable rail 35 is attached on each of the first movable rail 34 as to be movable in front-rear direction. Each of these movable rails 34 and 35 run along a direct line in front-rear direction. Front ends of the second movable rails 35 are attached on the freezer door 36; and the second movable rails 35 on right-hand and left-hand sides are connected with each other through the freezer door 36 to form a drawer door construction. The freezer door 36 is rectangular as long in horizontal direction, and shifts its front-rear-wise position by moving of each of the second movable rails 35 along a respective one of the first moving rails 34 that is in stationary state, and by moving of each of the first movable rails 34 along a respective one of the second movable rails 35 that is in stationary state. Thus, the freezer door 36 is closed when the first and second movable rails 34 and 35 have come to their rearmost positions, and is opened when the first and second movable rails 34 and 35 have come to their

foremost positions.

As shown in Fig.4, the rear wall of the inner casing 3 is attached with electromagnets 37, each of which is positioned to be within respective one of the lower grooves 33. Rear end
5 of each of the first movable rails 34 is attached with a magnetic plate, that is arranged in vertical direction and facing with front face of the electromagnet 37. Each of the electromagnets 37 is formed of wires coiled around a core. When the freezer door 36 is pushed in, each of the electromagnets 37 comes into
10 a magnetic field of the electromagnet 37 as to enact a magnetic attractive force so that the freezer door 36 is pulled into its closed-up position. In short, a mechanism for pulling in the freezer door 36 to its closed-up position is formed by the magnetic plates and the electromagnets 37.

15 As shown in Fig.3, the freezer door 36 is formed by assembling a door front plate 40, a door inner plate 41, a top cover cap 42 and a bottom cover cap 43 (please see Fig.2), and then by filling an inner space with urethane foam 39 that is a heat insulator. The door front plate 40 is formed by bending
20 a steel plate in an angled-C shape as seen vertically as to have openings at rear, top and bottom sides, which are respectively closed by the door inner plate 41, the top cover cap 42 and the bottom cover cap 43 that are formed of synthetic resin. Thus, top and bottom openings formed between the door
25 front and door inner plates 40 and 41 are respectively closed

by the top and bottom cover caps 42 and 43.

As shown in Fig.5, the door inner plate 41 has, at its all-around fringe in a rectangular shape, a vertical attaching face 44 that has a groove 44a, for attaching a door-sealing gasket 45 that is formed of rubber and pushed into the groove 44a. A groove 44a that is opened rearward; and the groove 44a and the door sealing gasket 45 are arranged to run along whole of the attaching face 44 in a manner to encircle the freezer door 36. Door sealing part 46 of the door sealing gasket 45 is a hollow tube having a cavity and has a partitioner wall 48 within the cavity so that the cavity is partitioned to an outer sealing part 49 on periphery side of the door and an inner sealing part 50 on center side. When the freezer door 38 has been pushed in to reach the closed-up position, the outer sealing part 49 is pressed to be elastically deformed by: door-upper fringe part of the outer sealing part 49 is sandwiched between the door inner plate 41 and the lower gasket seat 23 on the front plate 21; door-right-hand and door-left-hand side fringe parts are sandwiched respectively between the door inner plate 41 and the right-hand side flange 6 of the outer casing 2 and between the door inner plate 41 and the left-hand side flange 7; and door-lower fringe part is sandwiched between the door inner plate 41 and the bottom flange 5 of the outer casing 2. In this way, front opening of the freezer chamber 24 is air-tightly closed.

As shown in Fig.5, a locking magnet 51 is inserted in the outer sealing part 49 of the door sealing gasket 45, in an annular arrangement as to run along whole periphery of the freezer door 36. Thus, the freezer door 36 is held at the closed-up position not only by action of the electromagnet 37 but also by magnetic attracting force between the locking magnet 51 and the flanges 5-7 of the outer casing 2 and between the locking magnet 51 and the front plate 21. The door inner plate 41 of the freezer door 36 has a bead (fringe-rib protrusion) 52, or rearward terraced portion, on inner fringe of the inner sealing part 50, in an annular arrangement as to run along whole periphery of the door inner plate 41. Dimension of press deformation of the door sealing gasket 45 in a state the freezer door 36 is fully closed is set in a manner that the outer and inner sealing parts 49 and 50 protrude rearward than a rear face of the fringe-rib protrusion 52, by a protrusion distance of " ΔH " in Fig. 5.

As shown in Fig. 1, a main freezer container 53, an middle-tier freezer container 54 and an top-tier freezer container 55, which are opened upward for facilitating taking in and out of foods, are arranged in this sequence as stacked from bottom in a three-story arrangement. The main freezer container 53 is attached on a pair of the second movable rails 35 on the freezer door 36; the middle-tier freezer container 54 is attached on fringe of the upward opening of the main freezer

container 53; and thus, the main and middle-tier freezer containers 53 and 54 are pushed in and pulled out, integrally with the freezer door 36.

As shown in Fig. 4, each of the right-hand and left-hand side walls of the inner casing 3 has an upper groove 33a running
5 along a direct line in front-rear direction, at above the lower groove 33. Right-hand and left-hand side horizontal flanges on the top-tier freezer container 55 are inserted respectively into the right-hand and left-hand side upper grooves in a manner
10 that the top-tier freezer container 55 is slidable in front-rear direction, separately with the main and middle-tier freezer container s 53 and 54.

As shown in Fig.1, rear wall on the freezer chamber 24 is attached with a rear air duct 56, which run vertically and
15 has a cooled air inlet 57 at bottom and a cooled air outlet on top. A fan device 58, which is formed of a fan connected on a rotation shaft of fan motor, is attached at inside of the rear air duct 56. When the fan device 58 is on work, air on the freezer chamber 24 is sucked into the cooled air inlet 57,
20 sent upward through the duct 56 and then sent out from the cooled air outlet. As shown in Fig.1, a front air duct 59, which runs vertically, is arranged on front side of the rear air duct 56 and has an inlet port at top, which is connected with the outlet of the rear air duct 56. The front air duct 59 has an outlet
25 61 (Fig.4) opened toward the main freezer container 53, and

outlet 62 opened toward the middle-tier freezer container 54 and an outlet 63 opened toward the top-tier freezer container 55. Thus, cooled air blown out from the rear air duct 56 is passing through the front air duct 59 and is sent out: to the
5 icemaker chamber 25 through an icemaker outlet 60, to the auxiliary freezer chamber 26 through another outlet, to the main, middle-tier and top-tier freezer containers 53-55 respectively through the outlet 61-63. The outlet 63 for the top-tier freezer container 55 is a tube having a rectangular
10 shape and is downwardly inclined in forward direction. As shown in Fig.4, a horizontal air-colliding face 64 is formed on the outlet 63 for the top-tier freezer container 55. As shown in Fig.1, a freezer evaporator 65, which comprises the refrigerant circuit and is connected with refrigerant outlet of the
15 compressor 18 in the machine room 17, is attached within the rear air duct 56 as to cool the air passing through the rear air duct 56. In this way, foods in the freezer chamber 24 and so on is kept at temperatures lower than 0°C by circulating thus cooled air.

20 As shown in Fig.3, a handle 66 is formed by; a vertical plate that is formed on the upper cover cap 42 of the freezer door 36 as to run throughout whole width dimension of the upper cover cap 42 as shown in Fig.2, and a recess 43 that is formed on the door front plate 40 of the freezer door 36 as to run
25 along the vertical plate except for its right-hand and left-hand

side end portion, as to come rear of the vertical plate for the handle 66 and as to be positioned more rearward than all the other part on front face of the freezer door 36. The recess 43 provides a space 67 for putting in fingers at a time of pulling
5 out the door by pulling the handle 66.

As shown in Fig.6, the upper cover cap 42 has a mechanism-housing recess 68 that is opened upward and rearward and has a stepped bottom face, in which its front part is lower than rear part of the stepped bottom face as shown in Fig. 5.
10 Right-left-wise center of the mechanism-housing recess 68 is deviated a little bit leftward than that of the freezer door 36. As shown in Fig.7, a door magnet 69 formed of a permanent magnet is attached in the mechanism-housing recess 68 at its left-rear corner. At rear of the door magnet 69, a door switch
15 70 is embedded in the front frame 27 of the insulator casing 1, and is formed by a proximity switch such as a hole IC as to make switching in response to magnet force and thereby controlling the rotation of the fan device 58. The door switch 70 is switched to ON-sate when the door magnet 69 comes into
20 a detection range of the door switch 70, at a time the freezer door 36 is shut; and the door switch 70 is switched to OFF-sate when the door magnet 69 comes out of a detection range of the door switch 70, at a time the freezer door 36 is opened. As for the freezer door 36, its position of switching off is in
25 rearward of a push-opened position; and thus the door switch

70 is switched from On-state to Off-state before the freezer door 36 reaches its push-opened position. As shown in Fig.7, a left-hand-side arm 71 and a right-hand side arm 72 that run in right-left direction of the refrigerator are arranged in the mechanism-housing recess 68. Left-hand-side end of the left-hand-side arm 71 and right-hand-side end of the right-hand-side arm 73 are pierced respectively by a left-hand-side shaft 72; and a right-hand-side shaft 74 that are fixed on bottom wall of the mechanism-housing recess 68; so that these arms 71 and 73 are rotatable about respective shafts 72 and 74 within the mechanism-housing recess 68. And, these arms 71 and 73 are rotatably connected with each other, in a kind of link arrangement, by a center shaft 75; which runs vertically pierces through the right-hand end of the left-hand-side arm 71 and through the right-hand-side arm 72. A straight line between the right-hand-side and left-hand-side shafts 71 and 74 is arranged in a right-left direction; and distances from the center shaft 75 to the right-hand-side and left-hand-side shafts 71 and 74 are same with each other.

As shown in Fig. 7, the upper cover cap 42 has a shaft rod 76, which is fixed as arranged on bottom of the mechanism-housing recess 68 and runs upward. Outer circumferential face of the shaft rod 76 is fitted with a coil part of a return spring 77. The return spring 77 is formed of a torsion spring and has a long arm and a short arm other

than the coil part. The upper cover cap 42 has a spring stopper 78 in a shape of protrusion, which is fixed as arranged on bottom wall of the mechanism-housing recess 68. The long arm of the return spring 77 is contacted with rear face of the right-hand-side arm 73; and the short arm of the return spring 77 is contacted with the spring stopper 78. A spring force of the return spring 77 is directly applied to the right-hand-side arm 73 in a counterclockwise direction on Fig. 7; and is indirectly applied to the left-hand-side arm 71 in a clockwise direction on Fig. 7. As shown in Fig. 7, the upper cover cap 42 has a stopper 79 that is fixed within the mechanism-housing recess 68, on front of the center shaft 75.

As shown in Fig. 7, within the mechanism-housing recess 68 of the upper cover cap 42, there is arranged as fixed a stopper 79, at front of the center shaft 75. The stopper 79 is formed of rubber, or a cushioning material, such as silicone or rubber, which is softer than those for the right-hand-side and left-hand-side arms 71 and 73. These arms 71 and 73 are kept in a non-active position to form a single straight line, by being driven to contact on the stopper 79 by spring force of the return spring 77. The right-hand-side arm 73 includes a manipulation arm 80, which means a part that comes to rear of and parallel with the left-hand-side arm 71 at a time of the non-active position. On the manipulation arm 80, fixed is a pin 81 that is cylindrical and protrudes upward.

As shown in Fig.7, the left-hand-side arm 71 is pierced as rotatable by a left-hand-side link shaft 82 at between the left-hand-side shaft 72 and the center shaft 75. The right-hand-side arm 73 is pierced as rotatable by a right-hand-side link shaft 83 at between the right-hand-side shaft 74 and the center shaft 75. Each of the right-hand-side and left-hand-side links 82 and 83 is shaped as solid cylindrical and extended in vertical direction. A distance between the left-hand-side link shaft 82 and the center shaft 75 is set as same with a distance between the right-hand-side link shaft 83 and the center shaft 75. The left-hand-side link shaft 82 is connected as rotatable with rear end of a left-hand-side horizontal plate 84; the right-hand-side link shaft 83 is connected as rotatable with rear end of a right-hand-side horizontal plate 85; and front ends of the left-hand-side and right-hand-side horizontal plates 84 and 85 are connected with a common manual-operation button 86. As shown in Fig.5, at a time no manipulation force is applied, the manual-operation button 86 is kept at non-manipulation position; at which the manual-operation button 86 juts out frontward from front face of the handle 66 by action of spring force of the return spring 77; and at which each of the right-hand-side and left-hand-side arms 73 and 71 is kept at the non-active position. The manual-operation button 86 is to be pushed in backward from the non-active position, along a straight line, by overcoming

the spring force of the return spring 77; and then, such pushing in is stopped by contacting with the stopper 79. As shown in Fig.8, on course of such pushing in, the left-hand-side arm 71 rotates counterclockwise about the left-hand-side shaft 72; and the right-hand-side arm 73 rotates clockwise about the right-hand-side shaft 74; and thus, the right-hand-side and left-hand-side arms 73 and 71 are shifted to non-active position as to form a dogleg shape with each other.

As shown in Fig.7, the upper cover cap 42 has a supporter shaft 87 on bottom face of the mechanism-housing recess 68. The supporter shaft 87 is solid cylindrical and extended in vertical direction; and the supporter shaft 87 is rotatably inserted into a hole of a horizontal plate-shaped magnet mount 88, which has an arc-shaped cam slit 81 as a through hole on the magnet mount 88. The cam slit 81 is inserted by the pin 81 of the right-hand-side arm 73. The pin 81 serves for rotating the magnet mount 88; and at a time the manual-operation button 86 is in the non-active position, the pin 81 is positioned at rear end of the cam slit 81 so as to keep the magnet mount 88 at its non-active position as shown in Fig.7. On course of the pushing in of the manipulator button 86 from the non-active state shown in Fig.7 to the active state shown in Fig.8; the pin 81 induces counterclockwise rotation of the magnet mount 88 and thereby its shift from non-active position to active position.

As shown in Fig.7, a button magnet 90 formed of a permanent magnet is fixed on upper face of the magnet mount 88, as slightly spaced apart from the cam slit 89. The button magnet 90 is rectangular in a plan view, thus has a long side 91 and a short side 92 and also has a chamfered corner 93 at between the long and short sides 92 and 93. If and when the manual-operation button 86 is at the non-active position, the button magnet 90 is kept at its non-active position; at which the chamfered corner 93 is exactly facing rearward, and the long side 93 is obliquely facing rearward. As indicated by Fig.8, on course of pushing in of the manual-operation button 86 from its non-active position to the active position, the magnet mount 88 is counterclockwise rotated about the supporter shaft 87; thus, the button magnet 90 is moved as rotated about the supporter shaft 87 to come to active position of the magnet 90; at which the chamfered corner 93 is obliquely facing rearward and the long side 93 is exactly facing rearward. In Fig.7, a dot-dash line marked as "ML" designates a rotation trajectory of a right-hand-side end apex of the chamfered corner 93. The button magnet 90 is positioned in a manner that a portion of the rotation trajectory ML juts rearward out of a plane of the attaching face 44.

As shown in Fig.7, a button switch 94 is fixed at inside of the front frame bar 27; and is formed of a proximity switch such as a hole IC, status of which is switched by magnet force. If and when the manual-operation switch 86 is kept at its

non-active position and thus the button magnet 90 is kept at its non-active position; the magnet force acting from the button magnet 90 through its chamfered corner 93 onto the button switch 94 is relatively small and not large enough to actuate the button switch 94 as to keep it at non-active state. As shown in Fig.8, if and when the manual-operation switch 86 is pushed to take its active position and thus the button magnet 90 comes to its active position; the magnet force acting from the button magnet 90 through its long side 91 onto the button switch 94 is relatively large and large enough to actuate the button switch 94 as to switch it to active state from the non-active state. Hence, the button switch 94 detects whether the manual-operation switch is pushed in or not, in a non-contact manner.

As shown in Fig.5, the upper cover cap 42 is detachably attached with a mechanism-recess cover 95, which has a top plate 96 and a rear plate 97 that respectively cover up upper side and rear side of the mechanism recess 68. A portion of the rear plate 97 is located more rearward than the attaching face 44 for the door sealing gasket 45, of the door inner plate 41 of the freezer door 36; thus, enabling that a portion of the trajectory ML of the button magnet 90 juts rearwardly out of a plane of the attaching face 44. The mechanism-recess cover 95 covers up all of; the door magnet 69, the right-hand-side and left-hand-side arms 73 and 71, the return spring 77, the magnet mount 88 and the button magnet 90, as to be invisible

from outside. The top plate 96 of the cover 95 is contacted with top of the supporter shaft 87 for the magnet mount 88, under a connecting force between the cover 95 and the upper cover cap 42; so that the supporter shaft 87 supports the top
5 plate 96 at its bottom face.

As shown in Fig.5, the mechanism-recess cover 95 has at front end of the top plate 96, a rain gutter 98 that is formed as a ditch and runs along a straight line in right-left direction. The rain gutter 98 is for receiving water dropped on the top
10 plate 96 that has a slope 99 rising rearward from the rain gutter 98. Bottom face of the rain gutter 98 is inclined in a manner to descend from center of right-left-wise dimension toward its both ends; so that water in the rain gutter 98 flows rightward or leftward along inclined bottom face of the rain gutter 98
15 and then falls down along right-hand-side or left-hand-side end of the cover 95.

As shown in Fig.6, the upper cover cap 42 has a right-hand-side outlet gutter 100 and a left-hand-side outlet gutter 101, each of which runs in front-rear direction and is
20 formed as a ditch, and bottom face of each of which is inclined in a manner to descend rearward. Water fallen along the right-hand-side or left-hand-side end of the cover 95 is received by respective one of the outlet gutters 100 and 101, then flows rearward along the bottom face of the gutter 100 or 101 and
25 is discharged from the gutter. Thus, the rain gutter 98 and

the right-hand-side or left-hand-side outlet gutters 100 and 101 are for curbing of getting in of water from the mechanism-recess cover 95 into the mechanism-housing recess 68.

5 A door-opening device 110 is mounted on right-left-wise center portion of rear face of the front plate 21, on top of the freezer chamber 24, within the freezer compartment 20 as shown in Fig.1. In present embodiment, the door-opening device 110 is arranged in a partition-wall part that serves solely
10 for pulling out and accommodating of the main and top-tier freezer containers 53 and 55 and is not for heat insulation between upper and lower compartments. Thus, a useless space, which is not able to be used as storage space, is utilized for accommodating the door-opening device 110. As shown in Fig.10,
15 the door-opening device 110 has as a driving source, an electromagnetic solenoid 200 that is comprised of a solenoid coil 129 and a plunger 134; and moves freezer door 36 from its closed-up position to forward or in door-opening direction, when having been actuated at a time the door has been kept close.
20 The door-opening device 110 is in detail constructed as follows.

As shown in Fig.10, a solenoid casing 111 is upwardly opened, is shaped as elongated in front-rear direction, and has at its rear end, a horizontal seat face 112 that is seated in a manner of face-to-face contacting, on a horizontal receiving
25 face 64 of the outlet 63 for the top-tier freezer container

as shown in Fig.4. As shown in Fig.10, the solenoid casing 111, which is formed of synthetic resin, has a slope 113 at rear of the seat face 112 rising rearward. As shown in Fig.4, the slope 113 is seated on a surface of the outlet 63 for the top-tier freezer container, in a manner of face-to-face contacting.

As shown in Fig.10, each of right-hand-side and left-hand-side walls of the solenoid casing 111 is arranged over its length dimension except for front-end part of the casing 111; and has respective one of right-hand-side and left-hand-side cut-out portions 115 and 114 that are for receiving the front frame bar 27. As shown in Fig.4, the front-end part of the solenoid casing 111 is abutted on rear and bottom faces of the front frame bar 27 in a manner to receive it. As shown in Fig.10, bottom face of the solenoid casing 111 has at each of its front-right and front-left ends, a boss portion 116, which is tube-shaped and forms a vertical through hole. As shown in Fig.11, the front-end part of the solenoid casing 111 is secured on the bottom face of the front frame bar 27, by screws that are inserted through the boss portion 116 and are screwed on the front frame bar 27. The solenoid casing 111, which is arranged at right-left-wise center position in respect of the freezer door 36, has rounded ridges 117 having an arc-shaped vertical cross section, throughout ridges between front and bottom walls of the solenoid casing 111. The rounded

ridges 117 are for curbing injuring of a finger of user, which has been stuck between the freezer door 36 and the front-end part of the solenoid casing 111, at a time the user pushes in the freezer door 36 to its closed-up position. The rounded
5 ridges 117 are kind of chamfered portions.

As shown in Fig.12, the solenoid casing 12 has at its inside, a solenoid chamber 118 that is for receiving the electromagnetic solenoid 200 and is shaped as a recess upwardly opened. The solenoid chamber 118 has at its front wall, a
10 circular cut-out 119 upwardly opened; into which inserted is a bellow-holding fixture 120 that is a hollow cylinder opened to frontward and rearward. As shown in Fig.12, front-end portion of the bellow-holding fixture 120 is tapered to frontward to form a tapered portion 121. On rear-end portion of the
15 bellow-holding fixture 120, attached is a rear plate 122 that is circular and has a diameter larger than that of the fixture 120. On front-end portion of the bellow-holding fixture 120, attached is a front plate 123 that is rectangular and has a diameter larger than that of the fixture 120 as to form a structure
20 for engagement.

As shown in Fig.12, the solenoid casing 111 has right-hand-side and left-hand-side plates 125 and 124 at inside of the solenoid chamber 118, which are vertical and arranged to; come face-to-face with the front wall of the solenoid chamber
25 118 and be slightly distanced from it. In gaps from the front

wall of the solenoid chamber 118 to the plates 125 and 124,
the rear plate 122 of the bellow-holding fixture 120 is inserted
from above. Contacting of the rear plate 122 onto these plates
125 and 124 curbs rearward displacement of the bellow-holding
5 fixture 120; contacting of the rear plate 122 onto the front
wall of the chamber 118 curbs frontward displacement of the
bellow-holding fixture 120; and contacting of the front plate
123 onto bottom face of the solenoid casing 111 at outside of
the solenoid chamber 118 curbs circumferential displacement
10 of the fixture 120.

As shown in Fig.12, the solenoid casing 111 has on its
bottom face, a plurality of hollow cylindrical boss portions
126, at inside of the solenoid chamber 118. As shown in Fig.10,
the solenoid chamber 118 houses a coil casing 127, which is
15 shaped as an elongated rectangular box whose top and bottom
walls are omitted, and is thus comprised of front, rear,
right-hand-side and left-hand-side walls. As shown in Fig.12,
the coil casing 127 has a plurality of attaching portions 128,
which are hollow cylindrical and respectively fitted with outer
20 circumferential faces of the boss portions 126 as shown in Fig.10.
Inner circumferential faces of the boss portions 126 are engaged
with screws that have been brought from above; so that the coil
casing 127 is fixed within the solenoid chamber 118 by way of
fastening force of the screws.

25 As shown in Fig.10, within the coil casing 127 fixed is

a solenoid coil 129, which is hollow cylindrical and extends in front-rear direction, and starting end and finishing end of a spiral are connected with power-source lines 130. The power-source lines 130 are led out to outside of the solenoid chamber 118, through a common ditch 173 that is formed on bottom wall of the solenoid chamber 118 and is opened upward. The solenoid casing 111 has at its rear-left corner portion, an opening 131, through which the power-source lines 130 are led out to outside of the casing 111.

10 As shown in Fig.12, the power-source lines 130 are connected with a common electrical connector 132; which is arranged at outside of the casing 111 and coupled with a counterpart connector as to be connected with a power-source circuit. This power-source circuit is arranged within the machine room 17 on the insulator casing 1 and applies a driving power onto the solenoid coil 127 through the power-source lines 130 and relay contacts. These relay contacts are normally-open type and thus are kept as opened at a time a relay coil is Off-state without being fed with power; and then switched to be closed at a time the relay coil is switched to On-state by being fed with power. Thus, the solenoid coil 129 is supplied with power at the On-state of the relay coil and is not supplied with power at the Off-state.

25 As shown in Fig.13, a rear wall of the coil casing 127 has a circular through hole 133, through which the cylindrical

plunger 134 is inserted into the solenoid coil 129 as to be movable along a straight line in front-rear direction. The plunger 134 is formed of a magnetic material such as iron and is arranged in right-left-wise center of the freezer door 36.

5 Rear-end portion of the plunger 134 is attached with a circular-ring shaped flange element 135 that has a diameter larger than that of the plunger 134; and a stopper 136 is fixed within the solenoid casing 111, at rear of the flange portion 135.

10 As shown in Fig.13, outer circumferential face of the plunger 134 is fitted with a return spring 137, at between the flange element 135 and the rear wall of the coil casing 127. The return spring 137 is formed of a compressible coil spring, applies a rearward spring force to the plunger 134 at a time
15 the power is not applied to the solenoid coil so that the flange element 134 is kept in a rearmost position to contact with the stopper 136. At a time the solenoid is applied with power, a magnetic attractive force is applied from the solenoid coil 129 to the plunger 134 to move it frontward from the rearmost
20 position by overcoming the spring force of the return spring 137. As shown in Fig.14, frontward moving of the plunger 134 is stopped at a foremost position, at which each turn of wires are laterally abutted with adjacent ones. Then, at a time power supply is cut off, the plunger 134 is returned by the spring
25 force from the foremost position to the rearmost position to

abut on the stopper 136.

As shown in Fig.13, onto the solenoid casing 111, attached is a solenoid cover 138 formed of synthetic resin; which has as shown in Fig.10, a cover main body 139 shaped as a downward
5 opened cup, and a flange 140 that is formed around fringe of the cover main body 139 and has a plurality of through-holes 142. The flange 140 abuts on upper-end face of walls of the solenoid chamber 118 so that the solenoid cover 138 is secured thereon by screws that are inserted through the through-holes
10 142 as brought from the above. As shown in Fig.10, the cover main body 139 has a semicircular cut-out 141, which is opened downward and is combined with the opening 119 of the solenoid chamber 118 to form a circular opening 102 opened in front-rear direction as shown in Fig.13. In this circular opening 102,
15 fitted is the bellow-holding fixture 120 so that; inner face of the circular opening 102 abuts on outer face of the bellow-holding fixture 120 in a face-to-face contacting manner to make an air-tight sealing between them.

As shown in Fig.13, at between the flange 140 and the
20 upper-end face of the walls of the solenoid chamber 118, arranged and elastically sandwiched as held is a gasket 143 formed of rubber such as EPDM to make an air-tight sealing between the flange 140 and the upper-end face.

As shown in Fig.13, on front end of the plunger 134, attached
25 is rear end of the connector rod 144 extending in front-rear

direction; which is shaped as a solid cylinder coaxial with the plunger 134 and runs in front-rear direction; diameter of which is designed to be smaller than that of the plunger 134. The connector rod 144 runs through a hole of the front plate
5 of the coil casing 127 and further through the opening 102 of the solenoid chamber 118 and inside of the bellow-holding fixture 120 so that front end of the connector rod 144 comes front of the bellow-holding fixture 120. The solenoid casing 111 is attached on the front frame bar 27 in a manner that the connector
10 rod 144 is overlapped with the front frame bar 27 in a view seen in front-rear direction.

Outer circumferential face of the connector rod 144 is fitted with one end-portion of bellow 145 formed of rubber, which is a hollow tube having a circular cross section and
15 diameter gradually increasing from the one-end portion to other-end portion. As shown in Fig.13, the other-end portion of the bellow 145 is a grab portion 146 that is a hollow tube having a circular cross section and diameter gradually increasing from front to rear and is squeezingly fitted with
20 outer circumferential face of tapered part 121 of the bellow-holding fixture 120. A bellow-presser member 147 is fitted to the tapered part 121 as to clamp and secures the grab portion 146 of the bellow 145 so as to curb turning of the grab portion 146 in circumferential direction.

25 As shown in Fig.13, on the one-end portion of the bellow

145, arranged is a rectangular rod cover 148, which closes up the one-end portion of the bellow 145; and thus, the opening 102 of the solenoid chamber 118 and inside of the bellow-holding fixture 120 are air-tightly closed up, by the bellow 145, so as to curb entering of moisture from outside. Thus, inside of the solenoid chamber 118 is sealed off from outside by three members--the solenoid cover 138, the gasket 143 and the bellow 145. Into the rod cover 148, squeezingly fitted is a head 149 that is formed on front end of the connector rod 144. The front end of the connector rod 144 is connected with the one-end portion of the bellow 145 as to curb rotation between them, by a squeezing force between the rod cover 148 and the head 149; so that rotation of the connector rod 144 is curbed by the bellow 145 and the bellow-holding fixture 120.

As shown in Fig.13, at a time the plunger 134 is kept at its rearmost position, the bellow 145 is folded back at its intermediate portion so that the one-end portion and the other-end portion of the bellow 145 are arranged to be front of the bellow-holding fixture 120; and as shown in Fig.14, in accordance with frontward and rearward moving of the plunger 134, such folded-back line is transmitted to frontward and rearward respectively; by elastic deformation of the bellow 145 so as to allow frontward and rearward moving of the plunger 134 at between its foremost and rearmost positions.

As shown in Fig.12, on bottom plate of the solenoid casing

111, arranged are right-hand-side and left-hand-side vertical partition walls 151 and 150; each of which runs in front-rear direction, rear end of each of which is attached on front wall of the solenoid chamber 118, and front end of each of which is attached on front-end wall of the solenoid casing 111. These vertical partition walls 151 and 150 are opposed to and spaced apart with each other in a manner to form a push-rod-housing chamber 152.

As shown in Fig.12, at inside of the push-rod-housing chamber 152, arranged is a push rod 153; which is formed of synthetic resin and has a pusher 154, an arm 155 and a connector 156. The connector 156 is shaped as a vertically elongated hollow rectangular column having a bottom wall and has a cut-out 157 opened to upward at rear side of the hollow rectangular column. As shown in Fig.13, into the cut-out 157, inserted is front-end portion of the connector rod 144, by being brought from the above. The connector rod 144 is connected with the connector 156 as a result that the head 149 and the rod cover 148 of the bellows 145 are engaged with inner face of the connector 156.

The pusher 154 is shaped as a solid rectangular column running in front-rear direction; and is arranged in right-left-wise center of the freezer door 36 as shown in Fig.15. As shown in Fig.13, the pusher 154 is arranged in a height position lower than that of the connector rod 144; and is arranged at

between the bottom face of the front frame bar 27 and the bottom face of the solenoid casing 111 so as to be overlapped with the front frame bar 27 on a plan view seen from vertical direction, at a time the electromagnetic solenoid 200 is in OFF-state.

5 The arm 155 connects the connector 156 with the pusher 154 and is shaped as a horizontal board elongated in front-rear direction.

As in the above, the pusher rod 153 is a member separate to the connector rod 144 and is pushed through the connector
10 rod 144; thus, omitted are; aligning of axes between the plunger 134 and an actuator on inner face of the door; and bending processing of the pusher for arranging in a predetermined position. Thus, position of arranging the solenoid 200 is adjustable; and the solenoid 200 is arranged in an idle space
15 at rear of the front frame bar 27.

As shown in Fig.10, the pusher 154 has as its portion, a hollow cushioning portion 158, which is exposed to frontward by an opening 159 of the solenoid casing 111 and is formed of a cushioning material such as rubber, which is softer than
20 materials for remaining part of the pusher 158 and an inner plate 41 of the freezer door 36. If and when the solenoid coil 129 is non-active or not energized, the pusher 154 is kept at its rearmost position so that front face of the cushioning portion 158 is located more rearward than front face of the
25 front plate 21 and than front face of the front-end wall of

the solenoid casing 111. As shown in Fig.14, if and when the solenoid coil 129 is activated at a time the freezer door 36 is closed, the pusher 154 moves forward as coming out through the opening 159 of the solenoid casing 111 so as to push forward the freezer door 36 at its right-left-wise center portion. The cushioning portion 158 alleviates impact of collision between the pusher 154 and the inner plate 41 of the freezer door 36. Attractive forces of the locking magnets 51 and electromagnets 37 applied on the freezer door 36 are overcome by pushing force of the pusher 154 so that the freezer door 26 is pushed forward from its closed-off position. As shown in Fig.5, upper half of the pusher 154 is a gasket-pressing part 160; and is opposed to and slightly distanced from inner sealing part 50 of the door sealing gasket 45 at a time the pusher 145 is in its rearmost position. Front-end face of the pusher 154 is divided into the gasket-pressing part 160 and a door-pressing part 161, which is opposed to and slightly distanced from fringe-rib protrusion 52 of the freezer door 36. At a time the solenoid coil is activated, the plunger 134 moves forward from its rearmost position to frontward so that the freezer door 36 travels forward from its closed-up position as being pushed by the pusher 154. Motion of the pusher 154 is as follows.

As shown in Fig.5, if and when the solenoid coil 129 is activated, the gasket-pressing part 160 abuts on the inner sealing part 50 and presses it to be deformed at a timepoint

prior than abutting of the door-pressing part 161 onto the fringe-rib protrusion 52. The door-pressing part 161 presses the door 36 at a time the sealing part 50 has been deformed, so as to detach the locking magnet 51 of the door 36 from the front plate 21 and detach the two magnetic plates from the electromagnets 37, and thus to move the door 26 frontward from the closed-up position, as shown in Fig.16. At a time the door-pressing part 161 abuts on the fringe-rib protrusion 52, the upper half of the cushioning portion 158 is opposed to and slightly distanced from the gasket attaching face 44 so that the inner sealing part 50 would not completely be collapsed by pressing with the gasket-pressing part 160.

As shown in Fig.12, the left-hand-side vertical partition wall 150 of the solenoid casing 111 has a front-left guide 162 and a rear-left guide 163; and the right-hand-side vertical partition wall 151 has a front-right guide 164 and a rear-right guide 165. Each of these guides 162-165 juts into the push-rod-housing chamber 152 and has a bottom face that is slightly distanced from bottom face of the casing 111. The front-right and front-left guides 164 and 162 are opposed to each other and the rear-right and rear-left guides 165 and 163 are opposed to each other, as to sandwich the arm 55 from right-left direction. At a time of frontward and rearward moving of the plunger 134, the arm 155 is guided by the four guides 162-165 so as to achieve moving along a straight line.

Fig.13 shows the plunger 134 in its rearmost position; and Fig.14 shows the 134 in its frontmost position. The arm 155 is always placed within the solenoid casing 111, the four guides 162-165 do not touch with the pusher 154 and solely guide the arm 155.

5 As shown in Fig.3, the solenoid casing 111 is covered by a casing cover 166, in order to keep out cooled air and outside force and to improve safety by curbing of touching of user's hand on power source part. As shown in Fig.4, the casing cover 166 has a top plate, right-hand-side and left-hand-side plates
10 and a front plate; and upper side of the solenoid casing 111 is closed up by the casing cover 166. As indicated in Fig.10, each of the right-hand-side and left-hand-side plates of the casing cover 166 has a claw 167 at front-rear-wise center of dimension of the solenoid casing 111. Each of the two claws
15 167 juts out toward right-left-wise center of the solenoid casing 111 and is inserted into an engagement recess 168 that is formed on the solenoid casing 111 to be opened to downward and has a top face, with which the claw 167 is engaged. Such engaging curbs coming off of the casing cover 166 from the solenoid casing
20 111. Thus, upper side of the solenoid casing 111 is closed up by two elements---the front frame bar 27 and the casing cover 166.

 As shown in Fig.3, on front-end of the casing cover 166, arranged is a positioning protrusion 169, which juts out from
25 the top plate to downward and is shaped as a vertical plate

extending in right-left direction. The positioning protrusion 169 engages with a positioning recess 170, which is formed on the front frame bar 27. The casing cover 166 is kept at a target position by engaging force between the positioning protrusion
5 169 and the positioning recess 170.

As shown in Fig.11, the solenoid casing 111 has on its bottom face, a plurality of left-hand-side drain holes 171 and a plurality of right-hand-side drain holes 172; through which dew condensation water in the pusher-rod chamber 152 is
10 discharged to outside of the solenoid casing 111 when dew condensates in the chamber 152. As shown in Fig.12, each of the drain holes 171 and 172 is shaped as a straight-line slit; and each of the left-hand-side drain holes 171 runs rightward as starting from the left-hand-side vertical partition wall
15 151 while each of the right-hand-side drain holes 172 runs leftward from the right-hand-side vertical partition wall 152. The door-opening device 110 is constructed as explained hereto and mounted in the insulator casing 1 by following procedures.

As shown in Fig.4, the horizontal seat face 112 of the
20 solenoid casing 111 is placed on the horizontal receiving face 64 of the outlet 63 for the top-tier freezer container 55; and then, the slope 113 of the solenoid casing 111 is pressed on surface of the outlet 63. In such state, screws are inserted from downward through the two boss portions 116 of the solenoid
25 casing 111 and are screwed into the front frame bar 27 so that

rear face of the frame bar 27 is abutted with the solenoid casing 111 in front-rear direction. If and when each of the seat face 112 and the slope 113 is contacted with the outlet 63 that is for the top-tier freezer container 55, positioning of the solenoid casing 111 with respect to the front frame bar 27 in front-rear direction is achieved and thus, the screws inserted through the two boss portions 116 are easily arranged to their target positions.

After such fixing of the solenoid casing 111 onto the front frame bar 27; the positioning protrusion 169 of the casing cover 166 is inserted from upward into the positioning recess 170 of the solenoid casing 111; and then, while keeping such engagement between the protrusion 169 and the recess 170, rear-end portion of the casing cover 166 is pushed downward so that each of the two claws 167 pushes on and causes elastic deformation of a side plate of the solenoid casing 111, and then latched in the engagement recess 168. In such engaged or latched state, positioning of the casing cover 166 with respect to the solenoid casing 111 in front-rear direction is achieved; so that the claws 167 are easily aligned with the respective engagement recesses 168.

As shown in Fig.1, within the insulator casing 1 and at above the machine room 17, arranged as secured is a wiring-board box 171 that houses a controller wiring board, on which a controller circuit is mounted. The controller circuit is

chiefly formed of a microcomputer, has a CPU, a ROM and a RAM;
is electrically connected with the door switch 70 and the button
switch 94, determines whether the freezer door 36 is closed
or not by use of output signal from the door switch 70 and
5 determines whether the manual-operation switch 86 is pushed
in or not by use of output signal from the button switch 94.
The controller circuit is connected with a relay coil and
switches between energizing and non-energizing of the relay
coil in response to ON-OFF-state of the door and button switches
10 70 and 94 so that relay contacts are opened and closed so as
to achieve an ON-OFF controlling of the solenoid coil 129.

Fig.17 is a flowchart indicating a control program that
is prestored in the ROM on the control circuit. At a time power
is supplied, the CPU of the control circuit determines whether
15 the door switch 70 is activated or not, in step S1. For example,
if and when the freezer door 36 is in its closed-off position,
it is determined that the door switch 70 is ON-state, in the
step S1; and then timer T1 is reset to "0", at step S2. The
timer T1 counts a time lapsed from a timepoint the freezer door
20 36 has traveled to the closed-up position. The CPU activates
a timer-interrupt processing at a predetermined time interval;
and a predetermined unit value is added to a value on the timer
T1 at each time the timer interrupt processing is activated.

If and when resetting of the timer T1 has been made at
25 the step S2, it goes to step S3 and is determined whether the

door switch 70 is OFF-state or not, by the CPU. For example, the user has pulled out the freezer door 36 without pressing the manual-operation switch 86, and then the door switch 70 is switched from ON-state to OFF-state. Then, the CPU
5 determines that the door switch 70 is in OFF-state and it returns to Step 1. At a time the freezer door 36 is pushed back to the closed-off position in such OFF-state, it is determined that the door switch 70 is ON-state and resetting of the timer T1 to "0" is made at step S2.

10 At step S3, the CPU determines that the door switch 70 is not in OFF-state if and when the freezer door 36 is in the closed-up position; and at step S4, the CPU determines whether the button switch 94 is ON-state in or not. For example, at a time the user presses the manual-operation button 86 at a
15 state the freezer door 36 is at its closed-up position; then at Step 4, it is determined that button switch 94 is switched to ON-state; and at step S5, a value on the timer T1 after addition is compared with a motion inhibition time TW. This motion inhibition time TW is 1.5 second for example, and is prestored
20 in the ROM. If and when it is determined by the CPU in step S5, that the value on the timer T1 has not reached the motion inhibition time TW, it returns to step S3. Thus, if and when the user presses the manual-operation switch 86 and in same time pushes the freezer door 36 to the closed-up position; then,
25 the button switch 94 is activated to take ON-state while the

value on the timer T1 has not reached the motion inhibition time TW. In such occasion, such activation or ON-state of the button switch 94 is overridden to skip off activation of the door-opening device 110.

5 After the value on the timer T1 is determined to having reached the motion inhibition time TW; the relay coil is activated to start energizing of the solenoid coil 129, at step S6; and then, resetting of a timer T3 is made to take a value of "0", at step S7. This timer T3 counts a time lapsed from
10 a timepoint the solenoid coil 129 is activated. The CPU activates a timer-interrupt processing at a predetermined time interval; and a predetermined unit value is added to a value on the timer T3 at each time the timer-interrupt processing is activated.

15 After resetting of the timer T3 is made at step S7, it is determined by the CPU whether the door switch 70 is OFF-state or ON-state. For example, unless a pressing force surpassing that of the pusher 154 is applied on the freezer door 36, the solenoid coil 129 is started to be energized and thus the freezer
20 door 36 travels to forward from the closed-up position. Then, the CPU determines that the door switch 70 is in OFF-state, at step S8, and then it goes to step S9.

 After it is determined that the door switch 70 is in OFF-state at step S8; then, at step S12, the value on the timer
25 T3 after addition is compared with an expected limit value Tf,

which has been set for averting extraordinary rising of temperature that would otherwise be caused by continuous energizing of the solenoid coil 129. At a time the pressing force surpassing that of the pusher 154 is applied, the freezer door 36 would not travel to forward from the closed-up position and the solenoid coil 129 is continuously energized until reaching the expected limit time T_f . If the pressing force is removed until reaching the expected limit time T_f , the freezer door 26 travels to frontward by being pushed with the pusher 154. Then, it is determined at the step S8, that the door switch 70 is in OFF-state, and it goes to the step S9.

If the freezer door 36 has not traveled to frontward even after elapsing of the expected limit time T_f ; then, it goes from step S12 to step S11 so that the relay coil is deactivated and energizing of the solenoid coil 129 is stopped.

After going to step S9, resetting of a timer T2 is made by the CPU to take a value of "0". The timer T2 counts a time lapsed from a timepoint the door switch 70 is deactivated. The CPU activates a timer-interrupt processing at a predetermined time interval; and a predetermined unit value is added to a value on the timer T2 at each time the timer interrupt processing is activated.

After the resetting at step S9, a value on the timer T2 after addition is compared with an energization time T_e ($<T_f$), which is prestored in the ROM and tantamount to a time required

to move the plunger 134 from its rearmost position to its foremost position. If it is determined at step S10, that the value on the timer T2 has reached the energization time T_e , it goes to step S11; at which energizing of the solenoid coil 129 is stopped
5 by deactivating the relay coil. At a time the energizing has stopped, the freezer door 36 has been moved to forward from the closed-up position; thus, the user is able to pull out the freezer door 36 to its fully-opened position by grabbing the handle 66 of the door 36.

10 Fig.18 shows a time wise relationship among ON-OFF of the button switch 94, ON-OFF of the solenoid coil 129, ON-OFF of the door switch 70 and opening and closing of the freezer door 36. As starting from a state the freezer door 36 is in its closed-up position; the manual-operation switch 86 is
15 pressed to activate the button switch 94; then, the solenoid coil 129 is activated in synchronization with activating of the button switch 94; and thereafter, the door switch 70 detects frontward moving of the door 36 at a timepoint later than activating of the solenoid coil 129.

20 If the manual-operation switch 86 is pressed in at a time the freezer door 36 is in its opened-up position; the button switch 90 is not activated because no sufficient magnet force is applied to detection sphere of the button switch 94 from the button magnet 90. Thus, no activation is made to the solenoid
25 coil 129 and thus to the door-opening device 110. If pushing

in of the door 36 is made simultaneously with pressing in of the manual-operation switch 86, activating of the button switch 94 is detected at a timepoint the door switch 70 is switched from OFF-state to ON-state. Then, the value on the timer T1
5 after addition does not reach the motion inhibition time T_w ; and thus, the door-opening device 110 is not activated because even when the button switch 94 is activated by pressing the manual-operation switch 86, the solenoid coil 129 would not be activated. Only after that the value on the timer T1 reaches
10 the motion inhibition time T_w ; the solenoid coil 129 is activated by pressing of the manual-operation switch 86.

The first embodiment mentioned hereto has advantage as below. The solenoid chamber 118 is hermetically closed by the solenoid cover 138 except for inside of the bellow-holding
15 fixture 120; and the inside of the fixture is hermetically closed by the bellow 145 that covers not from frontward only the bellow-holding fixture 120 but also the connector rod 144; thereby curbing of entering of moisture from outside. Hence, curbed is ice formation on the electromagnetic solenoid 200
20 and thus malfunction of the plunger 134; and the freezer door 36 is surely moved to frontward from the closed-up position at a time the manual-operation switch 86 is pressed in and the door 36 is at its closed-up position. Moreover, the bellow 145 is elastically deformed in accordance with progress of
25 traveling of the connector rod 144 in front-rear direction;

hence, curbed is deterioration of
hermetically-sealed-off-state of the solenoid chamber 118 due
to rupturing of the bellow 145.

 The bellow 145, which is adopted for hermetically closing
5 the inside in respect of the bellow-holding fixture 120, is
folded back at somewhere between its front and rear ends in
a manner that front-rear dimension is varied in accordance with
traveling of the connector rod 144. Thus, the bellow 145 is
deformed in a manner that folding-back line on the bellow 145
10 travels so as to allow traveling of the connector rod 144. Hence,
curbed is stress concentration on any definite point on the
bellow 145 on course of travelling of the connector rod 144.
Meanwhile, the connector rod 144 has the head 149 shaped as
an elongated rectangle; the bellow 145 has the rectangular rod
15 cover 148; and the head 149 is forcefully fitted into the rod
cover 148; so that outer circumferential face of the head 149
is tightly fitted with inner circumferential face of the rod
cover 148. Hence, rotating of the bellow 145 with respect to
the connector rod 144 is prevented so that rupturing of the
20 bellow 145 due to its twisting about the connector rod 144 is
prevented.

 The bellow-holding fixture 120 has the rectangular front
plate 123 that makes surface-to-surface contact with bottom
face of the solenoid casing. Hence, rotating of the bellow
25 145 about its axis with respect to the solenoid casing 111 is

prevented so that rupturing of the bellows 145 due to its twisting about solenoid casing 111 is prevented. Meanwhile, the pusher 154 is arranged to press the right-left-wise center of the freezer door 36; thus, the freezer door 36 smoothly travels to frontward without wagging and clattering, after the solenoid 200 is activated at the closed-up position of the door 36.

The solenoid casing 111 is attached with the front frame bar 27 in a manner that the connector rod 144 is overlaid by the front frame bar 27 in a view seen from frontward. Thus, the solenoid casing 111 does not largely interfere with the top-tier freezer container 55 in the freezer chamber 25 or with the ice box 31 in the ice-maker chamber 25; and thereby minimized is diminishing of capacities of the top-tier freezer container 55 and the ice box 31. Moreover, the arm 155 connects the pusher 154 with the connector rod 144 in a manner that; the pusher 154 is positioned to be overlaid by the front frame bar 27 in a view seen from upward at a time the solenoid 200 is not activated. Thus, pressing of the pusher 154 on the freezer door 36 is smoothly made even with the connector rod 144 is overlaid by the front frame bar 27 in a view seen from frontward.

The pusher 154 has the cushioning portion 158; thus, impact of colliding of the pusher 154 on the freezer door 36 is alleviated. Hence, curbed are damaging and impact noise that would be caused by the colliding. Meanwhile, front end of the cushioning portion 158 is located more rearward than front face of the

front plate 21 at a time the solenoid 200 is not activated. Thus, the cushioning portion 158 does not jut out from the front face of the front plate 21 at a time the door 36 is in its opened-up position; and hence, food articles would not contact with the cushioning portion 158 at a time of taking out and taking in
5 of the food articles.

The pusher 154 is connected with the connector rod 144 in a manner that the front face of the cushioning portion 158 is located more rearward than front face of front-end wall of the solenoid casing 111 at a time the solenoid 200 is not energized.
10 Thus, contacting between the cushioning portion 158 and the food articles is further curbed. The front-end wall of the solenoid casing 111 is located more frontward than the cushioning portion 158; nevertheless, the solenoid casing 111 has a rounded
15 corner having an arc section at between bottom and front-end walls of the casing 111; and thus, curbed is injuring of a hand or fingers of the user at a time of taking in and out of the food articles to and from the main, middle-tier and top-tier freezer containers 53-55.

20 Bottom wall of the pusher-rod-chamber 152 has right-hand-side and left-hand-side drain holes 172 and 171. Thus, dew water is discharged from the chamber 152 to its outside at a time dew is formed in the chamber 152. Thus, curbed is ice formation on the pusher 154 and the arm 155, which would
25 otherwise cause malfunction. Moreover, each of the

right-hand-side drain holes 172 extends from the right-hand-side vertical partition wall 151; and each of the left-hand-side drain holes 171 extends from the left-hand-side vertical partition wall 150. Thus, the dew water is hard to
5 be remained in the pusher-rod-chamber 152; and hence, malfunction due to ice-formation on the pusher 154 and the arm 155 is surely prevented.

Trajectory of the arm 155 is stabilized by the front-left and rear-left guides 162 and 163 arranged on the left-hand-side
10 vertical partition wall 150 and by front-right and rear-right guides 164 and 165 on the left-hand-side vertical partition wall 151. Moreover, each of these guides 162-165 is distanced from bottom face of the pusher-rod-chamber 152; thus, flow of dew water is not disrupted by any of the guides 162-165 to achieve
15 reliable discharge of the dew water. Meanwhile, the solenoid casing 111 has the horizontal seat face 112 that is received by the receiving face 64 of the outlet 63 for the top-tier freezer container and has the slope 113 that abuts on an inclined face on the outlet 63; thus, flow of cooled air from the outlet 63
20 is not disturbed by the solenoid casing 111, and the solenoid casing 111 is stably supported on the outlet 63.

When the solenoid coil 129 of the solenoid 200 is supplied with power at a time the door 36 is in its closed-up position, the pusher 154 travels to forward and then, on first hand, its
25 gasket-pressing part 160 presses and deforms the inner sealing

part 50 of the door-sealing gasket 45 so that inside of the freezer chamber 24 is communicated with the outside so as to diminish negative pressure in the chamber 24. Thereafter, the door-pressing part 161 of the pusher 154 directly presses the fringe-rib protrusion 52 of the freezer door 36, not via the door-sealing gasket 45; and thereby, takes off the locking magnet 51 of the door-sealing gasket 45 from the front plate 21 as to push out the freezer door 36 to frontward. Hence, pressing force applied to the door-sealing gasket 45 is smaller than a case the pusher 145 pushes the freezer door 36 via the door-sealing gasket 45; and thus, curbed is plastic deformation of the door-sealing gasket 45 due to being repeatedly pressed.

<Second Embodiment>

As shown in Fig.19, a planar seat face 181 is arranged on the inner plate 41 of the freezer door 26 in place of the fringe-rib protrusion 52 in the first embodiment. At a time the door 36 is in its closed-up position, the seat face 181 comes to front of a plane of front face of the inner sealing part 50 of the gasket 45 and comes to front of a plane of non-fringe part of inner face of the inner plate 41. When the solenoid coil 129 is energized at a time the door 36 is in its closed-up position; then, the gasket-pressing part 160 of the pusher 154 presses and deforms the gasket 45 in a manner that inside of the chamber 24 is communicated with the outside to diminish the negative pressure in the chamber 24 at a time prior than

that the door-pressing part 161 presses the seat face 181.

Such pressing by the door-pressing part 161 is made at a time the inner-sealing part 50 is elastically deformed; and as shown in Fig.20, inner-sealing part 50 is deformed as inclined to forward about the outer sealing part 45; resultantly, a frontward force for taking off the locking magnet 51 is applied from the inner-sealing part 50 to the locking magnet 51. The door-pressing part 61 presses the seat face 181 to frontward at a time such force for taking off is applied to the locking magnet 51. Thus, the locking magnet 51 is easily taken off from the front plate 21; and the freezer door 36 is easily moved to frontward from the closed-up position. At a time the door-pressing part 161 abuts on the seat face 181 of the door 36 by way of the cushioning part 158; upper half of the cushioning part 158 is opposed to and distanced from the gasket-attaching face 44 of the inner plate 41; and the inner-sealing part 50 is pressed by the pusher 154 so as to be not completely collapsed.

<Third Embodiment>

As shown in Fig.21, the solenoid casing 111 has on its bottom face, a bottom heater 191 as fixed thereon, which is shaped as a sheet and is formed of a pair of aluminum sheets and a heating wire 192 sandwiched between these sheets. In the solenoid casing 111, the solenoid 200 is arranged as fixed to cover the bottom heater 191. As shown in Fig.22, the solenoid cover 183 has on its top face, a top heater 193 as fixed thereon,

which is shaped as a sheet and is formed of a pair of aluminum sheets and a heating wire 192 sandwiched between these sheets. The solenoid 200 is arranged within the solenoid chamber 118, at between the top and bottom heaters 193 and 191.

5 The heater wires 12 of the top and bottom heaters 193 and 191 are connected with a common heater-activating circuit that is connected to the control circuit. By the control circuit, the heater-activating circuit is driven in accordance with a pattern prestored in the ROM so that on-off of the top and bottom
10 heaters 193 and 191 is made according to a constant pattern that is common to the top and bottom heaters 193 and 191, which are for heating the solenoid.

Fig.23 is a flowchart showing a detail of a timer interrupt processing of the control circuit. The timer interrupt
15 processing is launched by the CPU at a constant time interval ΔT ; and the main processing shown in Fig.17 is temporarily stopped during the timer interrupt processing, and is restarted after completing of the timer interrupt processing.

At step S21 of Fig.23, it is determined by the CPU, whether
20 a heater-energization flag on the RAM is ON-state or not. The heater-energization flag is switched to OFF-state when the top and bottom heaters 193 and 191 are deactivated, and is switched to ON-state when the top and bottom heaters 193 and 191 are activated. If the heater-energization flag is determined to
25 be OFF-state, it goes to step S22.

At the step S22, it is determined by the CPU, whether a door-open flag on the RAM is ON-state or not. The door-open flag is switched to ON-state when it is determined at step S11 on Fig.17, that the door switch 70 is OFF-state as a result of activating the solenoid coil 129 at the step S6. If the door-open flag is determined to be ON-state at the step S22 on Fig.23, it goes to step S23, at which the top and bottom heaters 193 and 191 are activated. Then, resetting of a timer T4 on the RAM is made to take a value of "0"; and the heater-energization flag is switched to ON-state.

When the user presses the manual-operation button 86 at a time the door 36 is closed-up, the solenoid coil 129 is energized to activate the door-opening device 110 so that the door 36 travels to forward from its closed-up position. Opening of the door 36 allows that air from the outside enters into the freezer chamber 24 to thereby possibly contact with surface of the bellow 145. Inside of the bellow 145 is continuous with inside of the solenoid chamber 118 and is sealed off from its outside. Thus, when the air contacts a surface of the bellow 45, dew formation is occurred on the surface. Hence, when the door 36 is moved to its closed-up position at a time the dew is attached on the surface; the dew or dew water would be frozen to form a frost or ice so that the front-rear traveling of the plunger 134 would be stalled because inside of the freezer chamber 24 is cooled by air discharged from an outlet and the

outlets 60-63 on the cooled-air duct 59, respectively for top part of the freezer camber, the ice-maker chamber and the main, middle-tier and top-tier freezer container. Nevertheless, at a time the door 36 travels frontward from its closed-up position
5 by activating of the solenoid coil 129, the top and bottom heaters 193 and 191 are energized and air at inside of the solenoid chamber 118 is heated. Thus, formation of frost or ice on surface of the bellow 145 is curbed.

If the heater-energization flag is determined to be
10 ON-state, it goes from the step S21 to step S26, at which the value on the timer T4 is added by a unit time ΔT . The timer T4 counts a time lapsed from a timepoint the top and bottom heaters 193 and 191 are switched to be energized. After such addition is made at step S26, it goes to step S27, at which
15 the value on the timer T4 after the addition is compared with a limit time L1 that is prestored in the ROM. If it is determined that " $T4 \geq \text{limit time } L1$ " holds; then, it goes to step S28, at which the top and bottom heaters 193 and 191 are deactivated. Then, it goes to step S29, at which the heater-energizing flag
20 is switched to OFF-state.

The top and bottom heaters 193 and 191 are deactivated when the limit time L1 is elapsed from the timepoint the door switch 70 is deactivated. The limit time L1 is set as a time required for raising temperature in the solenoid chamber 118
25 to a level no dew formation is made on surface of the bellow

145; and inside of the solenoid chamber 118 is heated by the heaters 193 and 191, only for a period the dew is possibly formed on surface of the bellow 145.

The third embodiment mentioned hereto has following
5 advantages. The top and bottom heaters 193 and 191 are arranged within the solenoid chamber 118; thus, curbed are frost or ice formation and stalling of the plunger 134 of the solenoid 200 due to the frost or ice formation. Moreover, if and when the solenoid 200 is activated, the top and bottom heaters 193 and
10 191 are activated. Thus, the heaters are activated and deactivated in synchronization respectively with; beginning and ending of a period, during which probability of the dew formation is large. Hence, energizing of the top and bottom heaters 193 and 191 is not initiated at a time period, during
15 which heating is not needed. In this way, power consumption of the heaters 193 and 191 is trimmed down; and in same time, the frost or ice formation is curbed.

Deactivation of the heaters 193 and 191 is made at a timepoint the limit time L1 is elapsed from a timepoint the
20 heaters 193 and 191 are activated. Thus, the energizing of the heaters 193 and 191 is made only during the period having large probability of dew formation. Hence, power consumption of the heaters 193 and 191 is also trimmed down in this point of view.

25 In the third embodiment, the top and bottom heaters 193

and 191 may be energized on full-time base. Then, the on-off control is made on energizing of the top and bottom heaters 193 and 191 in a manner that; temperature signal outputted from a temperature sensor arranged in the solenoid chamber 118 is
5 converged to a constant value.

When the heaters 193 and 191 are energized on full-time base, energizing of these heaters may be made in accordance with operation status of the compressor 18. For example, the energizing is made at an energization ratio "A" for a period
10 the compressor 18 is in operation and at an energization ratio "B" for a period the compressor 18 is not in operation.

In the third embodiment, the limit time L1 may be set to be an average time period required for the user to pull out the freezer door 36 to the fully-opened position, take out and
15 in the food articles and returning the freezer door 36 to the closed-up position. In other words, the top and bottom heaters 193 and 191 may be energized only for a period the door 36 is assumed to be not in the closed-up position.

<Fourth Embodiment>

20 Fig.24 shows a detail of an alternate timer interrupt processing executed by the CPU in place of that in Fig.23. If the heater-energization flag is ON-state, it goes from the step S21 to a step S31, at which it is determined that the door switch 70 is ON-state or not. If determined to be ON-state, it goes
25 to step S28, at which the top and bottom heaters 193 and 191

are deactivated; then, it goes to step S29, at which the heater-energization flag is switched to be OFF-state. Thus, the top and bottom heaters 193 and 191 are deactivated at a time the user causes the door 36 to travel back to the closed-up position; hence, inside of the solenoid chamber 118 is heated only for a period ranging from a timepoint the door 36 is pushed frontward by energizing of the solenoid coil 129 to a timepoint the door 36 is closed up.

The fourth embodiment has following advantages. At a time the solenoid 200 is actuated, the top and bottom heaters 193 and 191 are activated; and at a time the door switch 70 is activated, the top and bottom heaters 193 and 191 are deactivated. Thus, the heaters 193 and 191 are energized only for a period having a high probability of forming dew on surface of the bellow 145; hence, the frost or ice formation on the surface of the bellow 145 is curbed and in same time, power consumption of the heaters 193 and 191 is trimmed down.

<Fifth Embodiment>

Fig.25 shows a detail of another alternate timer interrupt processing executed by the CPU in place of that in Fig.23. If the heater-energization flag is ON-state, it goes from the step S21 to a step S31, at which it is determined that the door switch 70 is ON-state or not. If determined to be ON-state, it goes to the step S28, at which the top and bottom heaters 193 are deactivated; then, it goes to step S29, at which the

heater-energization flag is switched to be OFF-state.

If determined to be in OFF-state at step S31 by the CPU,
it goes to the step S27, at which the value on the timer T4
after the addition is compared with a limit time L1 that is
5 prestored in the ROM. If it is determined that "T4 $\geq$ limit
time L1" holds; then, it goes to step S28, at which the top
and bottom heaters 193 and 191 are deactivated. Then, it goes
to step S29, at which the heater-energization flag is switched
to OFF-state. Thus, the heaters are activated in
10 synchronization with initiating of frontward moving of the door
36 from its closed-up position by activating the solenoid coil
129; and the heaters are deactivated at a time the door 36 comes
to its closed-up position, or at a time the limit time L1 is
elapsed from the activation of the solenoid coil 129.

15 The fifth embodiment has following advantages. Even when
the limit time L1 is elapsed since activation of the solenoid
coil 129, the heaters 193 and 191 are not energized if the door
switch 70 is not activated. Thus, when temperature of the
solenoid chamber 118 rises to a level no dew formation is made
20 on surface of the bellow 145, the heaters 193 and 191 are
deactivated even if the door 36 is not in its closed-up position.
Hence, it is curbed that time period for energizing the heaters
193 and 191 becomes unnecessarily long; and thereby, power
consumption of the heaters 193 and 191 is trimmed down.

25

<Sixth Embodiment>

Fig.26 shows a detail of a further alternate timer interrupt processing executed by the CPU in place of that in Fig.23. If the heater-energization flag is ON-state, it goes from the step S21 to a step S41, at which it is determined whether
5 a heater-off-waiting flag on the RAM is ON-state or not. The heater-off-waiting flag is for determining a deactivation timing, at which the top and bottom heaters 193 and 192 are deactivated. If determined to be OFF-state, it goes to step S31, at which the top and bottom heaters 193 are deactivated;
10 then, it goes to step S31, at which it is determined whether the door switch 70 is ON-state or not.

If determined to be ON-state of the door switch 70 at the step S31, it goes to step S42, at which resetting of the timer T5 is made to take a value of "0"; then, at step S43,
15 the heater-off-waiting flag is switched to ON-state. If the heater-off-waiting flag is determined to be ON-state at the step S41; it goes to step S44, at which the value of the timer T5 is added by a unit time ΔT . Then, it goes to step S45, at which the value on the timer T5 after the addition is compared
20 with a limit time L2 that is prestored in the ROM. If it is determined that " $T5 \geq \text{limit time } L2$ " holds; then, it goes to step S28, at which the top and bottom heaters 193 and 191 are deactivated. Then, it goes to step S29, at which the heater-energization flag is switched to OFF-state. Thus, the
25 heaters are activated in synchronization with initiating of

frontward moving of the door 36 from its closed-up position by activating the solenoid coil 129; and the heaters are deactivated at a time the limit time L2 is elapsed from a time point the door 36 has returned to the closed-up position.

5 The sixth embodiment has following advantages. The top and bottom heaters 193 and 191 are deactivated when the limit time L2 is elapsed from activation of the door switch 70. Thus, after the door 36 is moved back to its closed-up position, inside of the solenoid chamber 118 is heated by the top and bottom
10 heaters 193 and 191 for a time period as long as the limit time L2. Hence, the probability of averting the dew formation on surface of the bellow 145 becomes even higher; and frost or ice formation becomes even harder to be occurred.

<Seventh Embodiment>

15 At inside of the freezer chamber 24, arranged as fixed is a temperature sensor, which is formed of thermistor that outputs a temperature signal at a level depending on temperature in the chamber 24. The control circuit determines the temperature in the chamber 24 from the outputted temperature
20 signal and controls operation of a motor powering the compressor 18. Fig.27 shows a detail of a still further alternate timer interrupt processing executed by the CPU in place of that in Fig.23. If a door-opened flag is determined to be ON-state at step S22, it goes to a step S51, at which the temperature
25 in the freezer chamber 24 is determined from the temperature

signal.

After determining the temperature, it goes to step S52, at which thus determined temperature is compared with a dew formation value that is prestored in the ROM. The dew formation value is set to be a threshold value of temperature that does or does not cause dew formation on surface of the bellow 145 at a time the door 36 has been moved forward from the closed-up position. If it is determined by the CPU at step S52, that "detected temperature in the chamber $\geq$ dew formation value" holds; then, it goes to step S23, at which the top and bottom heaters 193 and 191 are activated.

The seventh embodiment has following advantages. When the temperature in the freezer chamber 24 is higher than the dew formation value, energization of the top and bottom heaters 193 and 191 is not initiated even if the solenoid 200 is actuated. Thus, the top and bottom heaters 193 and 191 are not energized even when the door 36 is moved forward from its closed-up position, if the temperature in the chamber 24 is in a range not causing the dew formation on surface of the bellow 145. Hence, energization of the top and bottom heaters 193 and 191 at unnecessary occasions is averted; thus, power consumption of the heaters 193 and 191 is further trimmed down.

In each of the third through sixth embodiments, the freezer chamber 24 may have a temperature sensor that outputs a temperature signal depending on the temperature in the chamber

24. If this is the case, it is desirable to take followings:
after determining ON-OFF state of the door-opened flag at the
step S22 in each of the Figs.23-26; if it is determined that
"detected temperature in the chamber $\geq$ dew formation value"
5 holds; then, the top and bottom heaters 193 and 191 are not
activated.

Each of the third through seventh embodiments may include
following manner of processing. At step S6 on Fig.17, the
door-opened flag is switched to be ON-state at a time the solenoid
10 coil 129 is activated; and at step S11 on Fig.17, the door-opened
flag is switched to be OFF-state at a time the solenoid coil
129 is deactivated. Then, at step S23 on each of Figs.23-27,
the top and bottom heaters 193 and 191 are activated in
synchronization of activating the solenoid coil 129.

15 In each of the third through seventh embodiments, inside
of the solenoid chamber 118 may be heated by either one of the
top and bottom heaters 193 and 191.

Each of the third through seventh embodiments may include
following manner of processing. The top and bottom heaters
20 193 and 191 are activated based on determining that the door
switch 70 is OFF-state, irrespective of ON-OFF state of the
solenoid coil 129. And, the top and bottom heaters 193 and
191 are deactivated if either one of following 1)-3) is
determined to be true. In other words, energization of the
25 top and bottom heaters 193 and 191 may be controlled as

a time the user has pressed the manual-operation button 86,
the solenoid coil 129 is energized to activate the door-opening
device 110; and the plunger 134 is moved by magnetic attraction
against force of the return spring 137 so that the freezer door
5 36 is moved forward from the closed-up position to be opened.

As shown in Fig.28 that is a partially sectional view,
the solenoid 200 has auxiliary yokes 202 and 203, which are
separate and distanced from each other in front-rear direction
and are arranged around a circumferential face of a hollow
10 cylindrical pipe 201 that is formed of brass and arranged at
inside of the solenoid 200; so that a curve of the attractive
force has two peaks distanced from each other. As shown in
a curve of the attractive force in a graph of Fig.29, a force
of taking off the gasket 45 not less than a load "L1" of 50N
15 is generated at a distance range "A" from 67mm, which indicates
the closed-up position, to 47mm where a door-opened position
is taken as "0"mm.

Then, in a distance range "B" from 47mm to 10mm, generated
is a force overcoming a load "L2" of the freezer door 36 and
20 pulling-back forces of; the magnetic plates on the first movable
rails 34; the electromagnet 37; and the mechanical pulling-back
construction. In a distance range "C", generated is a force
overcoming a door-open activating load "L3" that includes the
pulling back force of the first movable rails 34 and friction
25 forces, so as to reach the door-opened position, at which the

distance is taken as 0mm. Electric current applied to the coil of the solenoid 200 is set in a manner that the attractive force generated in the solenoid 200 exceeds the load L1-L3 in each of the distance ranges A-C.

5 In present embodiment, by supplying of 9000At (ampere turn), achieved is a dashed line curve of attractive force (V) shown in Fig.29. Such force overcomes all of; a force (L1) for taking out the gasket 45 when the door has been closed; a holding force (L2) of the mechanical pulling-back construction
10 of the first movable rails 34; and the friction force (L3) of the first movable rails 34. Thus, the door 36 is easily pushed out up to an opened-up position.

 This opened-up position does not indicate a stroke (65-70mm) of the plunger 134 at a time the solenoid 200 is
15 energized, and does indicate a position distanced from the closed-up position by about 200mm to 300mm as a result of momentum accumulated by a difference between the force generated by the solenoid 200 and the load for opening the door.

 By energizing the solenoid 200, the plunger 134 is moved
20 through the pipe 201 by the attractive force from its closed-up position shown in Fig.30(2) to a jut-out position shown in Fig.30(1), by overcoming spring force of the return spring 137 so that the return spring 137 is compressed up to its ultimately compressed length. At a time the plunger 134 moves forward,
25 the connector rod 144 also moves forward as to push forward

the pusher 154 because front end of the connector rod 144 engages with the connector 156; and thereby pressing inner face of the freezer door 36 to open it.

The solenoid 200 is energized for 1 second. After
5 actuating the plunger 134 to push forward the connector rod 144, the solenoid 200 is deactivated; and the plunger 134 moves back by the spring force of the return spring 137. Thus, it returns to waiting position preparing for next occasion of door opening. The door is opened in a manner as follows.

10 As shown in Fig.30, the solenoid 200 has; a long stroke of 67mm, which is about two times of that in conventional solenoid; a length dimension (Y) of the yoke 204 being 111mm; a length dimension (a) of the plunger 134 being 124mm; and length dimension (b) of the connector rod 144 being 136mm, which is
15 relatively large compared to the dimensions of the yokes and the plungers. At a time of opening the door 36, the solenoid 200 is energized and the connector rod 144 protrudes forward by a large dimension. For example, the stroke (S) of pushing motion is set to be 64mm in the embodiment.

20 The return spring 137 has an ultimately compressed length (P) of 3mm at a time turns of spiral are abutted with adjacent ones. At such state, front end of the plunger 134 does not jut out from front end of the pipe 201; and gravity center (G) of an assembly consisting of the plunger 134 and the connector
25 rod 144 is positioned at inside of the pipe 201.

At a time the door is being closed, the solenoid 200 is not energized; and thus, the plunger moves rearward by 80mm as the return spring 137 is being extended. A stopper 134 on the solenoid casing 111 averts further rearward moving of the plunger 134 to avert its coming off. In such state, the gravity center (G) of an assembly consisting of the plunger 134 and the connector rod 144 is positioned at a point slightly frontward from rear end of the pipe 201, by adjusting weights of the plunger 134 and the connector rod 144.

10 By above constructions, the gravity center (G) of the assembly is always kept within the pipe 201 not only at a time the door is being opened by pressing inner face of the tour 36 with the pusher rod 153 that is pushed forward by the plunger 134, but also at a time the door is being closed and thus the plunger is moved rearward by the return spring 137. Thus, even with a large stroke dimension, the plunger 134 would not come off from the pipe 201 and thus would not be tilted so that defective sliding due to chipping or shaving and resultant wearing are not occurred. Thus, the door-opening device has a long
15
20 lifetime.

As mentioned before, at a time the door is being opened, front end of the plunger 134 would not move beyond front end of the pipe 201 due to 3mm of the ultimately compressed length (P) of the return spring 137. Thus, not only the gravity center (G) of the assembly but also a magnetic equilibrium is deviated.
25

Hence, sharpness of releasing magnetic flux becomes more smooth; and the ultimate compressed length (P) causes decrease of returning force of the return spring 132 so that impact noise at a time of opening the door is decreased.

5 The above arranging of the gravity center (G) of the assembly consisting of the plunger 134 and the connector rod 144, within the pipe 201, might be made by increasing length dimension of the yoke 204. Nevertheless, this is disadvantageous because this would increase dimension and
10 weight of the door-opening device 110; and thus, adversely affects required strength of attaching site on the refrigerator, and damages efficiency due to leakage of magnetic influx.

 An alternate embodiment of the plunger is explained below. As shown in Fig. 31, a hollow center part 205 or cavity is formed
15 on rear-end portion of the plunger 134' in the solenoid 200' in order to take a weight balance; or a weight element 206 is attached on the connector rod 144'. In aforementioned embodiments, on contrary to this alternate embodiment, length dimension of the connector rod 144 is set to be larger than
20 that of the plunger 134; so that the gravity center of the assembly consisting of the plunger 134 and the connector rod 144 is always positioned within the pipe 201.

Brief Description of the Several Views of the Drawing

 Fig. 1 is a vertical sectional view of a refrigerator of
25 first embodiment of the invention, showing internal

construction of the refrigerator;

Fig.2 is a perspective view of the refrigerator;

Fig.3 is a vertical sectional view of a door-opening device and its surroundings, in the refrigerator;

5 Fig.4 is a partial perspective view of the refrigerator, showing a freezer compartment in a state an icemaker door, an upper freezer door and a main freezer door are detached from the refrigerator;

Fig.5 is a partial vertical sectional view showing a
10 deformed state of door-sealing gasket when the freezer door is closed up;

Fig.6 is a perspective view showing inside of a mechanism-housing recess;

Fig.7 is a plan view showing the inside of a
15 mechanism-housing recess in a state manual operation buttons have not been pressed;

Fig.8 is a plan view showing the inside of a mechanism-housing recess in a state a manual operation button has been pressed;

20 Fig.9 is a plan view showing a mechanism-recess cover that is attached on the mechanism-housing recess;

Fig. 10 is an exploded perspective view of a door-opening device;

Fig.11 is a perspective view showing a solenoid casing
25 attached on the refrigerator;

Fig.12 is an external view of the solenoid casing as well as a solenoid;

Fig.13 is a sectional view showing internal construction of the door-opening device in a state the solenoid is not energized;

Fig. 14 is a sectional view showing the internal construction of the door-opening device in a state the solenoid is energized;

Fig.15 is a sectional view showing a positional relationship among the manual-operation buttons, a pusher and a freezer door;

Fig.16 is a vertical sectional view as in Fig. 5, showing a state the pusher presses the freezer door;

Fig. 17 is a flow chart showing a main processing flow for a controller circuit;

Fig.18 is a diagram showing time-wise relationship among ON/OFF-states of a button switch, a solenoid and a door switch;

Fig.19 is vertical sectional view as in Fig. 5, showing a construction of second embodiment;

Fig.20 is a view in a manner as in Fig. 16, showing a construction of second embodiment in a state the pusher presses the freezer door;

Fig. 21 is a view in a manner as in Fig. 12, showing a construction of third embodiment;

Fig.22 is a view in a manner as in Fig. 10, showing a

construction of third embodiment;

Fig.23 is a flow chart showing a processing flow of timer interruption processing for heaters in the controller circuit;

Figs.24-27 are flow charts in a manner as in Fig. 23,
5 respectively showing a processing in fourth embodiment, fifth embodiment, sixth embodiment and seventh embodiment;

Fig.28 is a partially ruptured plan view of the door-opening device shown on Fig. 3, in a state the freezer door is opened;

10 Fig.29 is a graph showing a relationship between attracting force and moving distance, of the solenoid;

Fig.30 is a set of side views of the door-opening device, respectively in a state a pusher is protruded and in a state the door is closed;

15 and

Fig.31 is a side view showing a modified embodiment the door-opening device as modified from that shown in Fig. 3.

Reference Marks

1 insulator casing; 21 front plate; 24 freezer chamber; 27
20 front frame bar; 34 first movable rail 34; 35 second movable rail; 36 freezer door; 45 door-sealing gasket; 49
outer-sealing part for being clamped; 50 inner sealing part not for being clamped; 51 locking magnet (permanent magnet);
52 fringe-rib protrusion for being pressed; 63 outlet for
25 upper-tier freezer container, for discharging of cooled air;

64 receiving face; 70 door switch; 86 manual-operation
button; 94 button switch; 102 opening; 110 door-opening
device; 111 solenoid casing; 112 seat face; 113 slope; 118
solenoid chamber; 120 bellow-holding fixture as a hollow-tube
5 shaped element; 123 front plate for engagement; 127 coil
casing; 134 plunger; 137 return spring; 138 solenoid cover;
144 connector rod; 145 bellow for sealing off; 148 rod cover
for forceful fitting; 149 head; 150 left-hand-side partition
wall; 151 right-hand-side partition wall; 152
10 push-rod-housing chamber; 153 pusher rod; 154 pusher; 158
cushioning portion; 162,163 a front-left guide and a rear-left
guide as left-hand-side guides; 164,165 a front-right guide
and a rear-right guide as right-hand-side guides; 171,172
left-hand-side and right-hand-side drain holes for discharging
15 water; 181 seat face; 191,193 bottom and top heaters as heat
sources; 200 electromagnetic solenoid; 201 pipe; 202,203
auxiliary yokes; 204 yoke; 205 cavity; 206 weight element;
G gravity center.

Claims

1. A refrigerator comprising:

an insulator casing (1) that is box-shaped and opened to frontward;

5 a storage chamber (24) arranged in the insulator casing (1);

 a drawer door (36), which closes a front opening of the storage chamber (24) and which holds a container (53,54,55) at rear side of the door (36) in a manner as able to be pulled
10 out to forward by way of rails (34,35) that are arranged on side walls on the storage chamber (24);

 a solenoid casing (111), which is arranged within the storage chamber (24) and has a solenoid chamber (118);

 an electromagnetic solenoid (200), which is arranged in
15 the solenoid chamber (118) and has a plunger (134) that is movable in front-rear direction;

 an opening (102), which is formed on front wall of the solenoid chamber (118) and is opened in front-rear direction;

 a rod (144) that is arranged on the plunger (134) of the
20 solenoid (200);

 a sealing element (145), which is attached on the rod (144) from frontward as to hermetically close the opening (102) from its front side and is able to be deformed to allow moving in a front-rear direction, of the rod (144); and

25 a pusher (154), which is interlocked with the rod (144)

at outside of the solenoid chamber (118), and which travels forward in conjunction with the plunger (134) and the rod (144) to push out the drawer door (36) to forward from its closed-up position, if and when the solenoid (200) is actuated at a time
5 the door (36) is closed.

2. The refrigerator according to claim 1, wherein the sealing element is formed of a bellow (145) that is folded back at between two ends of the bellow so that its dimension in front-rear direction is being varied in accordance with moving
10 of the rod (144).

3. The refrigerator according to claim 1, further comprising; a polygonal head (149) that is arranged on front-end portion of the rod (144); and a forcefully fitted element (148) that is hermetically fitted with outer circumferential face
15 of the head (149).

4. The refrigerator according to claim 1, further comprising;

a hollow-cylindrical tube-shaped element (120) that is arranged in the solenoid chamber (118) and is opened in
20 front-rear direction;

a structure (123) for engagement that is arranged on the tube-shaped element (120) and engages with the solenoid casing (111) so as to curb rotation of the tube-shaped element (120) about its axis relative to the solenoid casing (111);

25 wherein the rod (144) is inserted through inside of the

tube-shaped element (120) and juts out to front of the solenoid chamber (118).

5. The refrigerator according to claim 1, further comprising;

5 a gasket (45), which is rectangular and arranged on the drawer door (36); and

a front frame bar (27), which is arranged in the insulator casing (1) and holds a front plate (21) that abuts on a fringe portion of the gasket (45); and

10 wherein the solenoid casing (111) is attached on the front frame bar (27) in a manner that; the rod (144) is positioned at rear of the front frame bar (27); and is overlapped with it in a view seen from front-rear direction.

6. The refrigerator according to claim 6,

15 wherein the pusher (154) is overlapped with the front frame bar (27) in a view seen from vertical direction, at a time the solenoid is not actuated; and

further comprising an arm (155) that connects the pusher (154) with the rod (144).

20 7. The refrigerator according to claim 7,

Wherein the pusher (154) is connected from the rod (144) through the arm (155) so that front face of the pusher (154) is located more rearward than front face of front plate (21) at a time the solenoid is not actuated.

25 8. The refrigerator according to claim 7, further

comprising:

right-hand-side and left-hand-side partition walls (151 and 150), which are arranged in the solenoid casing (111), run frontward from a wall of the solenoid chamber (118) and are
5 distanced from each other in a right-left direction;

a housing chamber (152), which is formed as defined by the right-hand-side and left-hand-side partition walls (151 and 150) and houses both of the pusher (154) and the arm (155);
and

10 drain holes (171,172), which are formed on the solenoid casing (111) at bottom face of the housing chamber (152).

9. The refrigerator according to claim 9, wherein the solenoid casing (111) has left-hand-side drain holes (171), each of which runs from the left-hand-side partition wall (150),
15 and has right-hand-side drain holes (172), each of which runs from the right-hand-side partition wall (151).

10. The refrigerator according to claim 9, further comprising:

left-hand-side guides (162,163), which are arranged on
20 the left-hand-side partition wall (150) and protrudes from it to rightward;

right-hand-side guides (164,165), which are arranged on the left-hand-side partition wall (151) and protrudes from it to leftward; and

25 wherein the right-hand-side and left-hand-side guides

(162-165) are upwardly distanced from bottom face of the housing chamber (152).

11. The refrigerator according to claim 1, wherein: the solenoid casing (111) has a front-end wall that is located more
5 frontward than front-end face of the pusher (154) at a time the solenoid (200) is not actuated.

12. The refrigerator according to claim 13, wherein the solenoid casing (111) has a rounded ridge (117) having an arc-shaped vertical cross section, at between front-end and
10 bottom walls of the solenoid casing (111).

13. The refrigerator according to claim 1, further comprising;

a cooled-air outlet (63), which is tube-shaped and inclined forwardly downward, and blows out cold air to inside
15 of the chamber (24); and

a horizontal receiving face (64) that is arranged on the cooled-air outlet (63); and

wherein the solenoid casing (111) has a seat face (112), which is received by the horizontal receiving face (64), and
20 has a slope (113) that abuts on an inclined surface of the cooled-air outlet (63).

14. The refrigerator according to claim 1, further comprising an electrical heat source (193, 191) that is arranged in the solenoid chamber (118) and heats inside of the solenoid
25 chamber (118).

15. The refrigerator according to claim 16,
further comprising a control circuit that controls
energizing of the heat source (193,191) and the solenoid (200);
wherein the control circuit activates the heat source
5 (193,191) so as to be switched from not-energized state to
energized state, when the solenoid (200) is activated at a time
the heat source (193,191) is not energized.

16. The refrigerator according to claim 17,
further comprising a door switch (70), electrical state
10 of which is switched from one to another and vice versa, depending
on whether the drawer door (36) is in its closed-up position
or not;

wherein the control circuit determines whether the door
(36) is closed or not, by energization state of the heat source
15 (193,191), and based on a signal outputted from the door switch
(70); and if the door (36) is determined to be closed, the control
circuit deactivates the heat source (193,191) at a time a
predetermined time has elapsed since then.

17. The refrigerator according to claim 17,
20 further comprising:
a temperature sensor that outputs a temperature signal
in accordance with temperature in the storage chamber (24);
wherein the control circuit determines whether
temperature in the storage chamber (24) is higher than a
25 predetermined temperature or not, based on the temperature

signal; and if the temperature in the chamber (24) is determined to be higher than the predetermined temperature, the control circuit does not activate the heat source (193,191), even when the solenoid (200) is energized at a time the heat source
5 (193,191) is not energized.

18. The refrigerator according to claim 1,
further comprising:

a front plate (21) that formed of magnetic material and is arranged in the insulator casing (1), at rear of the drawer
10 door (36);

a hollow gasket (45), which is arranged on the drawer door (36) at its all-around fringe, has a being-clamped part (49) that is clamped at between said front plate (21) and the drawer door (36) and has a not-being-clamped part (50) that
15 is not clamped at between said front plate (21) and the drawer door (36);

a permanent magnet (51), which is arranged at inside of the being-clamped part (49) and magnetically attracted to the front plate (21); and

20 a being-pressed part (52) that is arranged on rear face of the drawer door (36) and in vicinity of the not-being-clamped part (50) and is located more forward than rear face of the not-being-clamped part (50) of the gasket (45);

wherein at a time the drawer door (36) is closed up, the
25 pusher (154) is opposed to and distanced rearwardly from both

of; the not-being-clamped part (50) of the gasket (45); and the being-pressed part (52) of the drawer door (36).

19. The refrigerator according to claim 18, wherein, at a time the drawer door (36) is closed up, the being-pressed
5 part (52) of the door (36) is located more frontward than front face of the not-being-clamped part (50) of the gasket (45).

20. The refrigerator according to claim 1, wherein:
a door-opening actuation is made in a manner that; a switch
(70), state of which is switched by door-opening operation,
10 causes energizing of the solenoid (200), which is comprised of a hollow cylindrical pipe (201) and coil (129) wound around the pipe (201); then, a plunger (134), which moves substantially horizontally through the pipe (201), is moved by magnetic attractive force generated by energizing of the solenoid (200);
15 and a connector rod (144) attached on front end of the plunger (134) moves frontward to jut out so as to make the door-opening actuation; and

a gravity center (G) of an assembly consisting of the plunger (134) and the connector rod (144) is set to be always
20 located within the pipe (201).

21. The refrigerator according to claim 20, wherein length dimension of the connector rod (144) is larger than that of the plunger (134).

22. The refrigerator according to claim 20, wherein the
25 plunger (134) is hollow.

23. The refrigerator according to claim 20, wherein a weight element (206) is attached on the connector rod (144).