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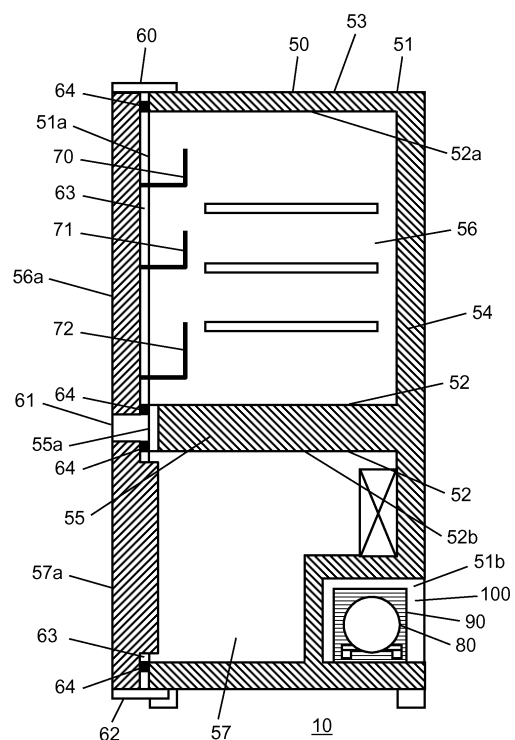
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(54) **REFRIGERATOR**

(57) A refrigerator (10) includes a heat insulation box (51) having a heat-insulated and defined storage compartment, a door which closes the storage compartment, and a compressor (80). The door is configured so that a natural frequency per unit time is lower than a lowest frequency at which the compressor (80) is operated. Accordingly, even when an operation frequency of the compressor (80) is switched by inverter control, for example, or storage items are stored in the door, it is possible to prevent the door from resonating. It is also possible to suppress vibration of the door against vibration of the compressor (80) without adding an anti-vibration member and prevent resonance.

FIG. 2



Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigerator, and more particularly, to structures of a heat insulation box, a door, and the like of the refrigerator.

BACKGROUND ART

[0002] In recent years, energy saving is in progress from a standpoint of protection of the global environment, and further improvement in usability and storage properties are demanded.

[0003] For example, there is such a method that, in order to improve a storage capacity of a storage compartment disposed in a lowermost portion, a concave portion is provided in a back portion of an uppermost portion of the storage compartment of a heat insulation box, and constituent devices of a refrigeration cycle are stored in the concave portion (e.g., see PTL 1).

[0004] FIG. 7 is a sectional side view showing a structure of conventional refrigerator 180.

[0005] Refrigerator 180 includes outer box 102 forming an outer wall of heat insulation box 101, inner box 103 forming a refrigerator inner wall of heat insulation box 101, and urethane heat insulation material 104 which is foamed and charged between outer box 102 and inner box 103.

[0006] Refrigerator 180 includes refrigerating compartment 105, freezing compartment 106, and vegetable compartment 107 in this order from above, and refrigerating compartment pivoted door 108 is provided at an opening of a front surface of refrigerating compartment 105.

[0007] Freezing compartment 106 and vegetable compartment 107 located lower than a central portion of heat insulation box 101 are respectively provided with freezing compartment drawer door 109 and vegetable compartment drawer door 112 in consideration of storage properties and usability. Freezing compartment drawer door 109 and vegetable compartment drawer door 112 are drawer-type doors from which items can be easily taken out.

[0008] Heat insulation box 101 is provided with concave portion 120. Concave portion 120 is provided by denting a top surface and a back portion extending from outer box upper surface 121 to outer box back surface 122 such that a back portion of refrigerating compartment 105 is lowered.

[0009] As viewed from front, left and right sides of concave portion 120 are closed with left and right walls of heat insulation box 101, but the left and right sides are opened upward and backward. The opened portion of concave portion 120 is covered with concave portion cover 125 which is formed from upper plate 123 and back plate 124 which is substantially perpendicular to upper plate 123. Concave portion cover 125 is detachably fixed

to heat insulation box 101 by screws or the like.

[0010] Compressor 131 and condenser 132 configure the refrigeration cycle. Compressor 131 and condenser 132 are disposed so as to be housed inside concave portion 120 together with machine compartment fan 133, and are covered with concave portion cover 125. Upper plate 123 and back plate 124 of concave portion cover 125 are provided with a plurality of ventilation holes 134 for dissipating heat.

[0011] Evaporator 135 serving as a device which configures the refrigeration cycle is disposed on a back portion of freezing compartment 106 together with cooling fan 136.

[0012] According to this configuration, vegetable compartment 107 which is a lowermost storage compartment has a larger depth than other storage compartments.

[0013] That is, according to the above-described configuration, compressor 131, condenser 132, and the like are housed in an upper portion of a back surface of heat insulation box 101. Accordingly, as compared with a case where compressor 131 and condenser 132 are housed in a lower portion of the back surface of heat insulation box 101, a larger capacity of vegetable compartment 107 can be secured, and vegetable compartment 107 can be made to have a larger depth. Even if a high pressure device is disposed on an upper portion of heat insulation box 101, it is possible to lower a barycenter of the entire heat insulation box 101 to stabilize heat insulation box 101 by increasing a storage weight in vegetable compartment 107 which is the lowermost storage compartment.

[0014] In the conventional configuration, however, compressor 131 which is one of vibration-generating sources of refrigerator 180 is provided on the uppermost portion of the heat insulation box. Accordingly, there is a problem that refrigerating compartment pivoted door 108, which is the uppermost door that is most frequently used, is likely to be vibrated by vibration of compressor 131.

[0015] Conventionally, even when compressor 131 is provided in a lower portion of heat insulation box 101, since the uppermost door disposed at an uppermost position is located higher than the other doors, there is a problem that the uppermost door is likely to swing. If compressor 131 is disposed in an upper portion of heat insulation box 101, there is a possibility that vibration of refrigerating compartment pivoted door 108 remarkably appears as compared with a case where compressor 131 is disposed in a lower portion of heat insulation box 101.

[0016] Here, assume that an amount of consumed power of refrigerator 180 is reduced by using inverter-control which controls operation by switching an operation frequency of compressor 131 into a plurality of levels. In such a case, if a lowest frequency of compressor 131 is made lower than a household power supply frequency, e.g., 50 Hz, the operation frequency of compressor 131 becomes equal to a natural frequency per unit time of refrigerating compartment pivoted door 108 in some cas-

es. In this case, refrigerating compartment pivoted door 108 is likely to resonate.

[0017] Further, if storage items can be stored in the side of refrigerating compartment 105 of refrigerating compartment pivoted door 108, since the natural frequency of refrigerating compartment pivoted door 108 including the storage items is changed to a smaller frequency in accordance with the weight of storage items, a possibility of generation of resonance increases.

Citation List

Patent Literature

[0018] PTL 1: Unexamined Japanese Patent Publication No. 2001-99552

SUMMARY OF THE INVENTION

[0019] The present invention has been made in view of the above problems, and provides a refrigerator capable of suppressing vibration of a door against vibration of a compressor without adding an anti-vibration member, and capable of preventing resonance.

[0020] A refrigerator of the present invention includes a heat insulation box having a heat-insulated and defined storage compartment, a door which closes the storage compartment, and a compressor. The door is configured such that a natural frequency of the door per unit time is lower than a lowest frequency at which the compressor is operated.

[0021] According to this configuration, since the natural frequency per unit time of the door which closes the storage compartment is lower than the lowest frequency at which the compressor is operated, resonance of the door can be prevented even when an operation frequency of the compressor is switched by the inverter-control or the storage items are stored in the door, for example.

[0022] Hence, according to the refrigerator of the present invention, it is possible to suppress vibration of the door against vibration of the compressor without having to add an anti-vibration member, and prevent resonance.

BRIEF DESCRIPTION OF DRAWINGS

[0023]

FIG. 1 is a front view of a refrigerator according to a first embodiment of the present invention.

FIG. 2 is a side sectional view showing an internal structure of the refrigerator in the first embodiment of the present invention.

FIG. 3 is an exploded perspective view of a heat insulation box of the refrigerator in the first embodiment of the present invention.

FIG. 4 is a front view of a refrigerator in a second embodiment of the present invention.

FIG. 5 is a side sectional view showing an internal structure of the refrigerator in the second embodiment of the present invention.

FIG. 6 is an exploded perspective view of a heat insulation box of the refrigerator in the second embodiment of the present invention.

FIG. 7 is a side sectional view showing a structure of a conventional refrigerator.

DESCRIPTION OF EMBODIMENTS

[0024] Embodiments of the present invention will be described below with reference to the drawings. Note that the present invention is not limited to the embodiments.

FIRST EXEMPLARY EMBODIMENT

[0025] FIG. 1 is a front view of refrigerator 10 according to a first embodiment of the present invention, FIG. 2 is a side sectional view showing an internal structure of refrigerator 10, and FIG. 3 is an exploded perspective view of heat insulation box 51 of refrigerator 10.

[0026] Refrigerator 10 includes heat insulation box 51 having a heat-insulated and defined storage compartment, a door which closes the storage compartment, and compressor 80. The doors are configured such that a natural frequency per unit time is lower than a lowest frequency at which compressor 80 is operated.

[0027] Refrigerator 10 includes heat insulation box 51 in refrigerator body 50.

[0028] Heat insulation box 51 includes inner box 52 made of resin, outer box 53 made of a metal magnetic material such as a steel plate, and a heat insulation wall formed by charging heat insulation material 54 between inner box 52 and outer box 53.

[0029] Heat insulation box 51 includes front surface opening 51a. A plurality of heat-insulated and partitioned storage compartments, i.e., refrigerating compartment 56 and freezing compartment 57 are formed in this order from above by partition wall 55.

[0030] Refrigerating compartment 56 is cooled and held within a cooling temperature range, and freezing compartment 57 is cooled and held within a freezing temperature range.

[0031] As shown in FIG. 3, inner box 52 is configured by upper inner box 52a and lower inner box 52b. Upper inner box 52a integrally forms upper, lower, left, right, and far surfaces in refrigerating compartment 56, a front surface of upper inner box 52a is opened, and upper inner box 52a is formed into a substantially box-shape. Lower inner box 52b integrally forms upper, lower, left, right, and far surfaces of freezing compartment 57, a front surface of lower inner box 52b is opened, and lower inner box 52b is formed into a substantially box-shape.

[0032] As shown in FIG. 2, partition wall 55 is configured by a lower surface of upper inner box 52a, an upper surface of lower inner box 52b, and partition plate 55a.

Partition plate 55a is provided at a front surface of partition wall 55, and is made of a metal magnetic material such as a steel plate. Heat insulation material 54 of heat insulation box 51 is integrally foamed and charged into an internal space of partition wall 55.

[0033] Partition plate 55a is provided at the same position as a frontmost surface of outer box 53 in a longitudinal direction of heat insulation box 51, and forms a part of front surface opening 51a.

[0034] Refrigerating compartment 56 and freezing compartment 57 are respectively provided with refrigerating compartment door 56a and freezing compartment door 57a (storage compartment doors) which close front surface opening 51a when the doors are closed.

[0035] As shown in FIG. 1, right upper and lower ends of refrigerating compartment door 56a and freezing compartment door 57a as viewed from front are turnably connected to heat insulation box 51 by upper hinge 60, middle hinge 61, and lower hinge 62, each having a rotation axis.

[0036] Upper hinge 60 is mounted on an upper end of heat insulation box 51, lower hinge 62 is mounted on a lower end of heat insulation box 51, and middle hinge 61 is mounted on partition plate 55a.

[0037] As shown in FIG. 2, each of the storage compartment doors is mounted such that a surface thereof on the side of heat insulation box 51 has space 63 of about 5 mm in the longitudinal direction between the storage compartment door and front surface opening 51a when the door is closed. In space 63, gaskets 64 having magnets are disposed on four upper, lower, left, and right sides of a surface of the storage compartment door on the side of heat insulation box 51. Gasket 64 can be attracted to front surface opening 51a, and brought into close contact with front surface opening 51a by a magnetic force of gasket 64. Therefore, it is possible to substantially hermetically seal the storage compartment.

[0038] Gasket 64 is a hollow elastic member made of a soft material such as rubber. Hence, even if a distance of space 63 in the longitudinal direction is slightly varied, it is possible to seal and hold the storage compartment by expansion and contraction of gasket 64 and attracting and holding force of the magnet.

[0039] As shown in FIG. 1, in this embodiment, sizes of refrigerating compartment door 56a and freezing compartment door 57a are equal to each other in a width direction of heat insulation box 51. However, in a height direction of heat insulation box 51, a height of refrigerating compartment 56 is higher than that of freezing compartment 57. That is, an area of refrigerating compartment door 56a which is the uppermost door is larger than that of freezing compartment door 57a.

[0040] As shown in FIG. 2, refrigerating compartment door 56a and freezing compartment door 57a are heat insulation walls into which heat insulation materials are charged. Although freezing compartment door 57a is thicker than refrigerating compartment door 56a, refrigerating compartment door 56a is heavier than freezing

compartment door 57a.

[0041] A surface of refrigerating compartment door 56a on the side of refrigerating compartment 56 is provided with a plurality of door shelves in which storage items can be stored. More specifically, small article shelf 70 for storing small articles such as seasoning material, beverage shelf 71 for storing beverage can, and bottle shelf 72 for storing large beverage such as PET bottles are disposed in this order from above at appropriate distances from one another in the vertical direction.

[0042] Refrigerator 10 is configured such that a natural frequency per unit time including a door shelf of refrigerating compartment door 56a (hereinafter, also simply referred to as natural frequency) becomes 33 Hz.

[0043] In this embodiment, freezing compartment door 57a does not have a door shelf, and a natural frequency of freezing compartment door 57a is 40 Hz.

[0044] Heat insulation box 51 has a refrigeration cycle which cools and holds each of the storage compartments at a predetermined temperature, and compressor 80 forms a part of the refrigeration cycle.

[0045] Compressor 80 is a reciprocating-type compressor in which a piston reciprocates in a cylinder to compress a refrigerant. As a refrigerant of the refrigeration cycle including compressor 80, it is possible to use a hydrocarbon-based refrigerant, e.g., isobutane.

[0046] To reduce an amount of consumed power of refrigerator body 50, compressor 80 is operated in such a manner that it is inverter-controlled to switch operation frequency of compressor 80 into a plurality of levels by controller 90. Controller 90 controls operation of compressor 80.

[0047] In this embodiment, the lowest frequency at which compressor 80 is operated is set to 35 Hz, which is lower than a household power supply frequency (50 Hz).

[0048] Compressor 80 and controller 90 are disposed in machine compartment 100. Machine compartment 100 is provided in lower concave portion 51b on a far side of a lower portion of heat insulation box 51. As shown in FIG. 1, compressor 80 and the hinges of the storage room doors are provided on the same side in a lateral direction of heat insulation box 51 as viewed from front (right side in the example in FIG. 1, but the present invention is not limited to this example, and it is only necessary that compressor 80 and the hinges are provided on the same side).

[0049] Operation and effect of refrigerator 10 having the above-described configuration will be described below.

[0050] First, if a user turns on a household power supply of refrigerator body 50, a high temperature and high pressure refrigerant discharged by compression action of compressor 80 circulates through the refrigeration cycle, and in this state, the storage compartments are cooled and held within a predetermined set temperature range.

[0051] At this time, controller 90 controls to switch from

a plurality of levels so that the operation frequency of compressor 80 becomes an optimal value in accordance with situations of the storage compartments. Controller 90 controls the operation of compressor 80 such that an amount of consumed power of refrigerator body 50 becomes low.

[0052] For example, if the temperature in the storage compartment is considerably higher than the predetermined temperature such as when the user first turns on the household power supply or when many storage items are stored in the storage compartment at once, controller 90 operates compressor 80 at a maximum frequency. Thereafter, the temperature in the storage compartment is gradually reduced, controller 90 switches the operation frequency of compressor 80 to a lower level and eventually, controller 90 operates compressor 80 at 35 Hz which is the lowest operation frequency.

[0053] The user can open refrigerating compartment door 56a and freely take storage items in and out from the door shelf. If an amount of storage items stored in the door shelf increases, the natural frequency of entire refrigerating compartment door 56a is continuously changed to a lower direction. On the other hand, if the amount of storage items stored in the door shelf is reduced, the natural frequency of entire refrigerating compartment door 56a is continuously changed to a high direction. However, since a natural frequency in a state where the storage items are not stored in the door shelf is 33 Hz, the natural frequency of entire refrigerating compartment door 56a does not reach 35 Hz, which is the lowest frequency of compressor 80.

[0054] On the other hand, since freezing compartment door 57a has a lighter weight than refrigerating compartment door 56a, a natural frequency of freezing compartment door 57a becomes greater than that of refrigerating compartment door 56a. In this embodiment, the natural frequency of freezing compartment door 57a is 40 Hz, which is greater than 35 Hz that is the lowest frequency of compressor 80. Further, since freezing compartment door 57a is not provided with a door shelf, the natural frequency of entire freezing compartment door 57a does not change, and resonance of freezing compartment door 57a is not generated unless controller 90 operates compressor 80 at 40 Hz.

[0055] When freezing compartment door 57a is also provided with the door shelf, the natural frequency of freezing compartment door 57a when a storage amount of storage items is maximum is measured, and compressor 80 is not operated in a range from that frequency to 40 Hz which is the natural frequency when the storage items are not stored in the door shelf of freezing compartment door 57a. Accordingly, it is possible that resonance is not generated at freezing compartment door 57a.

[0056] In this embodiment, the lowest frequency when compressor 80 is operated is 35 Hz. However, the present invention is not limited to this example. If the operation frequency of compressor 80 is set to a lower

value, it is possible to further reduce an amount of consumed power of refrigerator body 50.

[0057] That is, if a variation range of a weight of refrigerating compartment door 56a can be narrowed, the lowest frequency when compressor 80 is operated can be set to 34 Hz. Further, if a weight of refrigerating compartment door 56a can be increased by increasing refrigerating compartment door 56a in size, a natural frequency of refrigerating compartment door 56a can be lowered. This can further lower the lowest frequency when compressor 80 is operated.

[0058] In refrigerator 10 of this embodiment, since partition wall 55 and inner box 52 are integrally formed, a gap between partition wall 55 and heat insulation box 51 can be eliminated completely. If there is a gap between partition wall 55 and heat insulation box 51, vibration is generated in the fine gap when heat insulation box 51 is vibrated by compressor 80 or the like, and a chattering noise is generated in some cases. However, in the configuration of refrigerator 10 in this embodiment, there is no possibility that the chattering noise is generated.

[0059] Further, if there is a gap between partition wall 55 and heat insulation box 51, this also means that heat insulation box 51 is easily deformed. In particular, when refrigerating compartment door 56a disposed at the uppermost position is provided with a door shelf as in refrigerator 10 of this embodiment, it is necessary to take into consideration not only deformation immediately after heat insulation box 51 is produced but also deformation caused when the user stores the storage items in the door shelf.

[0060] In this embodiment, partition wall 55 and inner box 52 are integrally formed, and heat insulation material 54 in partition wall 55 and heat insulation material 54 of heat insulation box 51 are integrally foamed and charged. Accordingly, rigidity of heat insulation box 51 is increased, propagation of vibration to refrigerating compartment door 56a is suppressed, and it is possible to obtain strength and endurance with respect to storing of the storage items in the door shelf of refrigerating compartment door 56a.

[0061] In this embodiment, since inner box 52 is divided into upper inner box 52a and lower inner box 52b, there is a possibility that rigidity of heat insulation box 51 is deteriorated. However, if upper inner box 52a and lower inner box 52b are brought into close contact with heat insulation material 54, it is possible that rigidity is not deteriorated.

[0062] Due to the same reason as above, it is necessary to reduce the fine gap also in an opening/closing mechanism of refrigerating compartment door 56a and a sealing structure.

[0063] First, concerning the opening/closing mechanism, there is a drawer-type door in addition to a rotation-type door, but in the case of the drawer-type door, a fine gap is generally provided between heat insulation box 51 and refrigerating compartment door 56a in many cases. The rotation-type door is desirable because hinges

and refrigerating compartment door 56a can be connected to each other with almost no gap at all. Since refrigerating compartment door 56a which is the uppermost door is used most frequently, usability is high for the users if the rotation-type door is employed.

[0064] In this embodiment, compressor 80 and the hinges of refrigerating compartment door 56a are disposed on the same side in the lateral direction as viewed from front of heat insulation box 51. Accordingly, since vibration of compressor 80 is propagated from the hinge side of refrigerating compartment door 56a to refrigerating compartment door 56a, vibration of refrigerating compartment door 56a can be suppressed.

[0065] Next, concerning a sealing structure, it is necessary to seal and hold space 63 substantially hermetically, while absorbing production variation and shrinkage of heat insulation box 51 and storage compartment doors at the time of cooling operation. Therefore, it is desirable that an elastic member is used as gasket 64. If the elastic member is used, it is possible to suppress propagation of vibration from heat insulation box 51 to storage compartment doors at the same time,

[0066] As described above, in refrigerator 10 of this embodiment, there is no seam between partition wall 55 and inner box 52, and it is possible to eliminate a fine gap between connected portions of members. Thus, it is possible to suppress generation of vibration of heat insulation box 51 caused by vibration of compressor 80.

[0067] Since heat insulation material 54 in heat insulation box 51 and heat insulation material 54 of partition wall 55 are integrally formed, rigidity of heat insulation box 51 increases, and it is possible to suppress propagation of vibration of compressor 80.

[0068] Further, since the natural frequency, per unit time, of refrigerating compartment 56a which is the uppermost door provided on the uppermost portion is lower than the lowest frequency at which compressor 80 is operated, even when the operation frequency of compressor 80 is switched by inverter control or the storage items are stored in the door shelves, it is possible to prevent refrigerating compartment door 56a from resonating.

[0069] Since the weight of refrigerating compartment door 56a which is the uppermost door is made heavier than that of freezing compartment door 57a, it is possible to easily lower the natural frequency of the uppermost door.

[0070] In this embodiment, upper and lower ends of a right side of refrigerating compartment door 56a can be turnably opened by upper hinge 60 and middle hinge 61, and lower middle hinge 61 is fixed to partition wall 55. According to this configuration, a gap between connecting portions of heat insulation box 51 and refrigerating compartment door 56a can be set narrower as compared with a case where refrigerating compartment door 56a is configured to be capable of being drawn out, generation of vibration at the connecting portions can be suppressed.

[0071] Since space 63 between refrigerating compart-

ment door 56a and heat insulation box 51 is sealed by gasket 64 which is the elastic member, it is possible to suppress the propagation of vibration from heat insulation box 51 to refrigerating compartment door 56a, and vibration of refrigerating compartment door 56a can be suppressed.

SECOND EXEMPLARY EMBODIMENT

[0072] Next, refrigerator 20 in a second embodiment of the present invention will be described.

[0073] FIG. 4 is a front view of refrigerator 20 in the second embodiment of the present invention, FIG. 5 is a side sectional view showing an internal structure of refrigerator 20, and FIG. 6 is an exploded perspective view of heat insulation box 201 of refrigerator 20.

[0074] Refrigerator 20 of this embodiment is different from refrigerator 10 described in the first embodiment in that refrigerator 20 has three storage compartments, and compressor 230 is stored on a far side of an upper portion in heat insulation box 201.

[0075] Refrigerator 20 has refrigerator body 200 including heat insulation box 201.

[0076] Heat insulation box 201 includes inner boxes 202 made of resin, outer box 203 made of a metal magnetic material such as a steel plate, and a heat insulation wall formed by charging heat insulation material 204 between inner box 202 and outer box 203.

[0077] Heat insulation box 201 includes front surface opening 201a. Upper partition wall 205 and lower partition wall 206 form a plurality of heat-insulated and partitioned storage compartments, i.e., refrigerating compartment 207, vegetable compartment 208, freezing compartment 209 in this order from above.

[0078] Refrigerating compartment 207 and vegetable compartment 208 are cooled and held within a cooling temperature range, and freezing compartment 209 is cooled and held within a freezing temperature range, respectively.

[0079] As shown in FIG. 6, inner boxes 202 integrally form upper, lower, left, and right surfaces and a far surface in each of the storage compartments, front surfaces of inner boxes 202 are opened, and inner boxes 202 are formed into substantially box shapes. Inner boxes 202 are configured by upper inner box 202a, middle inner box 202b, and lower inner box 202c in this order from above.

[0080] As shown in FIG. 5, upper partition wall 205 is configured by a lower surface of upper inner box 202a, an upper surface of middle inner box 202b and upper partition plate 205a. Upper partition plate 205a is provided on a front surface of upper partition wall 205, and is made of metal magnetic material such as steel plate.

[0081] Lower partition wall 206 is configured by a lower surface of middle inner box 202b, an upper surface of lower inner box 202c and lower partition plate 206a. Lower partition plate 206a is provided on a front surface of lower partition wall 206, and is made of a metal magnetic material such as a steel plate.

[0082] Heat insulation material 204 of heat insulation box 201 is integrally foamed and charged into interior spaces of upper partition wall 205 and lower partition wall 206.

[0083] Upper partition plate 205a and lower partition plate 206a are provided at the same positions as a front-most surface of outer box 203 in a longitudinal direction of heat insulation box 201, and form a part of front surface opening 201a.

[0084] As shown in FIG. 4, refrigerating compartment 207 is provided with refrigerating compartment right door 207a and refrigerating compartment left door 207b which close front surface opening 201a when the doors are closed.

[0085] Vegetable compartment 208 is provided with vegetable compartment door 208a which closes front surface opening 201a when the door is closed, and freezing compartment 209 is provided with freezing compartment door 209a which closes front surface opening 201a when the door is closed.

[0086] Refrigerating compartment right door 207a and refrigerating compartment left door 207b are disposed at the same height in a height direction of heat insulation box 201. Refrigerating compartment right door 207a and refrigerating compartment left door 207b are divided on a left side of a center in a lateral direction of heat insulation box 201 as viewed from front. Hence, an area of refrigerating compartment right door 207a is larger than that of refrigerating compartment left door 207b.

[0087] Upper and lower ends of right sides of refrigerating compartment right door 207a, vegetable compartment door 208a, and freezing compartment door 209a are turnably connected to heat insulation box 201 in this order from above by upper right hinge 210, middle right hinge 211, middle hinge 212, and lower hinge 213.

[0088] Upper and lower ends of a left side of refrigerating compartment left door 207b are turnably connected to heat insulation box 201 by upper left hinge 214 and middle left hinge 215.

[0089] Upper right hinge 210 and upper left hinge 214 are mounted on an upper end of heat insulation box 201, and lower hinge 213 is mounted on a lower end of heat insulation box 201, respectively. Middle right hinge 211 and middle left hinge 215 are mounted on upper partition plate 205a, and middle hinge 212 is mounted on lower partition plate 206a, respectively.

[0090] As shown in FIG. 5, each of the storage compartment doors is mounted such that a surface of the storage compartment door on the side of heat insulation box 201 has space 216 of about 5 mm between the storage compartment door and front surface opening 201a in the longitudinal direction when the door is closed. In space 216, gaskets 217 having magnets are disposed on four upper, lower, left, and right sides of surfaces of the storage compartment doors on the side of heat insulation box 201. Since each of gaskets 217 can be attracted and brought into close contact with front surface opening 201a by a magnetic force of gasket 217, each of stor-

age compartments can be sealed substantially hermetically.

[0091] Gasket 217 is a hollow elastic member made of a soft material such as rubber. Hence, even if a longitudinal distance of space 216 is slightly varied, the storage compartment can be sealed and held by expansion and contraction of gasket 217 and attracting and holding force of the magnet.

[0092] As shown in FIG. 4, in this embodiment, an area of refrigerating compartment right door 207a is the largest among the storage compartment doors when refrigerator body 200 is viewed from front.

[0093] As shown in FIG. 5, each of the storage compartment doors is a heat insulation wall into which a heat insulation material is charged. In the heat insulation wall of refrigerating compartment right door 207a, there is disposed vacuum heat insulation material 207c having greater specific gravity and smaller thermal conductivity than the heat insulation material of other storage compartment doors. Among the storage compartment doors, refrigerating compartment right door 207a is configured to be heaviest.

[0094] A surface of refrigerating compartment right door 207a on the side of refrigerating compartment 207 is provided with a plurality of door shelves capable storing storage items. Specifically, small article shelf 220 for storing small articles such as a seasoning material, beverage shelf 221 for storing beverage can, and bottle shelf 222 for storing large beverage such as PET bottles are disposed in this order from above at appropriate distances from one another in the vertical direction.

[0095] Note that a width of each of the door shelves in this embodiment as viewed from front of heat insulation box 201 is smaller than that of each of door shelves of refrigerator 10 described in the first embodiment.

[0096] A natural frequency of refrigerating compartment right door 207a including the door shelf is 33 Hz.

[0097] In this embodiment, other storage compartment doors of refrigerating compartment right door 207a do not include door shelves, and a natural frequency of the storage compartment door is 40 Hz to 45 Hz.

[0098] Heat insulation box 201 includes a refrigeration cycle for cooling and holding each of the storage compartments at predetermined temperature, and compressor 230 forms a part of the refrigeration cycle.

[0099] Compressor 230 is a reciprocating-type compressor in which a piston reciprocates in a cylinder to compress a refrigerant. As a refrigerant of the refrigeration cycle including compressor 230, it is possible to use hydrocarbon-based refrigerant, e.g., isobutane.

[0100] To reduce an amount of consumed power of refrigerator body 200, compressor 230 is operated by controller 240 such that it is inverter-controlled to switch an operation frequency of compressor 230 into a plurality of levels. Controller 240 controls operation of compressor 230.

[0101] In this embodiment, a lowest frequency at which compressor 230 is operated is set to 35 Hz, which is

lower than the household power supply frequency (e.g., 50 Hz).

[0102] Compressor 230 and controller 240 are disposed in machine compartment 250 which is provided in upper concave portion 201b on a far side of an upper portion of heat insulation box 201. Compressor 230 is disposed on the side of refrigerating compartment right door 207a (right side) in the lateral direction as viewed from front of heat insulation box 201.

[0103] Operation and effect of refrigerator 20 having the above-described configuration will be described below.

[0104] First, when the user turns on a household power supply of refrigerator body 200, a high temperature and high pressure refrigerant discharged by compression action of compressor 230 circulates through the refrigeration cycle, and in this state, the storage compartments are cooled and held within a predetermined set temperature range.

[0105] At this time, controller 240 performs control to switch from a plurality of levels so that the operation frequency of compressor 230 becomes an optimal value in accordance with situations of the storage compartments. Controller 240 also controls compressor 230 such that an amount of consumed power of refrigerator body 200 becomes low.

[0106] For example, if the temperature in the storage compartment is considerably higher than the predetermined temperature such as when the user first turns on the household power supply or when many storage items are stored in the storage compartment at once, controller 240 operates compressor 230 at a maximum frequency. Thereafter, temperature in the storage compartment is gradually reduced, controller 240 switches the operation frequency of compressor 230 to a lower level, and eventually, controller 240 operates compressor 230 at 35 Hz which is the lowest operation frequency.

[0107] The user can open refrigerating compartment right door 207a to freely take items in and out from the door shelf. If an amount of storage items stored in the door shelf increases, the natural frequency of entire refrigerating compartment right door 207a is continuously changed to a lower direction. On the other hand, if the amount of storage items stored in the door shelf is reduced, the natural frequency of entire refrigerating compartment right door 207a is continuously changed to a high direction. However, since a natural frequency in a state where the storage items are not stored in the door shelf is 33 Hz, the natural frequency of entire refrigerating compartment right door 207a does not reach 35 Hz, which is the lowest frequency of compressor 230.

[0108] On the other hand, since other storage compartment doors are lighter in weight than refrigerating compartment right door 207a, the natural frequency of the other storage compartment doors become greater than that of refrigerating compartment right door 207a. In this embodiment, the natural frequency of the other storage compartment doors is 40 Hz to 45 Hz, which is

greater than 35 Hz that is the lowest frequency of compressor 230. Since the other storage compartment doors are not provided with door shelves, the natural frequency of the other storage compartment doors does not change. Hence, resonance of the other storage compartment doors is not generated unless controller 240 operates compressor 230 at 40 Hz to 45 Hz. That is, controller 240 causes compressor 230 to operate at an operation frequency other than the natural frequency of the other storage compartment door per unit time.

[0109] When the other storage compartment doors are also to be provided with door shelves, the following procedure should be employed. That is, a natural frequency of each of the storage compartment doors per unit time when a storage amount of storage items is maximum is measured, and compressor 230 is not operated in a range from that frequency to 40 Hz to 45 Hz, which is the natural frequency when the storage items are not stored in the door shelf of each storage compartment door. Accordingly, it is possible that resonance of the other storage compartment door is not generated.

[0110] In this embodiment, the lowest frequency when compressor 230 is operated is 35 Hz. However, the present invention is not limited to this example. If the operation frequency of compressor 230 is lowered, it is possible to further reduce the amount of consumed power of refrigerator body 200.

[0111] For example, if a variation range of the weight of refrigerating compartment right door 207a can be narrowed, the lowest frequency when compressor 230 is operated can be set to 34 Hz. Further, if the weight of refrigerating compartment right door 207a can be increased by increasing refrigerating compartment right door 207a in size or the like, it is possible to lower the natural frequency of refrigerating compartment right door 207a. Accordingly, the lowest frequency when compressor 230 is operated can be reduced. In this embodiment, by using vacuum heat insulation material 207c, the weight of refrigerating compartment right door 207a is increased to lower the natural frequency of refrigerating compartment right door 207a.

[0112] Further, in this embodiment, an area of refrigerating compartment right door 207a is the largest. Accordingly, when vacuum heat insulation material 207c having smaller thermal conductivity than the heat insulation material of the other storage compartment doors is used, if the material is applied to refrigerating compartment right door 207a, it is possible to most reduce an amount of heat entering into heat insulation box 201 as compared with a case where the material is applied to the other storage compartment doors. If the amount of heat entering into heat insulation box 201 is reduced, a ratio of time during which compressor 230 is operated at the lowest frequency is increased. Thus, if the natural frequency of refrigerating compartment right door 207a is lowered, this is extremely effective for reducing the amount of consumed power of refrigerator body 200.

[0113] In refrigerator 20 of this embodiment, since up-

per partition wall 205, lower partition wall 206, and inner box 202 are integrally formed, it is possible to completely eliminate the gap between upper partition wall 205, lower partition wall 206, and heat insulation box 201. If there is a gap between upper partition wall 205 and lower partition wall 206, and inner box 202, vibration is generated in the fine gap when heat insulation box 201 is vibrated by compressor 230 or the like, and a chattering noise is generated in some cases. However, in the configuration of refrigerator 20 in this embodiment, there is no possibility that the chattering noise is generated.

[0114] Further, if there is a gap between upper partition wall 205 and lower partition wall 206, and inner box 202, this also means that heat insulation box 201 is easily deformed.

[0115] In particular, when refrigerating compartment right door 207a which is the uppermost door disposed at the uppermost position is provided with a door shelf as in refrigerator 20 of this embodiment, it is necessary to take, into consideration, not only deformation immediately after heat insulation box 201 is produced but also deformation caused when the user stores the storage items in the door shelf.

[0116] In this embodiment, upper partition wall 205 and inner box 202 are integrally formed, and heat insulation material 204 in upper partition wall 205 and heat insulation material 204 of heat insulation box 201 are integrally foamed and charged. Accordingly, with the increase in rigidity of heat insulation box 201, not only propagation of vibration to refrigerating compartment right door 207a is suppressed, but also strength and endurance with respect to storing of the storage items in the door shelf of refrigerating compartment right door 207a can be obtained.

[0117] In this embodiment, since inner box 202 is divided into upper inner box 202a, middle inner box 202b, and lower inner box 202c, there is a possibility that the rigidity of heat insulation box 201 is deteriorated. However, if inner boxes and heat insulation material 204 are brought into close contact with each other, a configuration can be obtained in which the rigidity is not deteriorated.

[0118] When levels of vibration and rigidity can be admissible, lower partition wall 206 may be formed from a member which is different from that of inner box 202. In this case, the number of inner boxes 202 is reduced (middle inner box 202b and lower inner box 202c can be formed from one inner box), and it is possible to improve factory productivity and to suppress generation of failure such as leaking of heat insulation material 204 from lower partition wall 206 when heat insulation material 204 is foamed and charged.

[0119] Concerning the above-described fine gap, it is necessary to reduce the gap due to the same reason also in the opening/closing mechanism of refrigerating compartment right door 207a and the sealing structure.

[0120] First, concerning the opening/closing mechanism, there is a drawer-type door in addition to the rota-

tion type door, but in the case of the drawer-type door, generally, there is a fine gap between heat insulation box 201 and refrigerating compartment right door 207a in many cases. The rotation type door is desirable because the hinge and refrigerating compartment right door 207a can be connected to each other with almost no gap. Further, since refrigerating compartment right door 207a and refrigerating compartment left door 207b which are the uppermost doors at the uppermost portions are frequently used, usability is high for the users if these doors are formed as rotation-type doors.

[0121] Concerning vegetable compartment door 208a and freezing compartment door 209a, if these doors do not have a problem of vibration, it may be preferable, in terms of usability, to employ drawer-type doors depending on a size of heat insulation box 201.

[0122] In this embodiment, compressor 230 is disposed on the side of refrigerating compartment right door 207a in the lateral direction as viewed from front of heat insulation box 201 (FIG. 4). Accordingly, since vibration of compressor 230 is preferentially propagated toward refrigerating compartment right door 207a, it is possible to suppress vibration at refrigerating compartment left door 207b which is lighter in weight than refrigerating compartment right door 207a. Note that the present invention is not limited to this example, and compressor 230 may only be disposed on the side of the heavier door in the lateral direction as viewed from front of heat insulation box 201.

[0123] Next, concerning a sealing structure, it is necessary to seal and hold space 216 substantially hermetically while absorbing production variation and shrinkage of heat insulation box 201 and the storage compartment doors at the time of cooling operation. Hence, it is desirable to use an elastic member as gasket 217. If an elastic member is used, it is possible to suppress propagation of vibration from heat insulation box 201 to the storage compartment doors at the same time.

[0124] In this embodiment, since compressor 230 is disposed on the far side of the upper portion of heat insulation box 201, a depth of a lower storage compartment, e.g., vegetable compartment 208 can be widened as compared with refrigerator 10 of the first embodiment. On the other hand, in refrigerator 20, a depth on the far side of an upper portion of refrigerating compartment 207 becomes narrow, but usability for the user is not deteriorated since the user's hand cannot easily reach this space and usability is poor.

[0125] As described above, in refrigerator 20 of this embodiment, there is no seam between upper partition wall 205 and inner box 202, and a fine gap at the connecting portions of the parts can be eliminated. Therefore, it is possible to suppress generation of vibration of heat insulation box 201 caused by vibration of compressor 230.

[0126] Since heat insulation material 204 in heat insulation box 201 and heat insulation material 204 of upper partition wall 205 are integrally formed, the rigidity of heat

insulation box 201 is increased, and it is possible to suppress the propagation of vibration of compressor 230.

[0127] Further, the natural frequency, per unit time, of refrigerating compartment right door 207a which is the uppermost door provided at the uppermost portion is lower than the lowest frequency at which compressor 230 is operated. Accordingly, even when the operation frequency of compressor 230 is switched by inverter control or when the storage items are stored in the door shelves, it is possible to prevent refrigerating compartment right door 207a from resonating.

[0128] Since compressor 230 is disposed on the far side of the upper portion of heat insulation box 201, the depth of vegetable compartment 208 which is the lower storage compartment can be widened.

[0129] Since the weight of refrigerating compartment right door 207a is heavier than that of the other storage compartment doors, a natural frequency of a door on the uppermost side and on the side where compressor 230 is disposed can easily be lowered.

[0130] In this embodiment, the upper and lower ends of the right side of refrigerating compartment right door 207a as viewed from front can be turnably opened by upper right hinge 210 and middle right hinge 211, and middle right hinge 211 on the lower side is fixed to upper partition wall 205. According to this configuration, a gap at the connecting portions between heat insulation box 201 and refrigerating compartment right door 207a can be set narrow as compared with a case where refrigerating compartment right door 207a is configured to be drawn out, and it is possible to suppress generation of vibration at the connecting portions.

[0131] Gaskets 217 which are elastic members seal space 216 between refrigerating compartment right door 207a and heat insulation box 201. Accordingly, it is possible to suppress propagation of vibration from heat insulation box 201 to refrigerating compartment right door 207a, and it is possible to suppress vibration of refrigerating compartment right door 207a which is the uppermost door.

[0132] The storage compartment door of refrigerating compartment 207 which is the uppermost door is divided into refrigerating compartment right door 207a and refrigerating compartment left door 207b in the lateral direction as viewed from front of heat insulation box 201, and compressor 230 is disposed on the side of heavier refrigerating compartment right door 207a. Accordingly, since the vibration of compressor 230 is preferentially propagated to heavier refrigerating compartment right door 207a to which the vibration is less likely to be transmitted, it is possible to suppress vibration of lighter refrigerating compartment left door 207b.

[0133] In each of the embodiments, the description has been made of the example in which the heat insulation box is heat insulated and partitioned into a plurality of storage compartments, but the refrigerator of the present invention is not limited to this example. For example, the present invention can also be applied to a refrigerator

provided with a heat insulation box having only one heat insulated and defined storage compartment. In this case, the same resonance preventing effect can be obtained if a natural frequency, per unit time, of a door which closes this storage compartment is set lower than a lowest frequency at which the compressor is operated.

[0134] Concerning a refrigerator provided with a heat insulation box having a plurality of storage compartments, the same resonance preventing effect can be obtained if a natural frequency, per unit time, of a door other than the uppermost door which closes that storage compartment is set lower than a lowest frequency at which a compressor is operated.

[0135] In each of the embodiments, compressor 80, 230 is disposed on the far side of the lower portion or the upper portion of heat insulation box 51, 201, but the present invention is not limited to this example. No matter which position of heat insulation box 51, 201 compressor 80, 230 is disposed, the same resonance preventing effect can be obtained if a natural frequency, per unit time, of a door which closes a storage compartment is set lower than a lowest frequency at which a compressor 80, 230 is operated.

[0136] In each of the embodiments, the description has been made of the example in which at least the uppermost partition wall disposed at the uppermost position and the inner box are integrally formed, and the heat insulation material in the uppermost partition wall and the heat insulation material of the heat insulation box are integrally foamed and charged, but the present invention is not limited to this example. For example, even when the partition wall and the inner box are not integrally formed, it is possible to prevent the door from resonating if a relation between a natural frequency of a door and a lowest operation frequency of a compressor is satisfied.

INDUSTRIAL APPLICABILITY

[0137] As described above, according to the present invention, it is possible to suppress vibration of a door against vibration of a compressor and to prevent resonance without adding an anti-vibration member or the like, and without increasing costs and the number of assembling processes. Therefore, the present invention can be applied not only to a refrigerator but also to a freezer, a heat insulating compartment, and the like.

REFERENCE MARKS IN THE DRAWINGS

[0138]

10, 20	refrigerator
50, 200	refrigerator body
51, 201	heat insulation box
51a, 201a	front surface opening
51b	lower concave portion
52, 202	inner box
52a, 202a	upper inner box

52b, 202c	lower inner box
53, 203	outer box
54, 204	heat insulation material
55	partition wall
55a	partition plate
56, 207	refrigerating compartment
56a	refrigerating compartment door
57, 209	freezing compartment
57a, 209a	freezing compartment door
60	upper hinge
61, 212	middle hinge
62, 213	lower hinge
63, 216	space
64, 217	gasket
70, 220	small article shelf
71, 221	beverage shelf
72, 222	bottle shelf
80, 230	compressor
90, 240	controller
100, 250	machine compartment
201b	upper concave portion
202b	middle inner box
205	upper partition wall
205a	upper partition plate
206	lower partition wall
206a	lower partition plate
207a	refrigerating compartment right door
207b	refrigerating compartment left door
207c	vacuum heat insulation material
208	vegetable compartment
208a	vegetable compartment door
210	upper right hinge
211	middle right hinge
214	upper left hinge
215	middle left hinge

Claims

1. A refrigerator comprising:

a heat insulation box having a heat-insulated and defined storage compartment;
a door which closes the storage compartment;
and
a compressor,
wherein the door is configured such that a natural frequency of the door per unit time is lower than a lowest frequency at which the compressor is operated.

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

a partition wall configured to heat-insulate and partition the heat insulation box into a plurality of the storage compartments in a vertical direction; and

a plurality of the doors which respectively close the plurality of storage compartments, wherein a natural frequency, per unit time, of an uppermost one of the plurality of doors is lower than the lowest frequency at which the compressor is operated, the uppermost door closing the storage compartment.

3. The refrigerator according to claim 2, further comprising a plurality of the partition walls, wherein the heat insulation box is configured by foaming and charging a heat insulation material between an outer box and an inner box, at least an uppermost one of the plurality of partition walls and the inner box are integrally formed, and a heat insulation material in the uppermost partition wall and a heat insulation material in the heat insulation box are integrally foamed and charged.

4. The refrigerator according to claim 2 or 3, wherein the compressor is disposed on a far side of an upper portion of the heat insulation box.

5. The refrigerator according to claim 2 or 3, wherein the uppermost door is heavier than the other door.

6. The refrigerator according to claim 2 or 3, wherein upper and lower portions of one of left and right ends of the uppermost door as viewed from front is turnably opened by a pair of hinges, and a lower one of the pair of hinges is fixed to the uppermost partition wall.

7. The refrigerator according to claim 2 or 3, further comprising an elastic member for sealing a space between the uppermost door and the heat insulation box.

8. The refrigerator according to claim 2 or 3, wherein the uppermost door is divided into a left door and a right door in a lateral direction as viewed from front of the heat insulation box, and the compressor is disposed adjacent to a heavier one of the left door and the right door.

9. The refrigerator according to claim 5, further comprising a controller which controls operation of the compressor, wherein the controller operates the compressor at an operation frequency other than a natural frequency per unit time of the other door.

FIG. 1

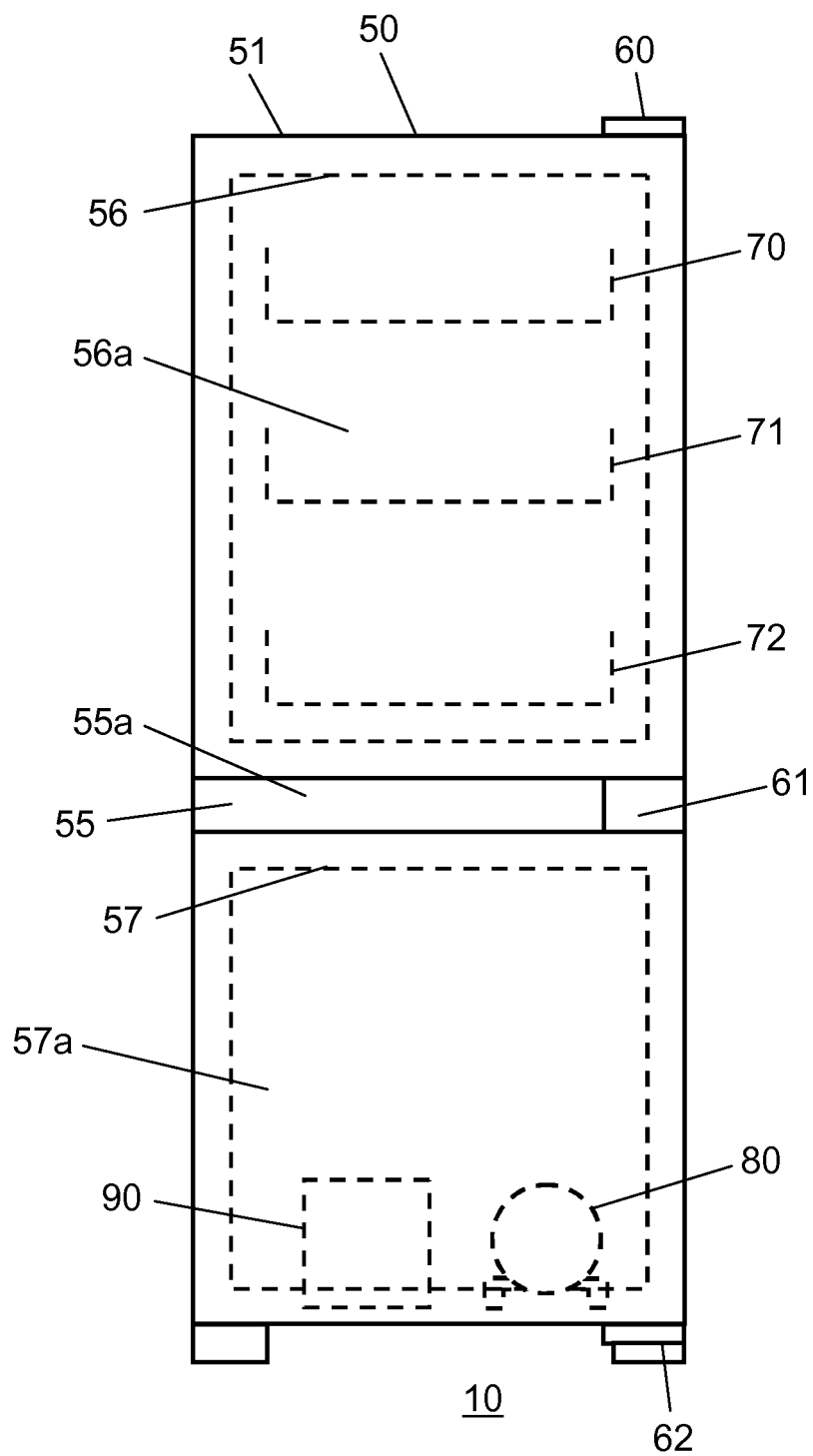


FIG. 2

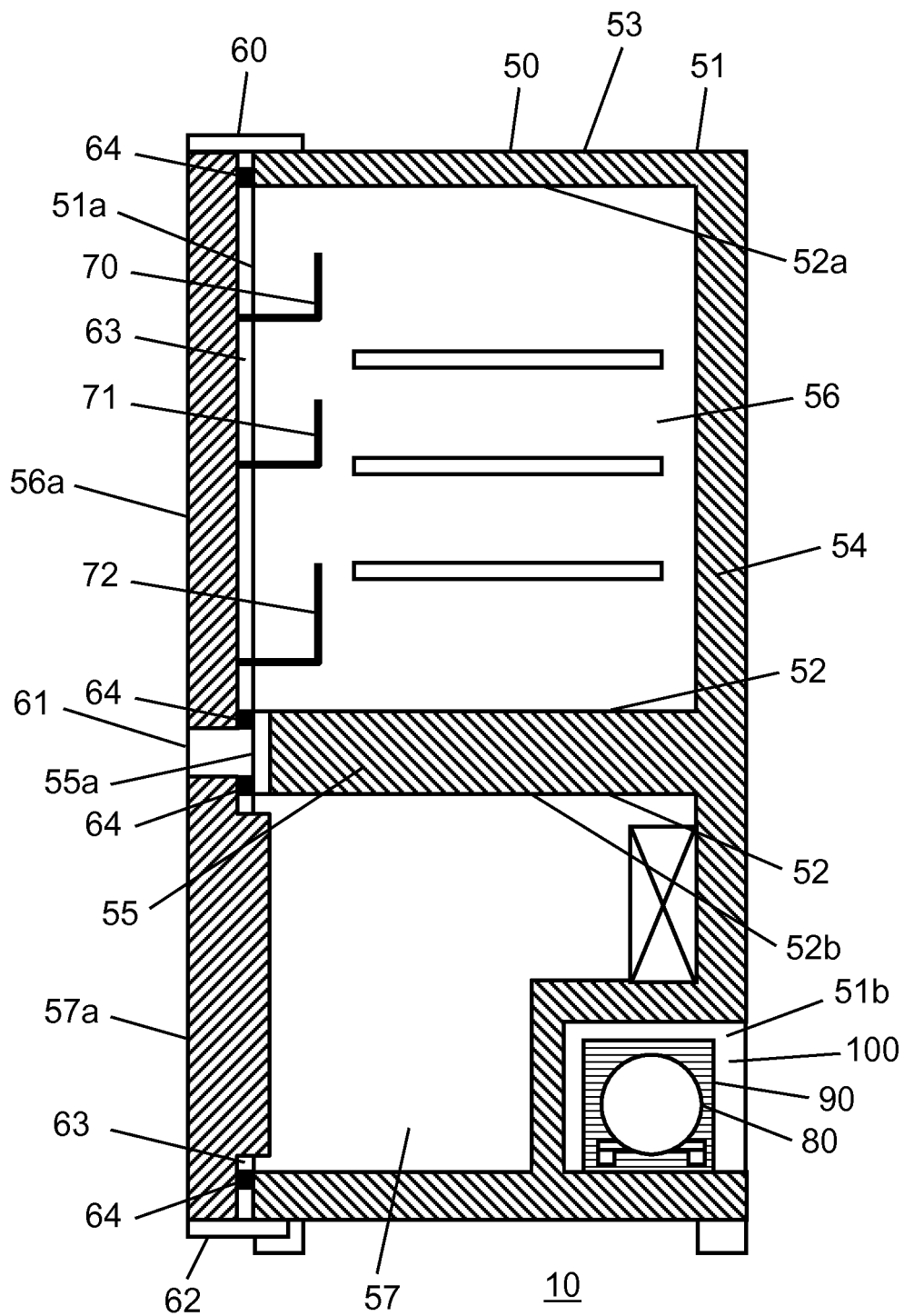


FIG. 3

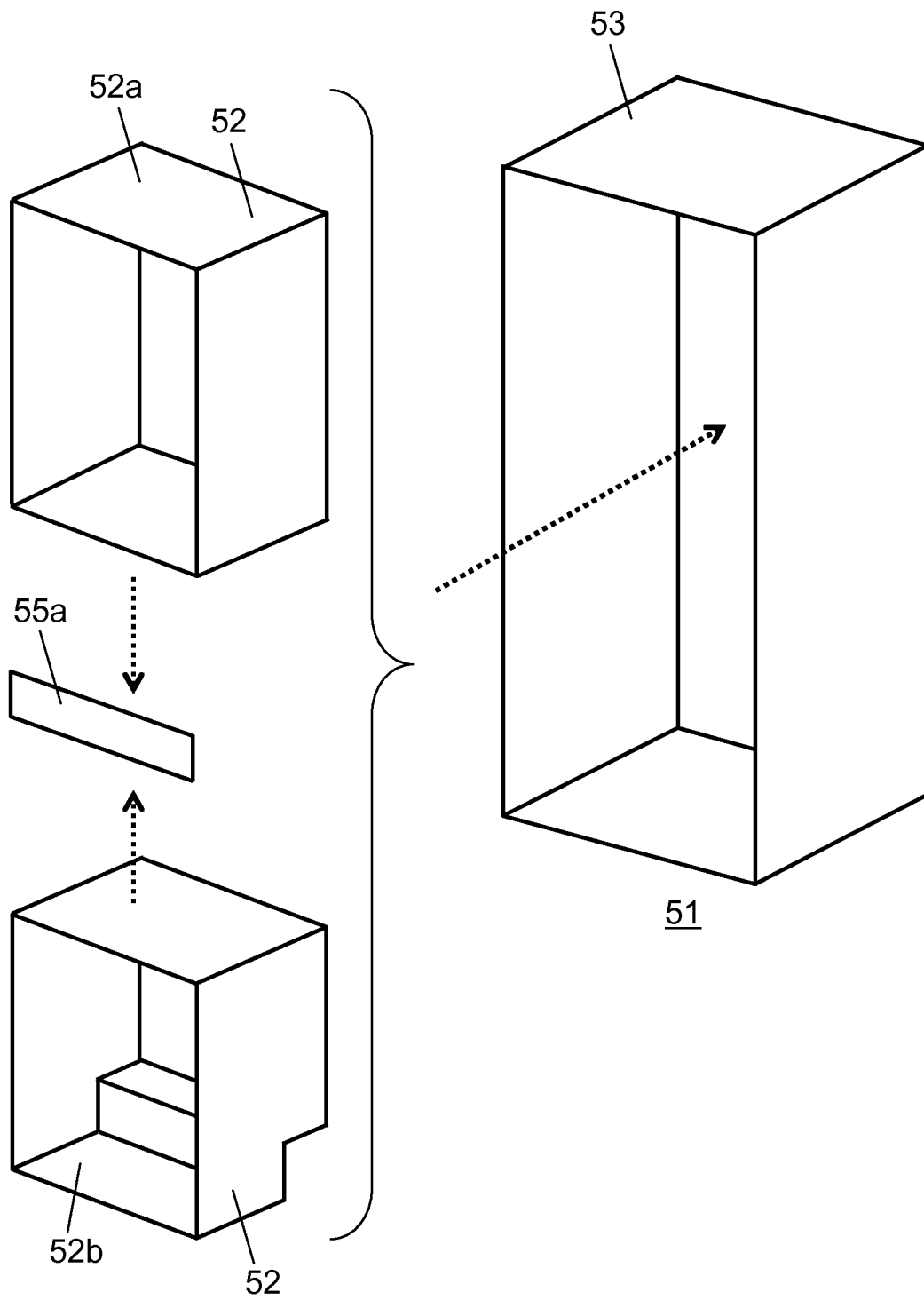


FIG. 4

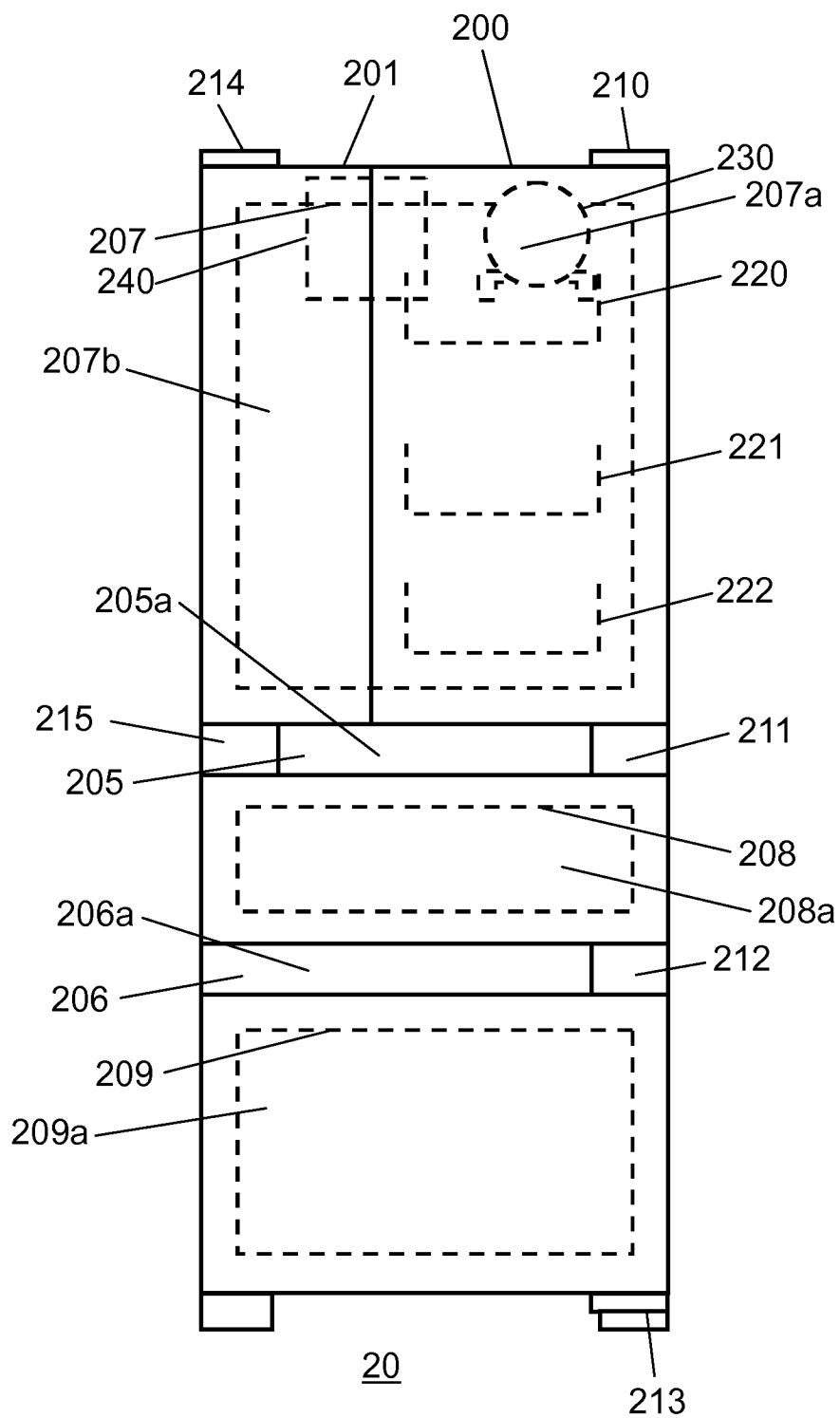


FIG. 5

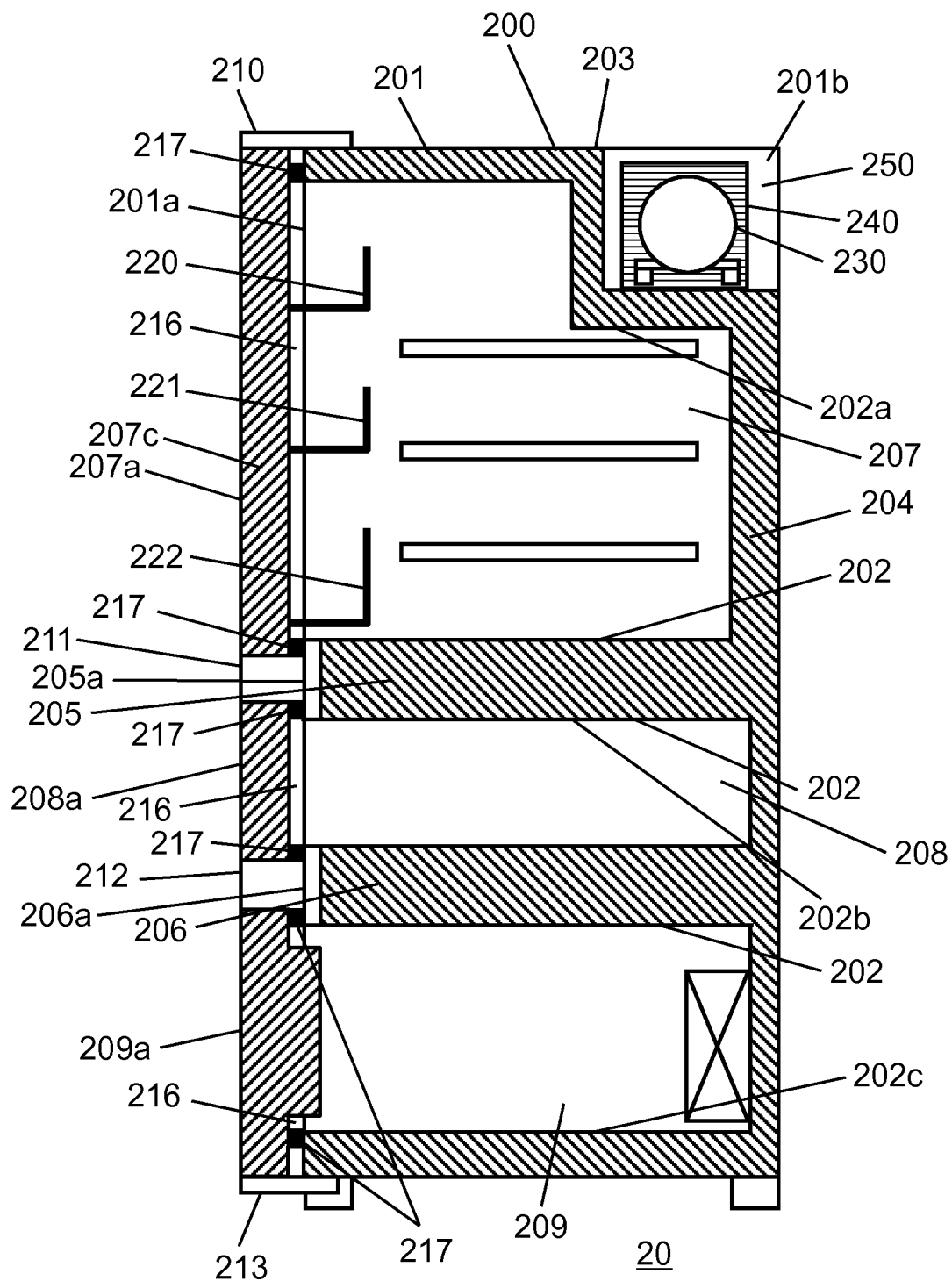


FIG. 6

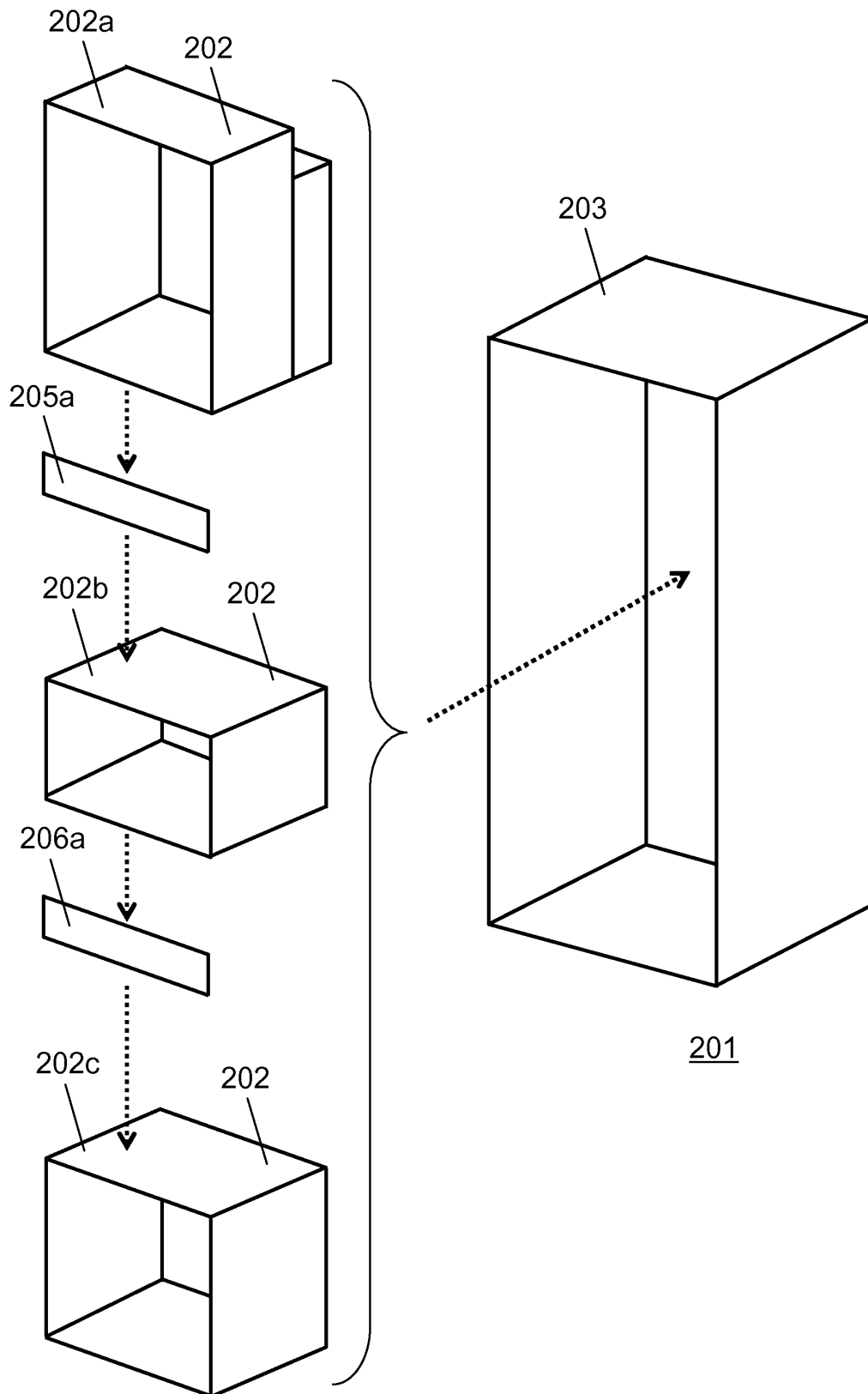
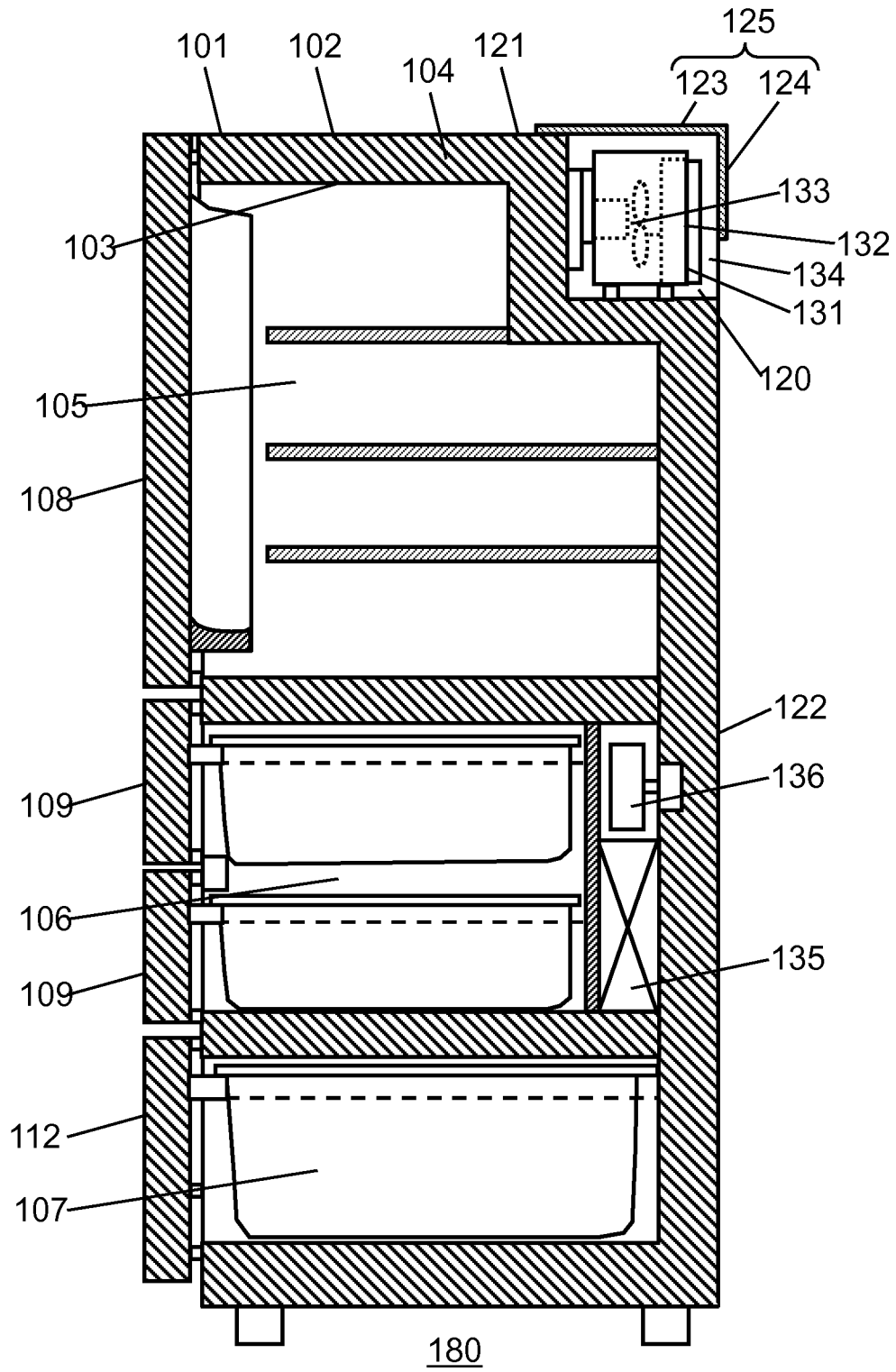


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/004123

A. CLASSIFICATION OF SUBJECT MATTER

F25D23/02 (2006.01) i, F25D19/00 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25D23/02, F25D19/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012

Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2008-292096 A (Hitachi Appliances, Inc.), 04 December 2008 (04.12.2008), entire text; all drawings (particularly, paragraph [0004]) (Family: none)	1-4, 6, 7 5, 8, 9
Y A	JP 2003-14357 A (Mitsubishi Electric Corp.), 15 January 2003 (15.01.2003), entire text; all drawings (particularly, paragraphs [0006], [0007]) (Family: none)	1-4, 6, 7 5, 8, 9
Y	JP 11-311478 A (Toshiba Corp.), 09 November 1999 (09.11.1999), entire text; all drawings (particularly, paragraph [0017]; fig. 2) (Family: none)	3, 7

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

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Date of the actual completion of the international search
18 July, 2012 (18.07.12)

Date of mailing of the international search report
31 July, 2012 (31.07.12)

Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/004123

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2006-84091 A (Matsushita Electric Industrial Co., Ltd.), 30 March 2006 (30.03.2006), entire text; all drawings (particularly, paragraph [0017]; fig. 1 to 3) (Family: none)	3
Y	JP 2006-78174 A (Hitachi, Ltd.), 23 March 2006 (23.03.2006), entire text; all drawings (particularly, paragraphs [0034], [0040], [0042]; fig. 1, 2, 4, 6) (Family: none)	4
Y	JP 2001-99552 A (Sanyo Electric Co., Ltd.), 13 April 2001 (13.04.2001), entire text; all drawings (particularly, claim 1; fig. 1 to 3) (Family: none)	4
Y	JP 2005-344961 A (Matsushita Electric Industrial Co., Ltd.), 15 December 2005 (15.12.2005), entire text; all drawings (particularly, paragraph [0030]; fig. 1, 2) (Family: none)	6

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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