

DESCRIPTION

TITLE OF INVENTION

Refrigerator

5 TECHNICAL FIELD

[0001] The present invention relates to a refrigerator.

BACKGROUND ART

[0002] A conventionally used refrigerator comprises a refrigerant circuit configured to pass refrigerant through a compressor, a condenser, a decompression device, and an
10 evaporator in this order. For example, Japanese Patent Laying-Open No. 2019-070465 (PTL 1) discloses a refrigerator comprising a condenser using flat tubes, a first header, and a second header. The first and second headers are provided at opposite ends of the flat tubes. The first and second headers are formed in a generally hollow cylindrical shape.

15 CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 2019-070465

SUMMARY OF INVENTION

TECHNICAL PROBLEM

20 [0004] The refrigerator described in the above publication has the first and second headers formed in a generally hollow cylindrical shape. Therefore, when the flat tube is inserted into the first and second headers such that a longitudinal direction of the flat tube orthogonal to the axial direction of the flat tube is along the radial direction of the first and second headers, a large gap results between the inner wall of each of the first
25 and second headers and an end of the flat tube in the axial direction of the flat tube.

Thus in the cylindrical first and second headers an unnecessary volume results. Thus the first and second headers have an increased volume. Therefore, the first and second headers act as a liquid reservoir when the refrigerant is liquefied. This invites a problem, that is, the refrigerant circuit uses an increased amount of refrigerant.

[0005] An object of the present invention is to provide a refrigerator capable of suppressing an increase in volume of a first header and a second header.

SOLUTION TO PROBLEM

[0006] A refrigerator of the present invention comprises a housing and a refrigerant circuit. The refrigerant circuit is accommodated in the housing. The refrigerant circuit comprises a compressor, a condenser, a decompression device, and an evaporator. The refrigerant circuit is configured to pass refrigerant through the compressor, the condenser, the decompression device, and the evaporator in this order. The condenser comprises a first header, a second header, and a plurality of flat tubes. The second header is spaced from the first header in a first direction. The plurality of flat tubes extend in the first direction and are connected to each of the first and second headers, and also extend in a second direction intersecting the first direction. The first and second headers each have an inner circumference configured in an elliptical shape having a minor axis and a major axis. The inner circumference has the minor axis along the first direction and the major axis along the second direction.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] The present refrigerator has first and second headers each having an inner circumference formed in an elliptical shape having a minor axis and a major axis with the minor axis along the first direction and the major axis along the second direction. By reducing a dimension of the first and second headers in the first direction, an increase in volume of the first and second headers can be suppressed.

BRIEF DESCRIPTION OF DRAWINGS

[0008] Fig. 1 is a perspective view schematically showing a configuration of a refrigerator according to an embodiment on a front side.

Fig. 2 is a perspective view schematically showing the configuration of the refrigerator according to the embodiment on a rear side.

Fig. 3 is a circuit diagram schematically showing a refrigerant circuit of the refrigerator according to the embodiment.

Fig. 4 is a front view schematically showing a configuration of a machinery

chamber of the refrigerator according to an embodiment.

Fig. 5 is a perspective view schematically showing a configuration of a machinery chamber condenser of the refrigerator according to the embodiment.

Fig. 6 is a perspective view schematically showing a configuration of a flat tube
5 of the machinery chamber condenser of the refrigerator according to an embodiment.

Fig. 7 is a top view schematically showing an arrangement of the flat tube of the machinery chamber condenser of the refrigerator and a first header according to an embodiment.

Fig. 8 is a top view schematically showing an arrangement of a flat tube of a
10 machinery chamber condenser of a refrigerator and a first header according to a comparative example.

DESCRIPTION OF EMBODIMENTS

[0009] Hereinafter, an embodiment will be described with reference to the drawings.
Hereinafter, identical or equivalent components are identically denoted and will not be
15 described redundantly.

[0010] A configuration of a refrigerator 10 according to the embodiment will be described with reference to Figs. 1 and 2. Refrigerator 10 according to the embodiment comprises a housing 20 and a refrigerant circuit 30. Refrigerator 10 is configured to cool the interior of refrigerator 10 to a target temperature by using
20 refrigerant circuit 30 accommodated in housing 20.

[0011] Housing 20 has a front side FS, a rear side RS, a right side SS1, a left side SS2, a ceiling portion TS, and a bottom portion BS. In the embodiment, a direction in which front side FS and rear side RS face each other is referred to as a frontward/rearward direction. A direction in which right side SS1 and left side SS2
25 face each other is defined as a rightward/leftward direction. A direction in which ceiling portion TS and bottom portion BS face each other is defined as an upward/downward direction. The frontward/rearward direction, the rightward/leftward direction, and the upward/downward direction are orthogonal to one another.

[0012] Housing 20 is in the form of a box with front side FS side open. Housing 20 has an outer box constituting an external shell of housing 20 and an inner box constituting an inner wall of housing 20, and is provided therebetween for example with urethane and a vacuum heat insulating material. In the interior of housing 20, a partition wall is provided that partitions an internal space of housing 20 into a plurality of storage compartments. Housing 20 thus has the plurality of storage compartments.

[0013] Housing 20 has first to fifth storage compartments as the plurality of storage compartments. For example, housing 20 includes a vegetable compartment 21 as a first storage compartment, a freezer compartment 22 as a second storage compartment, an ice maker compartment 23 as a third storage compartment, a switchable compartment 24 as a fourth storage compartment, and a refrigerator compartment 25 as a fifth storage compartment. Housing 20 is provided on front side FS with a first door 21a to a fifth door 25a for vegetable compartment 21, freezer compartment 22, ice maker compartment 23, switchable compartment 24, and refrigerator compartment 25.

[0014] Vegetable compartment 21 is provided in refrigerator 10 at a lowermost portion. Vegetable compartment 21 is a storage compartment for mainly accommodating vegetables. Vegetable compartment 21 has a first opening OP1 provided on front side FS. First opening OP1 is covered with first door 21a so as to be openable and closable.

[0015] Freezer compartment 22 is provided above vegetable compartment 21. Freezer compartment 22 is a storage compartment that is set to a freezing temperature to freeze articles accommodated in the refrigerator. Freezer compartment 22 has a second opening OP2 provided on front side FS. Second opening OP2 is covered with second door 22a so as to be openable and closable. Freezer compartment 22 has an internal temperature set to be lower than that of vegetable compartment 21.

[0016] Ice maker compartment 23 and switchable compartment 24 are disposed above freezer compartment 22 on right and left sides side by side. Ice maker compartment 23 is a storage compartment that stores ice produced in the refrigerator by an ice maker. Ice maker compartment 23 has a third opening OP3 provided on front side FS. Third

opening OP3 is covered with third door 23a so as to be openable and closable.

Switchable compartment 24 is a storage compartment which can switch a temperature zone depending on the application. Switchable compartment 24 has a fourth opening OP4 provided on front side FS. Fourth opening OP4 is covered with fourth door 24a so as to be openable and closable.

[0017] Refrigerator compartment 25 is provided in refrigerator 10 at an uppermost portion. Refrigerator compartment 25 is a storage compartment that is set to a temperature of an extent which does not freeze articles accommodated in the refrigerator. Refrigerator compartment 25 has a fifth opening OP5 provided on front side FS. Fifth opening OP5 is covered with fifth door 25a so as to be openable and closable.

[0018] Each storage compartment is distinguished by a settable temperature zone (a set temperature zone). For example, vegetable compartment 21, freezer compartment 22, ice maker compartment 23, and refrigerator compartment 25 can have their respective internal temperatures set to about 7°C, about - 18°C, about - 13°C, and about 5°C, respectively. In addition, switchable compartment 24 can have an internal temperature switched to a temperature zone such as chilled (about 0°C) or mildly frozen (about -8°C). The storage compartments have their respective internal temperatures set such that vegetable compartment 21 is highest and freezer compartment 22 is lowest. Each storage compartment's set temperature is not limited thereto. Each storage compartment is provided with an intra-compartment temperature sensor, and the operation of the refrigeration cycle and the operation of each unit are controlled so that a sensed value of the sensor is a set temperature.

[0019] Referring to Figs. 1 and 3, refrigerant circuit 30 is accommodated in housing 20. Refrigerant circuit 30 includes a compressor 31, a condenser 32, a decompression device 33, and an evaporator 34.

[0020] Refrigerant circuit 30 is composed of compressor 31, condenser 32, decompression device 33, and evaporator 34 interconnected via a pipe. Refrigerant circuit 30 is configured such that refrigerant passes through compressor 31, condenser

32, decompression device 33, and evaporator 34 in this order.

[0021] Refrigerant circuit 30 is configured such that refrigerant passing through decompression device 33 and refrigerant passing through a pipe between evaporator 34 and compressor 31 exchange heat.

5 [0022] Refrigerant circuit 30 passes refrigerant for example of R600a (HC refrigerant), R134a (HFC refrigerant), and R1234yf (HFO refrigerant). Refrigerant circuit 30 uses refrigerant in an amount for example of 84 g.

[0023] Compressor 31 is configured to suck, compress and discharge refrigerant. Compressor 31 has a suction side connected to evaporator 34 and a discharging side
10 connected to condenser 32. Compressor 31 is configured to compress refrigerant to be high-temperature and high-pressure refrigerant. Compressor 31 is driven for example by an inverter and controlled to operate depending on the condition inside refrigerator 10.

[0024] Condenser 32 is configured to receive high-temperature and high-pressure
15 refrigerant from compressor 31 and allow the refrigerant to radiate heat to condense the refrigerant. Condenser 32 includes a machinery chamber condenser 32a, a condenser pipe 32b, and a cabinet pipe 32c.

[0025] Machinery chamber condenser 32a is connected to compressor 31 and condenser pipe 32b. Machinery chamber condenser 32a has one end located upstream
20 along flow of refrigerant and connected to compressor 31, and the other end located downstream along flow of refrigerant and connected to condenser pipe 32b.

[0026] Condenser pipe 32b is configured to receive and further condense refrigerant condensed in machinery chamber condenser 32a. Condenser pipe 32b has a function to condense refrigerant. Condenser pipe 32b is connected to machinery chamber
25 condenser 32a and cabinet pipe 32c. Condenser pipe 32b has one end located upstream along flow of refrigerant and connected to machinery chamber condenser 32a, and the other end located downstream along flow of refrigerant and connected to cabinet pipe 32c. Condenser pipe 32b is disposed on each of right side SS1, left side SS2, and rear side RS of housing 20.

[0027] Cabinet pipe 32c is configured to prevent condensation on front side FS of housing 20. Cabinet pipe 32c is configured to further condense refrigerant condensed in condenser pipe 32b. Cabinet pipe 32c has a function to condense refrigerant.

5 [0028] Cabinet pipe 32c is configured to maintain a surface temperature of front side FS of housing 20 to be equal to or higher than external air's dew point temperature by heat of condensation of refrigerant. Cabinet pipe 32c is disposed at an edge of housing 20 on front side FS. The edge of housing 20 on front side FS has a width for example of 3 cm. Cabinet pipe 32c is disposed around first opening OP1 to fifth opening OP5.

10 [0029] Cabinet pipe 32c is connected to condenser pipe 32b and decompression device 33. Cabinet pipe 32c has one end located upstream along flow of refrigerant and connected to condenser pipe 32b, and the other end located downstream along flow of refrigerant and connected to decompression device 33.

15 [0030] Decompression device 33 is configured to decompress refrigerant flowing out of cabinet pipe 32c. Decompression device 33 is for example a capillary tube. Decompression device 33 is connected to cabinet pipe 32c and evaporator 34. That is, decompression device 33 has one end located upstream along flow of refrigerant and connected to cabinet pipe 32c, and the other end located downstream along flow of refrigerant and connected to evaporator 34.

20 [0031] Evaporator 34 is configured to evaporate refrigerant decompressed by decompression device 33. Evaporator 34 is configured to exchange heat between air in a cooler chamber 27 and refrigerant to cool the air in cooler chamber 27 to generate cold air. Evaporator 34 is configured such that the cold air generated in cooler chamber 27 is fed to each storage compartment via an air passage (not shown) to cool
25 air in each storage compartment. Evaporator 34 functions as a cooler. Evaporator 34 is connected between decompression device 33 and compressor 31. Evaporator 34 has one end located upstream along flow of refrigerant and connected to decompression device 33, and the other end located downstream along flow of refrigerant and connected to compressor 31.

[0032] Housing 20 includes a machinery chamber 26 and cooler chamber 27.

Machinery chamber 26 is provided in housing 20 at a lower portion on rear side RS.

Machinery chamber 26 communicates with an outside of housing 20. Compressor 31, machinery chamber condenser 32a, and decompression device 33 are disposed in
5 machinery chamber 26.

[0033] Cooler chamber 27 is provided in housing 20 on rear side RS. Cooler chamber 27 is disposed above machinery chamber 26. Evaporator 34 is disposed in cooler

chamber 27. In cooler chamber 27, a cooler chamber air blower fan (not shown) is disposed for supplying each storage compartment with cold air generated by evaporator

10 34. Cooler chamber 27 communicates with each storage compartment via an air passage (not shown). Each storage compartment is provided on rear side RS with an air blowing outlet (not shown) for blowing out cold air passing through an air passage (not shown) to each storage compartment. Each air blowing outlet is provided with a damper (not shown) opened/closed to control each storage compartment in temperature.

15 [0034] Reference will now be made to Fig. 4 to describe how compressor 31, machinery chamber condenser 32a, decompression device 33, and a machinery chamber air blower fan 40 are disposed in machinery chamber 26. Also will be described how a state of refrigerant passing through machinery chamber condenser 32a changes. For the sake of simplicity, Fig. 4 does not show a pipe connected to
20 compressor 31, machinery chamber condenser 32a, and decompression device 33.

[0035] Machinery chamber air blower fan 40 is disposed in machinery chamber 26.

Machinery chamber air blower fan 40 is configured to blow air in machinery chamber 26. Machinery chamber condenser 32a is disposed upstream of machinery chamber

25 blower fan 40 as seen along a flow WF of air blown by machinery chamber air blower fan 40. Compressor 31 is disposed downstream of machinery chamber air blower fan 40 as seen along air flow WF. Decompression device 33 is disposed downstream of compressor 31 as seen along air flow WF.

[0036] Machinery chamber 26 communicates with an outside of housing 20, and accordingly, air in machinery chamber 26 has a temperature equivalent to that external

to housing 20. Refrigerant passing through machinery chamber condenser 32a exchanges heat with air in machinery chamber 26 and thus alters to a liquid state.

[0037] A configuration of machinery chamber condenser 32a will be described in detail with reference to Figs. 5 and 6. In an embodiment, machinery chamber condenser 32a

5 is a heat exchanger using a multi-flow flat tube. The multi-flow flat tube is a porous tube. That is, a large number of through holes TH are provided inside the flat tube.

In an embodiment, machinery chamber condenser 32a is a finless heat exchanger.

Machinery chamber condenser 32a is not limited to a finless heat exchanger and may be a fin-and-tube type heat exchanger.

10 [0038] Machinery chamber condenser 32a includes a first header HP1, a second header HP2, and a plurality of flat tubes SP. First header HP1, second header HP2, and the plurality of flat tubes SP are configured to internally pass refrigerant therethrough.

[0039] First and second headers HP1 and HP2 are provided for distributing refrigerant's flow rate. First header HP1 has a hollow structure communicating in the

15 upward/downward direction from an upper side to a lower side. Second header HP2 internally has a hollow structure separated in the upward/downward direction into an upper side and a lower side.

[0040] An inflow pipe CP1 and an outflow pipe CP2 are connected to second header HP2. Inflow pipe CP1 is connected to second header HP2 on a lower side as seen in

20 the upward/downward direction. Inflow pipe CP1 is connected inside second header HP2 at a lower portion. Outflow pipe CP2 is connected to second header HP2 on an upper side as seen in the upward/downward direction. Outflow pipe CP2 is connected inside second header HP2 at an upper portion as seen in the upward/downward direction.

25 [0041] First and second headers HP1 and HP2 are disposed to face each other.

Second header HP2 is spaced from first header HP1 in a first direction D1. First and second headers HP1 and HP2 each internally have a refrigerant passage passing refrigerant therethrough.

[0042] First and second headers HP1 and HP2 each include an elliptical pipe having

closed opposite ends. First and second headers HP1 and HP2 each have an inner circumference IC formed in an elliptical shape having a minor axis A1 and a major axis A2. Inner circumference IC has minor axis A1 along first direction D1. Inner circumference IC has major axis A2 along a second direction D2 intersecting first direction D1. Minor axis A1 of inner circumference IC has a dimension (or a minor diameter) for example of 16 mm or less. Major axis A2 of inner circumference IC has a dimension (or a major diameter) for example of 16 mm or more.

[0043] Minor axis A1 is along a direction intersecting air flow WF. Major axis A2 is along air flow WF. First and second headers HP1 and HP2 can thus have a reduced dimension in the direction intersecting air flow WF. This can reduce airflow resistance caused by first and second headers HP1 and HP2 against air flow WF.

[0044] The plurality of flat tubes SP extend in first direction D1. The plurality of flat tubes SP are connected to first and second headers HP1 and HP2. The plurality of flat tubes SP each have one end (a first end) connected to first header HP1 and the other end (a second end) connected to second header HP2. The plurality of flat tubes SP are disposed between first and second headers HP1 and HP2.

[0045] The plurality of flat tubes SP each have a flat shape. The plurality of flat tubes SP each have a flat shape in a cross section thereof orthogonal to the axial direction thereof. The plurality of flat tubes SP each have a generally rectangular shape in the cross section thereof orthogonal to the axial direction thereof.

[0046] The plurality of flat tubes SP extend in second direction D2 intersecting first direction D1. The plurality of flat tubes SP are each configured such that the cross section thereof orthogonal to the axial direction thereof has a longer side in a direction along second direction D2.

[0047] The plurality of flat tubes SP are spaced from one another in a third direction D3 intersecting first and second directions D1 and D2. The plurality of flat tubes SP are each configured such that the cross section thereof orthogonal to the axial direction thereof has a shorter side in a direction along third direction D3. Third direction D3 is the upward/downward direction. The plurality of flat tubes SP are disposed in

parallel. The plurality of flat tubes SP are each larger in width in second direction D2 than in third direction D3.

[0048] The plurality of flat tubes SP each have the shorter side with a dimension for example of 1.8 mm or more. The plurality of flat tubes SP each have the longer side
5 with a dimension for example of 12 mm or more. The plurality of flat tubes SP are each spaced from another for example by a distance of 10 mm or less. The plurality of flat tubes SP are each formed for example of aluminum.

[0049] The plurality of flat tubes SP each have a plurality of through holes TH aligned in second direction D2. The plurality of through holes TH each pass through each of
10 the plurality of flat tubes SP in first direction D1. That is, the plurality of through holes TH each pass through each of the plurality of flat tubes SP in first direction D1 from one end to the other end. The plurality of through holes TH communicate with a refrigerant passage of each of first and second headers HP1 and HP2 so as to pass refrigerant through through holes TH.

15 [0050] Reference will now be made to Figs. 1 and 3 to describe an operation of refrigerator 10 according to the embodiment.

[0051] Refrigerant passing through refrigerant circuit 30 is initially compressed by compressor 31 into high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant flows into condenser 32 and is condensed
20 while passing through condenser 32. Specifically, the high-temperature and high-pressure gas refrigerant flows into machinery chamber condenser 32a, exchanges heat therein with air in machinery chamber 27 while passing through machinery chamber condenser 32a, and is thus condensed into a gas-liquid two-phase refrigerant.

[0052] The gas-liquid two-phase refrigerant condensed by machinery chamber
25 condenser 32a flows into condenser pipe 32b, exchanges heat therein with air external to housing 20 by heat conduction while passing through condenser pipe 32b, and is thus further condensed.

[0053] The gas-liquid two-phase refrigerant condensed by condenser pipe 32b flows into cabinet pipe 32c, exchanges heat therein with air external to housing 20 by heat

conduction while passing through cabinet pipe 32c, and is thus further condensed into a liquid refrigerant. While the gas-liquid refrigerant passes through cabinet pipe 32c, the refrigerant's heat is radiated. The refrigerant's heat radiated from the gas-liquid two-phase refrigerant passing through cabinet pipe 32c prevents dew condensation
5 around the opening of each storage compartment.

[0054] The liquid refrigerant condensed by cabinet pipe 32c flows into decompression device 33 and is decompressed by decompression device 33 to be low-temperature and low-pressure liquid refrigerant. The low-temperature and low-pressure liquid refrigerant flows into evaporator 34, and while the liquid refrigerant passes through
10 evaporator 34, heat exchange is done with air in cooler chamber 27, and the liquid refrigerant thus evaporates into gas refrigerant.

[0055] While doing so, the air in cooler chamber 27 is cooled by evaporator 34. The air cooled by evaporator 34 is blown by a cooler chamber air blower fan (not shown) to each storage compartment via an air passage (not shown). In this way, each storage
15 compartment has its internal air cooled. The gas refrigerant evaporated by evaporator 34 flows into compressor 31 and is again compressed into high-temperature and high-pressure gas refrigerant. This refrigeration cycle is repeated to maintain temperature in refrigerator 10 at a set temperature.

[0056] Hereinafter reference will be made to Fig. 5 to describe flow of refrigerant in machinery chamber condenser 32a. Refrigerant flowing through inflow pipe CP1 into
20 second header HP2 flows from a lower inside of second header HP2 into first header HP1 through a plurality of ones of the plurality of flat tubes SP disposed on a lower side. The refrigerant flowing into first header HP1 flows through first header HP1 upward, and then flows into second header HP2 through a plurality of ones of the
25 plurality of flat tubes SP disposed on an upper side. The refrigerant flowing from first header HP1 into second header HP2 through the plurality of flat tubes SP flows out from second header HP2 through outflow pipe CP2.

[0057] Hereinafter reference will be made to Figs. 7 and 8 to describe a function and effect of refrigerator 10 according to the embodiment in comparison with a

comparative example.

[0058] Referring to Fig. 7, refrigerator 10 according to the embodiment comprises first header HP1 having inner circumference IC with minor axis A1 along first direction D1 and major axis A2 along second direction D2. Although not shown, refrigerator 10 according to the embodiment comprises second header HP2 having inner circumference IC with minor axis A1 along first direction D1 and major axis A2 along second direction D2.

[0059] Referring to Fig. 8, refrigerator 10 according to the comparative example comprises first header HP1 configured in a round shape (in the form of a perfect circle). Although not shown, refrigerator 10 according to the comparative example comprises second header HP2 configured in a round shape (in the form of a perfect circle). Second header HP2 and first header HP1 of the comparative example have an inner diameter determined in accordance with a width of flat tube SP in second direction D2. As a result, first header HP1 has an unnecessary volume in first direction D1.

Accordingly, first and second headers HP1 and HP2 have an increased volume. Because of this, first and second headers HP1 and HP2 act as a liquid reservoir when refrigerant is liquefied. This invites a problem, that is, refrigerant circuit 30 uses an increased amount of refrigerant.

[0060] Refrigerator 10 according to the embodiment comprises first and second headers HP1 and HP2 having inner circumference IC with minor axis A1 along first direction D1 and major axis A2 along second direction D2. When this is compared with first and second headers HP1 and HP2 configured in a round shape (in the form of perfect circle) as in the comparative example, the former allows first and second headers HP1 and HP2 to have a smaller dimension in first direction D1 and can thus suppress an increase in volume of first and second headers HP1 and HP2. This can in turn suppress an increase in an amount of refrigerant used by refrigerant circuit 30. A possibility of interfering with a regulation value set for an amount of refrigerant used can thus be reduced.

[0061] Refrigerator 10 according to the embodiment comprises a plurality of flat tubes

SP each having a plurality of through holes TH aligned in second direction D2, each passing through each of the plurality of flat tubes SP in first direction D1. This can enhance performance of machinery chamber condenser 32a for heat exchange.

[0062] Hereinafter, an exemplary variation of refrigerator 10 according to the

5 embodiment will be described with reference to Fig. 5. For the exemplary variation of refrigerator 10 according to the embodiment, minor axis A1 has a dimension such that refrigerant passing through first and second headers HP1 and HP2 has a flow velocity equal to or larger than zero penetration flow velocity.

10 [0063] When gas refrigerant flowing upward through a pipe has a flow velocity U_{gas} increasing beyond some flow velocity, liquid refrigerant generated through condensation forms a film along the wall of the pipe and moves upward along the wall of the pipe against its own weight. The flow velocity of the thus flowing gas refrigerant is referred to as zero penetration flow velocity U_{gas}' . When the gas refrigerant has flow velocity U_{gas} below zero penetration flow velocity U_{gas}' , the

15 liquid refrigerant falls smoothly along the wall of the pipe.

20 [0064] When a refrigerator is compared with an air conditioner and other similar refrigeration cycle apparatuses, the former passes gas refrigerant with a smaller flow velocity U_{gas} . Therefore, when first and second headers HP1 and HP2 have minor axis A1 with a large dimension (or minor diameter), there is a high possibility that the gas refrigerant may have flow velocity U_{gas} below zero penetration flow velocity U_{gas}' and liquid refrigerant may stagnate.

[0065] Gas refrigerant has flow velocity U_{gas} expressed by the following expression (1):

[0066]

$$U_{gas} = \frac{Gr}{\rho_{gas}S} \quad \dots (1)$$

25

[0067] where Gr represents refrigerant flow rate (in Kg/s) in a refrigerator, ρ_{gas} represents refrigerant gas density (in kg/m³) in the refrigerator, and S represents an area (in m²) in cross section of an inner circumference of a pipe in the refrigerator.

[0068] Zero penetration flow velocity U_{gas}' is expressed by the following expression (2):

[0069]

$$U_{gas}' = C \sqrt{D \left(\frac{\rho_{liq} - \rho_{gas}}{\rho_{gas}} \right) g} \quad \dots (2)$$

5 [0070] where C represents a flooding constant, D represents a dimension (in m) of minor axis A1 of first and second headers HP1 and HP2, ρ_{liq} represents refrigerant liquid density (in kg/m³), ρ_{gas} represents refrigerant gas density (in kg/m³), and g represents gravitational acceleration (in m/s²). Flooding constant C is a constant determined through an experiment, and is for example 0.56 or more and 1 or less.

10 [0071] Liquid refrigerant does not stagnate when first and second headers HP1 and HP2 have minor axis A1 determined such that gas refrigerant has flow velocity U_{gas} equal to or faster than zero penetration flow velocity U_{gas}' (gas refrigerant's flow velocity $U_{gas} \geq$ zero penetration flow velocity U_{gas}').

[0072] For example, when, under a refrigerator operating condition, in the refrigerator, 15 refrigerant flow rate G_r (Kg/s) is 1 Kg/s, refrigerant liquid density ρ_{liq} (kg/m³)/refrigerant gas density ρ_{gas} (kg/m³) is refrigerant liquid density/refrigerant saturated-gas density due to discharge pressure, flooding constant C is 1, and gravitational acceleration g (m/s²) is 9.8m/s², then, a dimension of the minor axis (or minor diameter) of first and second headers HP1 and HP2 allowing gas refrigerant to 20 have flow velocity U_{gas} equal to or faster than zero penetrative flow velocity U_{gas}' will be 4.1 mm or less according to expressions (1) and (2).

[0073] The exemplary variation of refrigerator 10 according to the embodiment provides minor axis A1 having a dimension such that refrigerant passing through first and second headers HP1 and HP2 has a flow velocity equal to or faster than zero 25 penetration flow velocity. This can prevent liquid refrigerant from stagnating in first and second headers HP1 and HP2. Therefore, an amount of refrigerant used in refrigerant circuit 30 can be reduced. High performance of machinery chamber

condenser 32a for heat exchange can be maintained while suppressing an increase in the amount of refrigerant used.

[0074] It should be understood that the embodiments disclosed herein have been described for the purpose of illustration only and in a non-restrictive manner in any respect. The scope of the present invention is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the meaning and scope equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0075] 10 refrigerator, 20 housing, 30 refrigerant circuit, 31 compressor, 32 condenser, 32a machinery chamber condenser, 32b condenser pipe, 32c cabinet pipe, 33 decompression device, 34 evaporator, 40 machinery chamber air blower fan, A1 minor axis, A2 major axis, D1 first direction, D2 second direction, D3 third direction, HP1 first header, HP2 second header, IC inner circumference, SP flat tube, Ugas' zero penetration flow velocity.

CLAIMS

1. A refrigerator comprising:
a housing; and
5 a refrigerant circuit accommodated in the housing,
the refrigerant circuit comprising a compressor, a condenser, a decompression
device, and an evaporator,
the refrigerant circuit being configured to pass refrigerant through the
compressor, the condenser, the decompression device, and the evaporator in this order,
10 the condenser comprising:
a first header;
a second header spaced from the first header in a first direction; and
a plurality of flat tubes each extending in the first direction to be
connected to each of the first and second headers, and also extending in a second
15 direction crossing the first direction,
the first and second headers each having an inner circumference formed in an
elliptical shape having a minor axis and a major axis,
the inner circumference having the minor axis along the first direction and the
major axis along the second direction.
20
2. The refrigerator according to claim 1, wherein the minor axis has a
dimension allowing the first and second headers to pass the refrigerant at a flow
velocity equal to or larger than a zero penetration flow velocity.
- 25 3. The refrigerator according to claim 1 or 2, wherein
the plurality of flat tubes each have a plurality of through holes TH aligned in
the second direction, and
the plurality of through holes each pass through each of the plurality of flat
tubes in the first direction.

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