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(54)

REFRIGERATION SYSTEM

(57)

It is an object of the present invention to sufficiently reduce the pressure pulsation in a refrigeration system that employs carbon dioxide or the like as a refrigerant. A refrigeration system (1) according to the present invention comprises a first refrigerant passage (204), a π -type silencer (20, 20a), and a second refrigerant passage (205). The π -type silencer has a first silencing space (201), a second silencing space (202), and a communication path (203, 203a). The first silencing space communicates with the first refrigerant passage. The second silencing space is disposed below the first silencing space. The communication path extends from the lower end of the first silencing space to the outside of the first silencing space and communicates with the second silencing space. The second refrigerant passage extends from the lower end of the second silencing space.

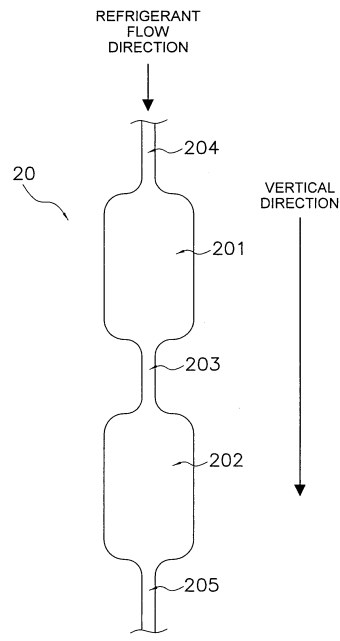


FIG. 2

Description**TECHNICAL FIELD**

5 **[0001]** The present invention relates to a refrigeration system and particularly to a refrigeration system in which a π -type silencer is employed as a silencer.

BACKGROUND ART

10 **[0002]** In recent years, refrigeration systems that employ carbon dioxide as a refrigerant have become commoditized. However, when carbon dioxide is employed as a refrigerant in a refrigeration system in this manner, there arises the problem that the density of the refrigerant and the speed of sound in the refrigerant become larger and pressure pulsation inevitably becomes larger. In order to counter this problem, in recent years, various methods of reducing pressure pulsation in refrigeration systems have been proposed (e.g., see patent citation 1, patent citation 2, non-patent citation 1 and non-patent citation 2).

Patent Citation 1: JP-A No. 6-10875

Patent Citation 2: JP-A No. 2004-218934

20 Non-Patent Citation 1: Sakae Yamada and Iwao Ôtani, "Orifisu oyobi π -gata hairetsu kûkisô ni yoru myakudô jokyo", Transactions of the Japan Society of Mechanical Engineers (Second Part), December 1968, Vol. 34, No. 268, pp. 2139-2145.

Non-Patent Citation 2: The Japan Society of Mechanical Engineers, editor, "Jirei ni manabu ryûtai kanren shindo", First Edition, Gihodo Shuppan Co., Ltd., September 20, 2003, pp. 190-193.

DISCLOSURE OF THE INVENTION

<Technical Problem>

30 **[0003]** It is an object of the present invention to sufficiently reduce pressure pulsation in a refrigeration system that employs carbon dioxide and the like as a refrigerant.

<Solution to the Problem>

35 **[0004]** A refrigeration system according to a first aspect of the present invention comprises a first refrigerant passage, a π -type silencer, and a second refrigerant passage. The π -type silencer includes a first silencing space, a second silencing space, and a communication path. The first silencing space communicates with the first refrigerant passage. The second silencing space is disposed below the first silencing space. The communication path extends from the lower end of the first silencing space to the outside of the first silencing space and communicates with the second silencing space. The second refrigerant passage extends from the lower end of the second silencing space. Note that, in this refrigeration system, the refrigerant may flow in the order of: the first refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the second refrigerant passage, or in the opposite order of: the second refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the first refrigerant passage.

40 **[0005]** The π -type silencer is incorporated in this refrigeration system. For this reason, in this refrigeration system, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, the second silencing space is disposed below the first silencing space, and the communication path extends from the lower end of the first silencing space to the outside of the first silencing space and communicates with the second silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space. In addition, in this refrigeration system, the second refrigerant passage extends from the lower end of the second silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the second silencing space. Therefore, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the π -type silencer.

45 **[0006]** A refrigeration system according to a second aspect of the present invention is the refrigeration system according to the first aspect of the present invention, wherein the communication path extends into the inside of the second silencing space.

50 **[0007]** In this refrigeration system, the communication path extends into the inside of the second silencing space. Thus, in this refrigeration system, just the communication path can be extended long without changing the size of the entire π -type silencer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, in this refrigeration system, the pressure pulsation reduction effect can be

made larger without changing the size of the entire π -type silencer.

[0008] A refrigeration system according to a third aspect of the present invention comprises a first refrigerant passage, a π -type silencer, and a second refrigerant passage. The π -type silencer has a first silencing space, a second silencing space, a communication path, and an oil return hole. The first silencing space communicates with the first refrigerant passage. The second silencing space is disposed below the first silencing space. The communication path extends from the inside to the outside of the first silencing space through the lower end and communicates with the second silencing space. The oil return hole is disposed in the lower end portion of the communication path inside the first silencing space. The second refrigerant passage extends from the lower end of the second silencing space. Note that, in this refrigeration system, the refrigerant may flow in the order of: the first refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the second refrigerant passage, or in the opposite order of: the second refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the first refrigerant passage.

[0009] The π -type silencer is incorporated in this refrigeration system. Thus, in this refrigeration system, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, the second silencing space is disposed below the first silencing space, and the communication path extends from the inside to the outside of the first silencing space through the lower end and communicates with the second silencing space, and the oil return hole is disposed in the lower end portion of the communication path inside the first silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space, and just the communication path can be extended long without changing the size of the entire π -type silencer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer. In addition, in this refrigeration system, the second refrigerant passage extends from the lower end of the second silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the second silencing space. Therefore, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the π -type silencer, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

[0010] A refrigeration system according to a fourth aspect of the present invention is the refrigeration system according to the third aspect of the present invention, wherein the communication path extends into the inside of the second silencing space.

[0011] In this refrigeration system, the communication path extends into the inside of the second silencing space. Thus, in this refrigeration system, just the communication path can be extended even longer without changing the size of the entire π -type silencer. Therefore, in this refrigeration system, the pressure pulsation reduction effect can be made even larger without changing the size of the entire π -type silencer.

[0012] A refrigeration system according to a fifth aspect of the present invention comprises a first refrigerant passage, a π -type silencer, and a second refrigerant passage. The π -type silencer has a first silencing space, a second silencing space, and a communication path. The first silencing space communicates with the first refrigerant passage. The second silencing space and the first silencing space are disposed side-by-side. The communication path extends from the lower end of the first silencing space and through the outside of the first silencing space to the lower end of the second silencing space and communicates with the second silencing space. The second refrigerant passage communicates with the second silencing space. Note that, in this refrigeration system, the refrigerant may flow in the order of: the first refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the second refrigerant passage, or in the opposite order of: the second refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the first refrigerant passage.

[0013] The π -type silencer is incorporated in this refrigeration system. Thus, in this refrigeration system, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, the second silencing space and the first silencing space are disposed side-by-side, and the communication path extends from the lower end of the first silencing space and through the outside of the first silencing space to the lower end of the second silencing space and communicates with the second silencing space. Thus, in this refrigeration system, the entire length of the π -type silencer can be shortened. Consequently, in this refrigeration system, the options for the disposition of the π -type silencer can be expanded.

[0014] A refrigeration system according to a sixth aspect of the present invention is the refrigeration system according to the fifth aspect of the present invention, wherein the first refrigerant passage is inserted from the upper end of the first silencing space and extends into the inside of the first silencing space.

[0015] In this refrigeration system, the first refrigerant passage is inserted from the upper end of the first silencing space and extends into the inside of the first silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space when the refrigerant flows from the second silencing space to the first silencing space.

[0016] A refrigeration system according to a seventh aspect of the present invention is the refrigeration system according to the fifth or sixth aspect of the present invention, wherein the second refrigerant passage is inserted from the upper end of the second silencing space and extends into the inside of the second silencing space.

[0017] In this refrigeration system, the second refrigerant passage is inserted from the upper end of the second silencing space and extends into the inside of the second silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the second silencing space when the refrigerant flows from the first silencing space to the second silencing space.

[0018] A refrigeration system according to an eighth aspect of the present invention is the refrigeration system according to the fifth aspect of the present invention, wherein the first refrigerant passage extends from the upper end of the first silencing space. In addition, the second refrigerant passage extends from the upper end of the second silencing space.

[0019] In this refrigeration system, the first refrigerant passage extends from the upper end of the first silencing space, and the second refrigerant passage extends from the upper end of the second silencing space. Thus, in this refrigeration system, a π -type silencer having a simple configuration can be used. Therefore, in this refrigeration system, manufacturing cost reduction can be expected.

[0020] A refrigeration system according to a ninth aspect of the present invention is the refrigeration system according to the fifth aspect of the present invention, wherein the first refrigerant passage extends from the lower end of the first silencing space. In addition, the second refrigerant passage extends from the lower end of the second silencing space.

[0021] In this refrigeration system, the first refrigerant passage extends from the lower end of the first silencing space, and the second refrigerant passage extends from the lower end of the second silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space and the second silencing space.

[0022] A refrigeration system according to a tenth aspect of the present invention is the refrigeration system according to any one of the fifth through ninth aspects of the present invention, wherein a mesh member fills the communication path.

[0023] In this refrigeration system, the mesh member fills the communication path. Thus, in this refrigeration system, reflection waves can be prevented from arising inside the communication path.

[0024] A refrigeration system according to an eleventh aspect of the present invention comprises a first refrigerant passage, a π -type silencer, and a second refrigerant passage. The π -type silencer has a first silencing space, a second silencing space, and a communication path. The first silencing space communicates with the first refrigerant passage. The second silencing space and the first silencing space are disposed side-by-side. The communication path extends from the lower end of the first silencing space and through the outside of the first silencing space to the upper end of the second silencing space and communicates with the second silencing space. The second refrigerant passage communicates with the second silencing space. Note that, in this refrigeration system, the refrigerant flows in the order of: the first refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the second refrigerant passage.

[0025] The π -type silencer is incorporated in this refrigeration system. Thus, in this refrigeration system, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, the second silencing space and the first silencing space are disposed side-by-side, and the communication path extends from the lower end of the first silencing space and through the outside of the first silencing space to the upper end of the second silencing space and communicates with the second silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space, the entire length of the π -type silencer can be shortened, and the communication path can be made longer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space, the options for the disposition of the π -type silencer can be expanded, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

[0026] A refrigeration system according to a twelfth aspect of the present invention is the refrigeration system according to the eleventh aspect of the present invention, wherein the second refrigerant passage extends from the lower end of the second silencing space.

[0027] In this refrigeration system, the second refrigerant passage extends from the lower end of the second silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the second silencing space.

[0028] A refrigeration system according to a thirteenth aspect of the present invention comprises a first refrigerant passage, a π -type silencer, and a second refrigerant passage. The π -type silencer has a first silencing space, a second silencing space, and a communication path. The first silencing space communicates with the first refrigerant passage. The second silencing space and the first silencing space are disposed side-by-side. The communication path extends from the inside of the first silencing space and through the upper end thereof to the upper end of the second silencing space and communicates with the second silencing space. The second refrigerant passage communicates with the second silencing space. Note that, in this refrigeration system, the refrigerant may flow in the order of: the first refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the second refrigerant passage, or in the opposite order of: the second refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the first refrigerant passage.

[0029] The π -type silencer is incorporated in this refrigeration system. Thus, in this refrigeration system, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in

this refrigeration system, the second silencing space and the first silencing space are disposed side-by-side, and the communication path extends from the inside of the first silencing space and through the upper end thereof to the upper end of the second silencing space and communicates with the second silencing space. Thus, in this refrigeration system, even when the refrigerant flows from the first silencing space to the second silencing space, refrigerating machine oil can be prevented from collecting in the first silencing space, and the communication path can be made longer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

[0030] A refrigeration system according to a fourteenth aspect of the present invention is the refrigeration system according to the thirteenth aspect of the present invention, wherein the communication path extends from the upper end of the second silencing space into the inside of the second silencing space.

[0031] In this refrigeration system, the communication path extends from the upper end of the second silencing space into the inside of the second silencing space. Thus, in this refrigeration system, just the communication path can be extended even longer without changing the size of the entire π -type silencer. Therefore, in this refrigeration system, the pressure pulsation reduction effect can be made even larger without changing the size of the entire π -type silencer.

[0032] A refrigeration system according to a fifteenth aspect of the present invention is the refrigeration system according to the thirteenth or fourteenth aspect of the present invention, wherein the second refrigerant passage extends from the lower end of the second silencing space.

[0033] In this refrigeration system, the second refrigerant passage extends from the lower end of the second silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the second silencing space.

[0034] A refrigeration system according to a sixteenth aspect of the present invention comprises a first refrigerant passage, a π -type silencer, and a second refrigerant passage. The π -type silencer has a first silencing space, a second silencing space, and a communication path. The first silencing space communicates with the first refrigerant passage.

The second silencing space and the first silencing space are disposed side-by-side. The communication path extends from the side surface of the bottom portion of the first silencing space to the side surface of the bottom portion of the second silencing space and communicates with the second silencing space. The second refrigerant passage is connected to the side surface of the bottom portion of the second silencing space and communicates with the second silencing space. Note that, in this refrigeration system, the refrigerant flows in the order of: the first refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the second refrigerant passage.

[0035] The π -type silencer is incorporated in this refrigeration system. Thus, in this refrigeration system, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, the second silencing space and the first silencing space are disposed side-by-side. The communication path extends from the side surface of the bottom portion of the first silencing space to the side surface of the bottom portion of the second silencing space and communicates with the second silencing space, and the second refrigerant passage is connected to the side surface of the bottom portion of the second silencing space and communicates with the second silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space and the second silencing space.

[0036] A refrigeration system according to a seventeenth aspect of the present invention is the refrigeration system according to the sixteenth aspect of the present invention, wherein the communication path extends from the inside of the first silencing space into the inside of the second silencing space through the side surfaces of the bottom portions of the first silencing space and the second silencing space.

[0037] In this refrigeration system, the communication path extends from the inside of the first silencing space into the inside of the second silencing space through the side surfaces of the bottom portions of the first silencing space and the second silencing space. Thus, in this refrigeration system, just the communication path can be extended long without changing the size of the entire π -type silencer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, in this refrigeration system, the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

[0038] A refrigeration system according to an eighteenth aspect of the present invention is the refrigeration system according to the sixteenth or seventeenth aspect of the present invention, wherein the first refrigerant passage is connected to the side surface of the bottom portion of the first silencing space.

[0039] In this refrigeration system, the first refrigerant passage is connected to the side surface of the bottom portion of the first silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space and the second silencing space in either of the cases where the refrigerant flows in the order of: the first refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the second refrigerant passage or where the refrigerant flows in the order of: the second refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the first refrigerant passage.

[0040] A refrigeration system according to a nineteenth aspect of the present invention comprises a first refrigerant passage, a π -type silencer, a second refrigerant passage, a first oil drain passage, and a second oil drain passage. The

π -type silencer has a first silencing space, a second silencing space, and a communication path. The first silencing space communicates with the first refrigerant passage. The second silencing space and the first silencing space are disposed side-by-side. The communication path extends from the side surface of the first silencing space to the side surface of the second silencing space and communicates with the second silencing space. The second refrigerant passage communicates with the second silencing space. The first oil drain passage extends from the lower end of the first silencing space. The second oil drain passage extends from the lower end of the second silencing space. Note that, in this refrigeration system, the refrigerant may flow in the order of: the first refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the second refrigerant passage, or in the opposite order of: the second refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the first refrigerant passage.

[0041] The π -type silencer is incorporated in this refrigeration system. Thus, in this refrigeration system, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, the first oil drain passage extends from the lower end of the first silencing space, and the second oil drain passage extends from the lower end of the second silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space and the second silencing space.

[0042] A refrigeration system according to a twentieth aspect of the present invention is the refrigeration system according to the nineteenth aspect of the present invention, wherein the second oil drain passage merges with the first oil drain passage.

[0043] In this refrigeration system, the second oil drain passage merges with the first oil drain passage. Thus, in this refrigeration system, refrigerating machine oil to be sent to the π -type silencer can be gathered together and returned to the compressor and the like.

<Effects of the Invention>

[0044] In the refrigeration system according to the first aspect of the present invention, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the π -type silencer.

[0045] In the refrigeration system according to the second aspect of the present invention, just the communication path can be extended long without changing the size of the entire π -type silencer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, in this refrigeration system, the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

[0046] In the refrigeration system according to the third aspect of the present invention, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space, and just the communication path can be extended long without changing the size of the entire π -type silencer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer. In addition, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the second silencing space. Therefore, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the π -type silencer, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

[0047] In the refrigeration system according to the fourth aspect of the present invention, just the communication path can be extended even longer without changing the size of the entire π -type silencer. Therefore, in this refrigeration system, the pressure pulsation reduction effect can be made even larger without changing the size of the entire π -type silencer.

[0048] In the refrigeration system according to the fifth aspect of the present invention, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, the entire length of the π -type silencer can be shortened. Consequently, in this refrigeration system, the options for the disposition of the π -type silencer can be expanded.

[0049] In the refrigeration system according to the sixth aspect of the present invention, refrigerating machine oil can be prevented from collecting in the first silencing space when the refrigerant flows from the second silencing space to the first silencing space.

[0050] In the refrigeration system according to the seventh aspect of the present invention, refrigerating machine oil can be prevented from collecting in the second silencing space when the refrigerant flows from the first silencing space to the second silencing space.

[0051] In the refrigeration system according to the eighth aspect of the present invention, a π -type silencer having a simple configuration can be used. Therefore, in this refrigeration system, manufacturing cost reduction can be expected.

[0052] In the refrigeration system according to the ninth aspect of the present invention, refrigerating machine oil can be prevented from collecting in the first silencing space and the second silencing space.

[0053] In the refrigeration system according to the tenth aspect of the present invention, reflection waves can be prevented from arising inside the communication path.

[0054] In the refrigeration system according to the eleventh aspect of the present invention, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, the second silencing space and the first silencing space are disposed side-by-side, and the communication path extends from the lower end of the first silencing space to the upper end of the second silencing space through the outside of the first silencing space and communicates with the second silencing space. Thus, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space, the entire length of the π -type silencer can be shortened, and the communication path can be made longer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space, the options for the disposition of the π -type silencer can be expanded, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

[0055] In the refrigeration system according to the twelfth aspect of the present invention, refrigerating machine oil can be prevented from collecting in the second silencing space.

[0056] In the refrigeration system according to the thirteenth aspect of the present invention, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space even when the refrigerant flows from the first silencing space to the second silencing space, and the communication path can be made longer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

[0057] In the refrigeration system according to the fourteenth aspect of the present invention, just the communication path can be extended even longer without changing the size of the entire π -type silencer. Therefore, in this refrigeration system, the pressure pulsation reduction effect can be made even larger without changing the size of the entire π -type silencer.

[0058] In the refrigeration system according to the fifteenth aspect of the present invention, refrigerating machine oil can be prevented from collecting in the second silencing space.

[0059] In the refrigeration system according to the sixteenth aspect of the present invention, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space and the second silencing space.

[0060] In the refrigeration system according to the seventeenth aspect of the present invention, just the communication path can be extended long without changing the size of the entire π -type silencer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, in this refrigeration system, the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

[0061] In the refrigeration system according to the eighteenth aspect of the present invention, refrigerating machine oil can be prevented from collecting in the first silencing space and the second silencing space in either of the cases where the refrigerant flows in the order of: the first refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the second refrigerant passage or where the refrigerant flows in the order of: the second refrigerant passage $\rightarrow$ the π -type silencer $\rightarrow$ the first refrigerant passage.

[0062] In the refrigeration system according to the nineteenth aspect of the present invention, in this refrigeration system, the pressure pulsation can be sufficiently reduced even when carbon dioxide or the like is employed as a refrigerant. In addition, in this refrigeration system, refrigerating machine oil can be prevented from collecting in the first silencing space and the second silencing space.

[0063] In the refrigeration system according to the twentieth aspect of the present invention, refrigerating machine oil to be sent to the π -type silencer can be gathered together and returned to the compressor and the like.

BRIEF DESCRIPTION OF THE DRAWINGS

[0064]

FIG. 1 is a diagram of a refrigerant circuit of an air conditioner pertaining to an embodiment of the present invention; FIG. 2 is a longitudinal sectional diagram of a π -type silencer that is incorporated in the refrigerant circuit of the air conditioner pertaining to the embodiment of the present invention;

FIG. 3 is a longitudinal sectional diagram of a π -type silencer pertaining to modification A;

FIG. 4 is a longitudinal sectional diagram of a π -type silencer pertaining to modification A;

FIG. 5 is a longitudinal sectional diagram of a π -type silencer pertaining to modification B;
 FIG. 6 is a longitudinal sectional diagram of a π -type silencer pertaining to modification B;
 FIG. 7 is a longitudinal sectional diagram of a π -type silencer pertaining to modification B;
 FIG. 8 is a longitudinal sectional diagram of a π -type silencer pertaining to modification C;
 FIG. 9 is a longitudinal sectional diagram of a π -type silencer pertaining to modification D;
 FIG. 10 is a longitudinal sectional diagram of a π -type silencer pertaining to modification E;
 FIG. 11 is a longitudinal sectional diagram of a π -type silencer pertaining to modification F;
 FIG. 12 is a longitudinal sectional diagram of a π -type silencer pertaining to modification F; and
 FIG. 13 is a longitudinal sectional diagram of a π -type silencer pertaining to modification G.

EXPLANATION OF THE REFERENCE NUMERALS

[0065]

1	Air Conditioner (Refrigeration System)
20, 20a, 20b, 20c, 20d, 20e, 20f, 20g, 20h, 20i, 20j, 20k	π -type Silencer
201, 201c, 201i	First Silencing Space
202, 202c, 202i	Second Silencing Space
203, 203a, 203b, 203c, 203f, 203g, 203i, 203j, 203k	Communication Path
204, 204e, 204h, 203g, 203f	First refrigerant passage
205, 205e, 205h	Second refrigerant passage
206	Oil return hole
206k	First oil drain passage
207k	Second oil drain passage

BEST MODE FOR CARRYING OUT THE INVENTION

<Configuration of Air Conditioner>

[0066] FIG. 1 shows a general refrigerant circuit 2 of an air conditioner 1 pertaining to an embodiment of the present invention.

[0067] The air conditioner 1 uses carbon dioxide as a refrigerant, is capable of cooling operation and heating operation, and is mainly configured by the refrigerant circuit 2, blower fans 26 and 32, a controller 23, a high-pressure pressure sensor 21, a temperature sensor 22, an intermediate-pressure pressure sensor 24 and the like.

[0068] The refrigerant circuit 2 is mainly equipped with a compressor 11, a π -type silencer 20, a four-way switch valve 12, an outdoor heat exchanger 13, a first electrically powered expansion valve 15, a liquid receiver 16, a second electrically powered expansion valve 17 and an indoor heat exchanger 31, and the devices are, as shown in FIG. 1, interconnected via refrigerant pipes.

[0069] Additionally, in the present embodiment, the air conditioner 1 is a discrete-type air conditioner and may also be said to be configured by: an indoor unit 30 that mainly includes the indoor heat exchanger 31 and the indoor fan 32; an outdoor unit 10 that mainly includes the compressor 11, the π -type silencer 20, the four-way switch valve 12, the outdoor heat exchanger 13, the first electrically powered expansion valve 15, the liquid receiver 16, the second electrically powered expansion valve 17, the high-pressure pressure sensor 21, the intermediate-pressure pressure sensor 24, the temperature sensor 22 and the controller 23; a first communication pipe 41 that interconnects a refrigerant liquid pipe of the indoor unit 30 and a refrigerant liquid pipe of the outdoor unit 10; and a second communication pipe 42 that interconnects a refrigerant gas pipe of the indoor unit 30 and a refrigerant gas pipe of the outdoor unit 10. It will be noted that the refrigerant liquid pipe of the outdoor unit 10 and the first communication pipe 41 are interconnected via a first close valve 18 of the outdoor unit 10 and that the refrigerant gas pipe of the outdoor unit 10 and the second communication pipe 42 are interconnected via a second close valve 19 of the outdoor unit 10.

(1) Indoor Unit

[0070] The indoor unit 30 mainly includes the indoor heat exchanger 31, the indoor fan 32 and the like.

[0071] The indoor heat exchanger 31 is a heat exchanger for causing heat exchange between the refrigerant and room air that is air inside an air-conditioned room.

[0072] The indoor fan 32 is a fan for taking the air inside the air-conditioned room into the inside of the unit 30 and

blowing out air-conditioned air, which is air after heat has been exchanged with the refrigerant via the indoor heat exchanger 31, back inside the air-conditioned room.

[0073] Additionally, because the indoor unit 30 employs this configuration, the indoor unit 30 is capable, during cooling operation, of generating air-conditioned air (cool air) by causing heat to be exchanged between the room air that has been taken inside by the indoor fan 32 and liquid refrigerant that flows through the indoor heat exchanger 31 and is capable, during heating operation, of generating air-conditioned air (warm air) by causing heat to be exchanged between the room air that has been taken inside by the indoor fan 32 and supercritical refrigerant that flows through the indoor heat exchanger 31.

(2) Outdoor Unit

[0074] The outdoor unit 10 mainly includes the compressor 11, the π -type silencer 20, the four-way switch valve 12, the outdoor heat exchanger 13, the first electrically powered expansion valve 15, the liquid receiver 16, the second electrically powered expansion valve 17, the outdoor fan 26, the controller 23, the high-pressure pressure sensor 21, the temperature sensor 22, the intermediate-pressure pressure sensor 24 and the like.

[0075] The compressor 11 is a device for sucking in low-pressure gas refrigerant that flows through a suction pipe, compressing the low-pressure gas refrigerant to a supercritical state, and thereafter discharging the supercritical refrigerant to a discharge pipe. It will be noted that, in the present embodiment, the compressor 11 is an inverter rotary-type compressor.

[0076] The π -type silencer 20 is, as shown in FIG. 1, disposed between a discharge side of the compressor 11 and the four-way switch valve 12. The π -type silencer 20 is, as shown in FIG. 2, configured by a first silencing space 201, a second silencing space 202 and a communication path 203 that allows the first silencing space 201 and the second silencing space 202 to be communicated. It will be noted that, in the air conditioner 1 pertaining to the present embodiment, a discharge path of the compressor 11 is connected to the first silencing space 201 via a first refrigerant passage 204 and that a heat transfer path of the outdoor heat exchanger 13 or the indoor heat exchanger 31 is connected to the second silencing space 202 via a second refrigerant passage 205. In other words, the refrigerant always flows in the order of: the first silencing space 201 $\rightarrow$ the communication path 203 $\rightarrow$ the second silencing space 202. The first silencing space 201 is a substantially cylindrical space, with the refrigerant passage 204 being connected to the upper end thereof in the axial direction and the communication path 203 being connected to the lower end thereof in the axial direction. The second silencing space 202 is a substantially cylindrical space, with the communication path 203 being connected to the upper end thereof in the axial direction and the refrigerant passage 205 being connected to the lower end thereof in the axial direction. The communication path 203 is a substantially cylindrical passage whose radius is smaller than the radii of the first silencing space 201 and the second silencing space 202, and the first silencing space 201 and the second silencing space 202 are connected to both sides of the communication path 203. It will be noted that, in the π -type silencer 20 pertaining to the present embodiment, the axes of the first silencing space 201, the second silencing space 202 and the communication path 203 are superposed. Additionally, the length of the communication path 203 is longer than $S_1/2(1/V_1+1/V_2)(c/\pi N_{\min})^2$ and shorter than $c/2f_t$. Here, S_1 is the cross-sectional area of the communication path 203, V_1 is the volume of the first silencing space 201, V_2 is the volume of the second silencing space 202, c is the speed of sound in carbon dioxide (when the pressure is 10 MPa, the density becomes 221.6 kg/m³ and the speed of sound becomes 252 m/sec), π is pi, $N_{\min}$ is the minimum number of rotations of the compressor 11, and f_t is a target reduction highest frequency. It will be noted that, in the air conditioner 1 pertaining to the present embodiment, the π -type silencer 20 is housed in the outdoor unit 10 such that the first silencing space 201 and the second silencing space 202 are arranged one above the other along the vertical direction.

[0077] The four-way switch valve 12 is a valve for switching the flow direction of the refrigerant in correspondence to each operation and is capable, during cooling operation, of interconnecting the discharge side of the compressor 11 and a high temperature side of the outdoor heat exchanger 13 and also interconnecting the suction side of the compressor 11 and a gas side of the indoor heat exchanger 31 and is capable, during heating operation, of interconnecting the discharge side of the compressor 11 and the second close valve 19 and also interconnecting the suction side of the compressor 11 and a gas side of the outdoor heat exchanger 13.

[0078] The outdoor heat exchanger 13 is capable, during cooling operation, of using air outside the air-conditioned room as a heat source to cool the high-pressure supercritical refrigerant that has been discharged from the compressor 11 and is capable, during heating operation, of evaporating the liquid refrigerant that returns from the indoor heat exchanger 31.

[0079] The first electrically powered expansion valve 15 is for depressurizing the supercritical refrigerant (during cooling operation) that flows out from a low temperature side of the outdoor heat exchanger 13 or the liquid refrigerant (during heating operation) that flows in through the liquid receiver 16.

[0080] The liquid receiver 16 is for storing surplus refrigerant in accordance with the operating mode and the air conditioning load.

[0081] The second electrically powered expansion valve 17 is for depressurizing the liquid refrigerant (during cooling operation) that flows in through the liquid receiver 16 or the supercritical refrigerant (during heating operation) that flows out from a low temperature side of the indoor heat exchanger 31.

[0082] The outdoor fan 26 is a fan for taking outdoor air into the inside of the unit 10 and discharging the air after the air has exchanged heat with the refrigerant via the outdoor heat exchanger 13.

[0083] The high-pressure pressure sensor 21 is disposed on the discharge side of the compressor 11.

[0084] The temperature sensor 22 is disposed on the outdoor heat exchanger side of the first electrically powered expansion valve 15.

[0085] The intermediate-pressure pressure sensor 24 is disposed between the first electrically powered expansion valve 15 and the liquid receiver 16.

[0086] The controller 23 is communicably connected to the high-pressure pressure sensor 21, the temperature sensor 22, the intermediate-pressure pressure sensor 24, the first electrically powered expansion valve 15, the second electrically powered expansion valve 17 and the like and controls the openings of the first electrically powered expansion valve 15 and the second electrically powered expansion valve 17 on the basis of temperature information that is sent from the temperature sensor 22, high-pressure pressure information that is sent from the high-pressure pressure sensor 21 and intermediate-pressure pressure information that is sent from the intermediate-pressure pressure sensor 24.

<Operation of Air Conditioner>

[0087] Operation of the air conditioner 1 will be described using FIG. 1. The air conditioner 1 is, as mentioned above, capable of performing cooling operation and heating operation.

(1) Cooling Operation

[0088] During cooling operation, the four-way switch valve 12 is in the state indicated by the solid lines in FIG. 1, that is, a state where the discharge side of the compressor 11 is connected to the high temperature side of the outdoor heat exchanger 13 and where the suction side of the compressor 11 is connected to the second close valve 19. Further, at this time, the first close valve 18 and the second close valve 19 are opened.

[0089] When the compressor 11 is started in this state of the refrigerant circuit 2, gas refrigerant is sucked into the compressor 11, is compressed to a supercritical state, is thereafter sent to the outdoor heat exchanger 13 via the four-way switch valve 12, and is cooled in the outdoor heat exchanger 13. It will be noted that, at this time, pressure pulsation of the refrigerant is dampened by the π -type silencer 20.

[0090] Then, the supercritical refrigerant that has been cooled is sent to the first electrically powered expansion valve 15. Then, the supercritical refrigerant that has been sent to the first electrically powered expansion valve 15 is depressurized to a saturated state and is thereafter sent to the second electrically powered expansion valve 17 via the liquid receiver 16. The refrigerant in the saturated state that has been sent to the second electrically powered expansion valve 17 is depressurized, becomes liquid refrigerant, is thereafter supplied to the indoor heat exchanger 31 via the first close valve 18, cools the room air, is evaporated and becomes gas refrigerant.

[0091] Then, the gas refrigerant is sucked back into the compressor 11 via the second close valve 19 and the four-way switch valve 12. In this manner, cooling operation is performed.

(2) Heating Operation

[0092] During heating operation, the four-way switch valve 12 is in the state indicated by the broken lines in FIG. 1, that is, a state where the discharge side of the compressor 11 is connected to the second close valve 19 and where the suction side of the compressor 11 is connected to the gas side of the outdoor heat exchanger 13. Further, at this time, the first close valve 18 and the second close valve 19 are opened.

[0093] When the compressor 11 is started in this state of the refrigerant circuit 2, gas refrigerant is sucked into the compressor 11, is compressed to a supercritical state, and is thereafter supplied to the indoor heat exchanger 31 via the four-way switch valve 12 and the second close valve 19. It will be noted that, at this time, pressure pulsation of the refrigerant is dampened by the π -type silencer 20.

[0094] Then, the supercritical refrigerant heats the room air in the indoor heat exchanger 31 and is cooled. The supercritical refrigerant that has been cooled is sent to the second electrically powered expansion valve 17 through the first close valve 18. The supercritical refrigerant that has been sent to the second electrically powered expansion valve 17 is depressurized to a saturated state and is thereafter sent to the first electrically powered expansion valve 15 via the liquid receiver 16. The refrigerant in the saturated state that has been sent to the first electrically powered expansion valve 15 is depressurized, becomes liquid refrigerant, is thereafter sent to the outdoor heat exchanger 13, is evaporated in the outdoor heat exchanger 13 and becomes gas refrigerant. Then, the gas refrigerant is sucked back into the

compressor 11 via the four-way switch valve 12. In this manner, heating operation is performed.

<Characteristics of Air Conditioner>

(1)

[0095] In the air conditioner 1 pertaining to the present embodiment, the π -type silencer 20 is connected to the discharge pipe of the compressor 11. For this reason, in the air conditioner 1, pressure pulsation can be sufficiently reduced.

(2)

[0096] In the air conditioner 1 pertaining to the present embodiment, the π -type silencer 20 is housed in the outdoor unit 10 such that the first silencing space 201 and the second silencing space 202 are arranged one above the other along the vertical direction. For this reason, in the air conditioner 1, refrigerating machine oil can be prevented from collecting in the π -type silencer 20.

(3)

[0097] In the π -type silencer 20 pertaining to the present embodiment, the length of the communication path is longer than $S_1/2(1/V_1+1/V_2)(c/\pi N_{\min})^2$ and shorter than $c/2f_t$. For this reason, in the air conditioner 1, the cutoff frequency of the π -type silencer 20 can be made equal to or less than the minimum number of rotations of the compression mechanism, and a frequency that is smaller than the target reduction highest frequency f_t can be reduced.

<Modifications>

(A)

[0098] In the air conditioner 1 pertaining to the preceding embodiment, there was employed the π -type silencer 20 that includes the communication path 203 that extends along the axial direction of the first silencing space 201 from the lower end of the first silencing space 201 and is connected to the upper end of the second silencing space 202, but instead of the π -type silencer 20, there may also be employed a π -type silencer 20a such as shown in FIG. 3. In the π -type silencer 20a, a communication path 203a that extends along the axial direction of the first silencing space 201 from the lower end of the first silencing space 201 penetrates the upper end of the second silencing space 202 and is inserted into the inside of the second silencing space 202. When the π -type silencer 20a is employed, just the communication path can be extended long without changing the size of the entire π -type silencer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

[0099] Further, there may also be employed a π -type silencer 20b such as shown in FIG. 4. In the π -type silencer 20b, a communication path 203b extends along the axis of the first silencing space 201 from the inside of the first silencing space 201 and through the lower end of the first silencing space 201 to the outside, and then penetrates the upper end of the second silencing space 202 and extends into the inside of the second silencing space 202. Additionally, in the π -type silencer 20b, an oil return hole 206 is disposed in the lower end portion of the communication path 203b inside the first silencing space 201. When the π -type silencer 20b is employed, refrigerating machine oil can be prevented from collecting in the π -type silencer, and just the communication path can be extended long without changing the size of the entire π -type silencer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, refrigerating machine oil can be prevented from collecting in the π -type silencer, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

(B)

[0100] In the air conditioner 1 pertaining to the preceding embodiment, there was employed the π -type silencer 20 where the axes of the first silencing space 201, the second silencing space 202 and the communication path 203 are superposed on a straight line and face the vertical direction, but instead of the π -type silencer 20, there may also be employed a π -type silencer 20c such as shown in FIG. 5. In the π -type silencer 20c, a first silencing space 201c and a second silencing space 202c are disposed side-by-side, and the axes of both of the silencing spaces 201c and 202c are along the vertical direction but are not superposed on a straight line. Additionally, in the π -type silencer 20c, a communication path 203c is U-shaped and extends from the lower end of the first silencing space 201c to the lower end of the second silencing space 202c. When the π -type silencer 20c is employed, the entire length of the π -type silencer

can be shortened. Consequently, the options for the disposition of the π -type silencer in the outdoor unit 10 can be expanded.

[0101] Further, there may also be employed a π -type silencer 20d such as shown in FIG. 6. The π -type silencer 20d is one where a mesh member 207 fills the communication path 203c of the π -type silencer 20c shown in FIG. 5. When

[0102] Further, there may also be employed a π -type silencer 20e such as shown in FIG. 7. The π -type silencer 20e is one where a first refrigerant passage 204e and a second refrigerant passage 205e are inserted into the insides of the first silencing space 201c and the second silencing space 202c of the π -type silencer 20c shown in FIG. 5. When the π -type silencer 20e is employed, it can be ensured that refrigerating machine oil does not collect in the first silencing space 201 c and the second silencing space 202c.

(C)

[0103] In the air conditioner 1 pertaining to the preceding embodiment, there was employed the π -type silencer 20 where the axes of the first silencing space 201, the second silencing space 202 and the communication path 203 are superposed on a straight line and face the vertical direction, but instead of the π -type silencer 20, there may also be employed a π -type silencer 20f such as shown in FIG. 8. In the π -type silencer 20f, a first silencing space 201c and a second silencing space 202c are disposed side-by-side, and the axes of both of the silencing spaces 201c and 202c are along the vertical direction but are not superposed on a straight line. Additionally, in the π -type silencer 20f, a communication path 203 f is U-shaped, penetrates the upper end of the first silencing space 201c from the inside of the first silencing space 201 c, extends to the upper end of the second silencing space 202c, penetrates the upper end of the second silencing space 202c and extends into the inside of the second silencing space 202c. When the π -type silencer 20f is employed, the entire length of the π -type silencer can be shortened, refrigerating machine oil can be prevented from collecting in the first silencing space 201 c and the second silencing space 202c, and just the communication path can be extended long without changing the size of the entire π -type silencer. Consequently, the options for the disposition of the π -type silencer in the outdoor unit 10 can be expanded, refrigerating machine oil can be prevented from collecting in the first silencing space 201 c and the second silencing space 202c, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

(D)

[0104] In the air conditioner 1 pertaining to the preceding embodiment, there was employed the π -type silencer 20 where the axes of the first silencing space 201, the second silencing space 202 and the communication path 203 are superposed on a straight line and face the vertical direction, but instead of the π -type silencer 20, there may also be employed a π -type silencer 20g such as shown in FIG. 9. In the π -type silencer 20g, a first silencing space 201c and a second silencing space 202c are disposed side-by-side, and the axes of both of the silencing spaces 201 c and 202c are along the vertical direction but are not superposed on a straight line. Additionally, in the π -type silencer 20g, a communication path 203g is S-shaped and extends from the lower end of the first silencing space 201 c to the upper end of the second silencing space 202c. When the π -type silencer 20g is employed, refrigerating machine oil can be prevented from collecting in the π -type silencer, the entire length of the π -type silencer can be shortened, and the communication path can be made longer without changing the size of the entire π -type silencer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, refrigerating machine oil can be prevented from collecting in the π -type silencer, the options for the disposition of the π -type silencer in the outdoor unit 10 can be expanded, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer. It will be noted that the communication path 203g that extends from the lower end of the first silencing space 201c may also penetrate the upper end of the second silencing space 202c and extend into the inside of the second silencing space 202c.

(E)

[0105] In the air conditioner 1 pertaining to the preceding embodiment, there was employed the π -type silencer 20 where the axes of the first silencing space 201, the second silencing space 202 and the communication path 203 are superposed on a straight line and face the vertical direction, but instead of the π -type silencer 20, there may also be employed a π -type silencer 20h such as shown in FIG. 10. In the π -type silencer 20h, a first silencing space 201c and a second silencing space 202c are disposed side-by-side, and the axes of both of the silencing spaces 201c and 202c are along the vertical direction but are not superposed on a straight line. Additionally, in the π -type silencer 20h, a first refrigerant passage 204h is connected to the lower end of the first silencing space 201c, and a second refrigerant passage 205h is connected to the lower end of the second silencing space 202c. Additionally, in the π -type silencer

20h, a communication path 203c is U-shaped and extends from the lower end of the first silencing space 201c to the lower end of the second silencing space 202c. When the π -type silencer 20h is employed, refrigerating machine oil can be prevented from collecting in the π -type silencer, and the entire length of the π -type silencer can be made shorter. Consequently, refrigerating machine oil can be prevented from collecting in the π -type silencer, and the options for the disposition of the π -type silencer in the outdoor unit 10 can be expanded.

(F)

[0106] In the air conditioner 1 pertaining to the preceding embodiment, there was employed the π -type silencer 20 where the axes of the first silencing space 201, the second silencing space 202 and the communication path 203 are superposed on a straight line and face the vertical direction, but instead of the π -type silencer 20, there may also be employed a π -type silencer 20i such as shown in FIG. 11. The π -type silencer 20i is housed in the outdoor unit 10 such that axes of a first silencing space 201i and a second silencing space 202i are superposed on a straight line and face the horizontal direction. Additionally, in the π -type silencer 20i, a first refrigerant passage 204 is connected to the lowermost portion of the outer end of the first silencing space 201i, and a second refrigerant passage 205 is connected to the lowermost portion of the outer end of the second silencing space 202i. Additionally, in the π -type silencer 20i, a communication path 203i interconnects the lowermost portion of the inner end of the first silencing space 201i and the lowermost portion of the inner end of the second silencing space 202i. When the π -type silencer 20i is employed, refrigerating machine oil can be prevented from collecting in the π -type silencer.

[0107] Further, there may also be employed a π -type silencer 20j such as shown in FIG. 12. In the π -type silencer 20j, a communication path 203j penetrates the lowermost portion of the inner end of the first silencing space 201i and the lowermost portion of the inner end of the second silencing space 202i and extends into the inside of the second silencing space 202i from the inside of the first silencing space 201 i. When the π -type silencer 20j is employed, refrigerating machine oil can be prevented from collecting in the π -type silencer, and the communication path can be made longer without changing the size of the entire π -type silencer. In a π -type silencer, the longer the communication path is, the larger the pressure pulsation reduction effect becomes. In other words, refrigerating machine oil can be prevented from collecting in the π -type silencer, and the pressure pulsation reduction effect can be made larger without changing the size of the entire π -type silencer.

(G)

[0108] In the air conditioner 1 pertaining to the preceding embodiment, there was employed the π -type silencer 20 where the axes of the first silencing space 201, the second silencing space 202 and the communication path 203 are superposed on a straight line and face the vertical direction, but instead of the π -type silencer 20, there may also be employed a π -type silencer 20k such as shown in FIG. 13. The π -type silencer 20k is housed in the outdoor unit 10 such that axes of a first silencing space 201i, a second silencing space 202i and a communication path 203k are superposed on a straight line and face the horizontal direction. Additionally, in the π -type silencer 20k, a first oil drain passage 206k extends from the lower end of the first silencing space 201 i, and a second oil drain passage 207k extends from the lower end of the second silencing space 202i. It will be noted that the first oil drain passage 206k and the second oil drain passage 207k merge midway and are connected to the suction pipe of the compressor 11 via a capillary. When the π -type silencer 20k is employed, refrigerating machine oil can be prevented from collecting in the π -type silencer. It will be noted that the communication path 203k may also penetrate the center of the inner end of the first silencing space 201i and the center of the second silencing space 202i and extend into the inside of the second silencing space 202i from the inside of the first silencing space 201i.

(H)

[0109] In the air conditioner 1 pertaining to the preceding embodiment, the π -type silencer 20 was connected to the discharge pipe of the compressor 11, but instead of this, the π -type silencer 20 may also be connected to the suction pipe of the compressor 11. Further, the π -type silencer 20 may also be connected to both the discharge pipe and the suction pipe of the compressor 11.

(I)

[0110] In the air conditioner 1 pertaining to the preceding embodiment, although it was not touched upon, when vessels such as an oil separator, an accumulator and a liquid receiver are present in the refrigerant circuit 2, the spaces inside of those may also be utilized as the first silencing space or the second silencing space. By so doing, the refrigerant circuit 2 can be simplified.

(J)

[0111] In the air conditioner 1 pertaining to the preceding embodiment, there was employed the π -type silencer 20 in which the two silencing spaces 201 and 202 are present, but instead of this, there may also be employed a π -type silencer where three or more silencing spaces are present. By so doing, an even larger pressure pulsation reduction effect can be expected.

(K)

[0112] In the air conditioner 1 pertaining to the preceding embodiment, there was employed an inverter rotary type compressor, but instead of this, there may also be employed a constant speed rotary compressor.

(L)

[0113] In the air conditioner 1 pertaining to the preceding embodiment, carbon dioxide was employed as the refrigerant, but instead of this, a refrigerant such as R22 or R410A may also be employed. Incidentally, when the pressure is 1.5 MPa, the density becomes 56.4 kg/m³ and the speed of sound becomes 169 m/sec. Further, when the pressure is 2.4 MPa, the density becomes 83.3 kg/m³ and the speed of sound becomes 174 m/sec.

(M)

[0114] In the π -type silencer 20 pertaining to the preceding embodiment, the shape of the first silencing space 201 was cylindrical, but in the present invention, the shape of the first silencing space 201 is not particularly limited and may also be a cuboid or a regular hexahedron, for example.

(N)

[0115] In the π -type silencer 20 pertaining to the preceding embodiment, the shape of the second silencing space 202 was cylindrical, but in the present invention, the shape of the second silencing space 202 is not particularly limited and may also be a cuboid or a regular hexahedron, for example.

(O)

[0116] In the π -type silencer 20 pertaining to the preceding embodiment, the first silencing space 201 and the second silencing space 202 were configured to have the same shape and the same volume, but in the present invention, the shapes and the volumes of the first silencing space 201 and the second silencing space 202 may also be different.

(P)

[0117] In the π -type silencer 20 pertaining to the preceding embodiment, the shape of the communication path 203 was cylindrical, but in the present invention, the shape of the communication path 203 is not particularly limited and may also be a cuboid, for example.

INDUSTRIAL APPLICABILITY

[0118] The refrigeration system according to the present invention has the characteristic that it can sufficiently reduce pressure pulsation even when carbon dioxide or the like is employed as a refrigerant, so the refrigeration system is suited to a refrigeration system that employs carbon dioxide or the like as a refrigerant.

Claims

1. A refrigeration system (1), comprising:

a first refrigerant passage (204);
 a π -type silencer (20, 20a) having
 a first silencing space (201) communicating with the first refrigerant passage,
 a second silencing space (202) disposed below the first silencing space, and

a communication path (203, 203a) extending from the lower end of the first silencing space to the outside of the first silencing space and communicating with the second silencing space; and
a second refrigerant passage (205) extending from the lower end of the second silencing space.

2. The refrigeration system according to claim 1, wherein the communication path (203a) extends into the inside of the second silencing space.

3. A refrigeration system, comprising:

a first refrigerant passage (204);
a π -type silencer (20b) having
a first silencing space (201) communicating with the first refrigerant passage,
a second silencing space (202) disposed below the first silencing space,
a communication path (203b) extending from the inside of the first silencing space and through the lower end to the outside of the first silencing space and communicating with the second silencing space, and
an oil return hole (206) disposed in the lower end portion of the communication path inside the first silencing space; and
a second refrigerant passage (205) extending from the lower end of the second silencing space.

4. The refrigeration system according to claim 3, wherein the communication path extends into the inside of the second silencing space.

5. A refrigeration system, comprising:

a first refrigerant passage (204, 204e, 204h);
a π -type silencer (20c, 20d, 20e, 20h) having
a first silencing space (201c) communicating with the first refrigerant passage,
a second silencing space (202c) disposed side-by-side with the first silencing space, and
a communication path (203c) extending from the lower end of the first silencing space to the lower end of the second silencing space through the outside of the first silencing space and communicating with the second silencing space; and
a second refrigerant passage (205, 205e, 205h) communicating with the second silencing space.

6. The refrigeration system according to claim 5, wherein the first refrigerant passage (204e) is inserted from the upper end of the first silencing space and extends into the inside of the first silencing space.

7. The refrigeration system according to claim 5 or claim 6, wherein the second refrigerant passage (204e) is inserted from the upper end of the second silencing space and extends into the inside of the second silencing space.

8. The refrigeration system according to claim 5, wherein the first refrigerant passage (204) extends from the upper end of the first silencing space, and the second refrigerant passage (205) extends from the upper end of the second silencing space.

9. The refrigeration system according to claim 5, wherein the first refrigerant passage (204h) extends from the lower end of the first silencing space, and the second refrigerant passage (205h) extends from the lower end of the second silencing space.

10. The refrigeration system according to any one of claim 5 through claim 9, wherein a mesh member (207) fills the communication path.

11. A refrigeration system, comprising:

a first refrigerant passage (204);
a π -type silencer (20g) having
a first silencing space (201c) communicating with the first refrigerant passage,
a second silencing space (202c) disposed side-by-side with the first silencing space, and

a communication path (203g) extending from the lower end of the first silencing space to the upper end of the second silencing space through the outside of the first silencing space and communicating with the second silencing space; and
 a second refrigerant passage (205) communicating with the second silencing space.

12. The refrigeration system according to claim 11, wherein
 the second refrigerant passage extends from the lower end of the second silencing space.

13. A refrigeration system, comprising:

a first refrigerant passage (204);
 a π -type silencer (20f) having
 a first silencing space (201c) communicating with the first refrigerant passage,
 a second silencing space (202c) disposed side-by-side with the first silencing space, and
 a communication path (203f) extending from the inside of the first silencing space and through the upper end thereof to the upper end of the second silencing space and communicating with the second silencing space; and
 a second refrigerant passage (205) communicating with the second silencing space.

14. The refrigeration system according to claim 13, wherein
 the communication path extends from the upper end of the second silencing space into the inside of the second silencing space.

15. The refrigeration system according to claim 13 or claim 14, wherein
 the second refrigerant passage extends from the lower end of the second silencing space.

16. A refrigeration system, comprising:

a first refrigerant passage (204);
 a π -type silencer (20i, 20j) having
 a first silencing space (201i) communicating with the first refrigerant passage,
 a second silencing space (202i) disposed side-by-side with the first silencing space, and
 a communication path (203i, 203j) extending from the side surface of the bottom portion of the first silencing space to the side surface of the bottom portion of the second silencing space and communicating with the second silencing space; and
 a second refrigerant passage (205) connected to the side surface of the bottom portion of the second silencing space and communicating with the second silencing space.

17. The refrigeration system according to claim 16, wherein
 the communication path (203j) extends from the inside of the first silencing space into the inside of the second silencing space through the side surfaces of the bottom portions of the first silencing space and the second silencing space.

18. The refrigeration system according to claim 16 or claim 17, wherein
 the first refrigerant passage is connected to the side surface of the bottom portion of the first silencing space.

19. A refrigeration system, comprising:

a first refrigerant passage (204);
 a π -type silencer (20k) having
 a first silencing space (201i) communicating with the first refrigerant passage,
 a second silencing space (202i) disposed side-by-side with the first silencing space, and
 a communication path (203k) extending from the side surface of the first silencing space to the side surface of the second silencing space and communicating with the second silencing space;
 a second refrigerant passage (205) communicating with the second silencing space;
 a first oil drain passage (206k) extending from the lower end of the first silencing space; and
 a second oil drain passage (207k) extending from the lower end of the second silencing space.

20. The refrigeration system according to claim 19, wherein

EP 2 058 610 A1

the second oil drain passage merges with the first oil drain passage.

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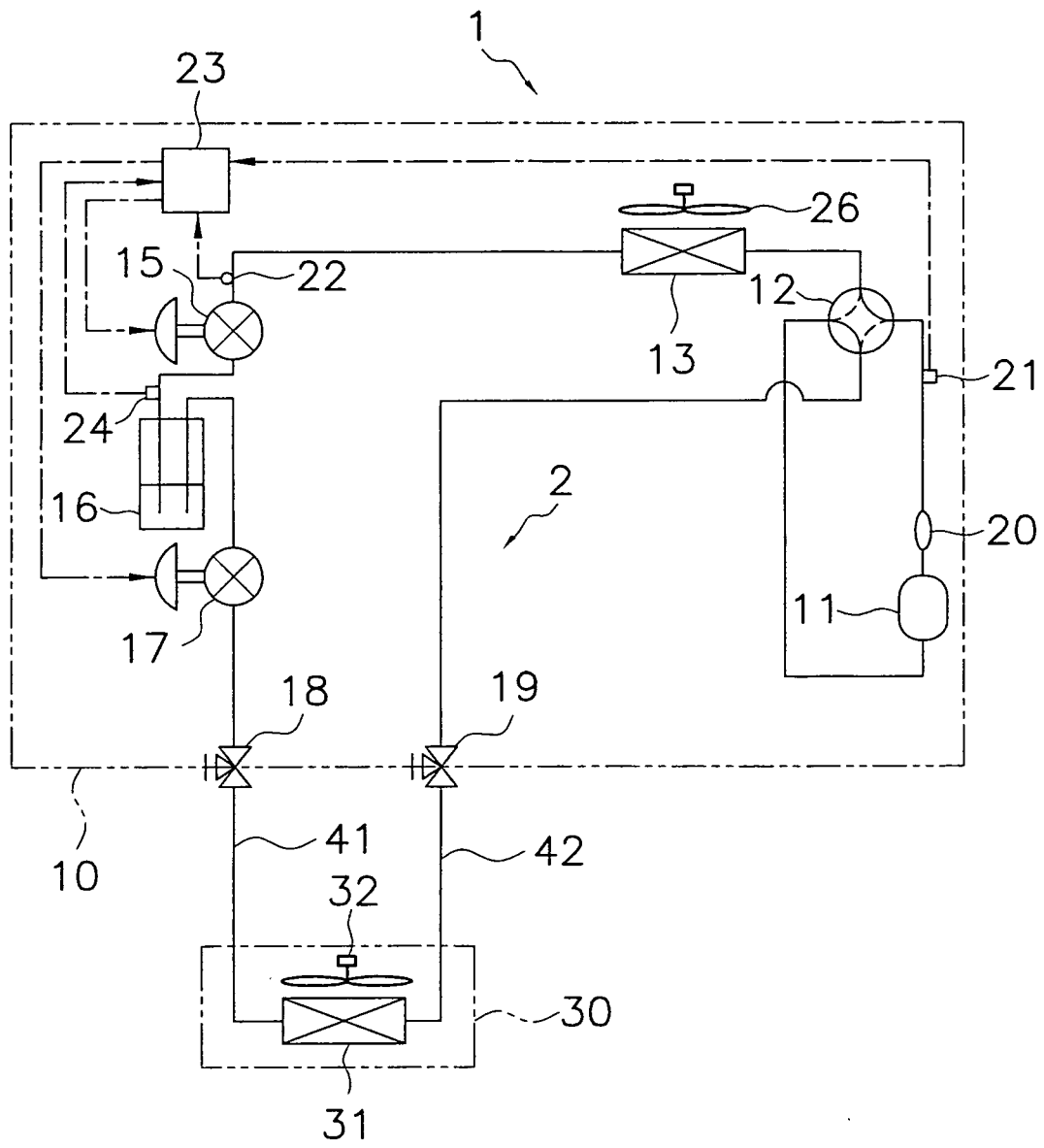


FIG. 1

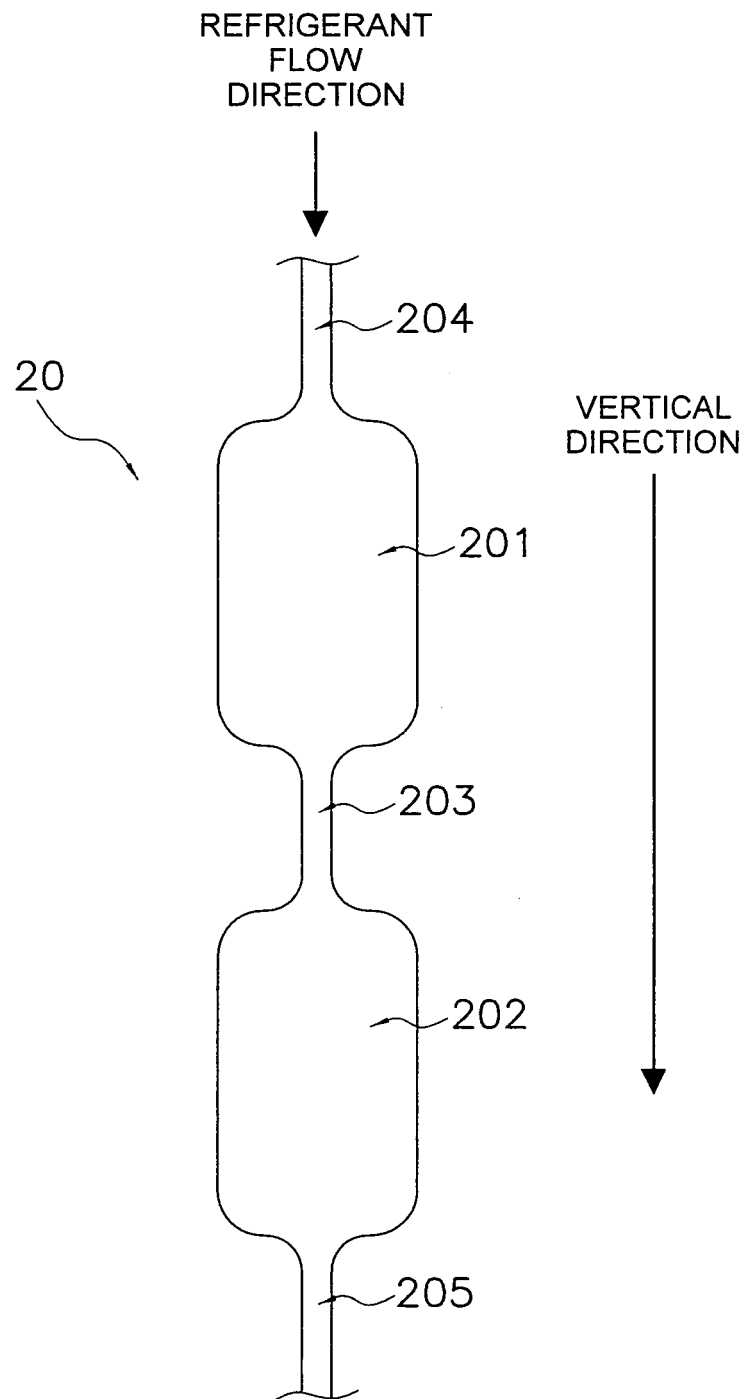


FIG. 2

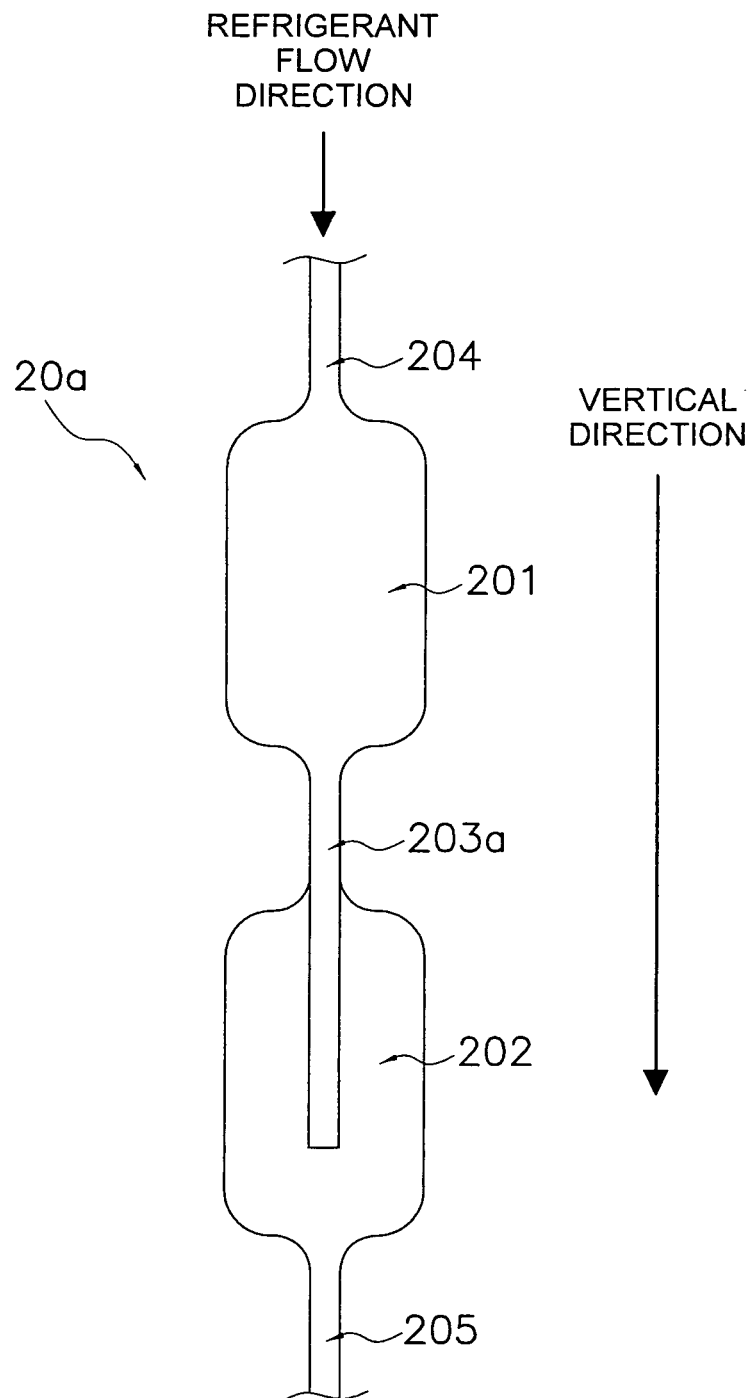


FIG. 3

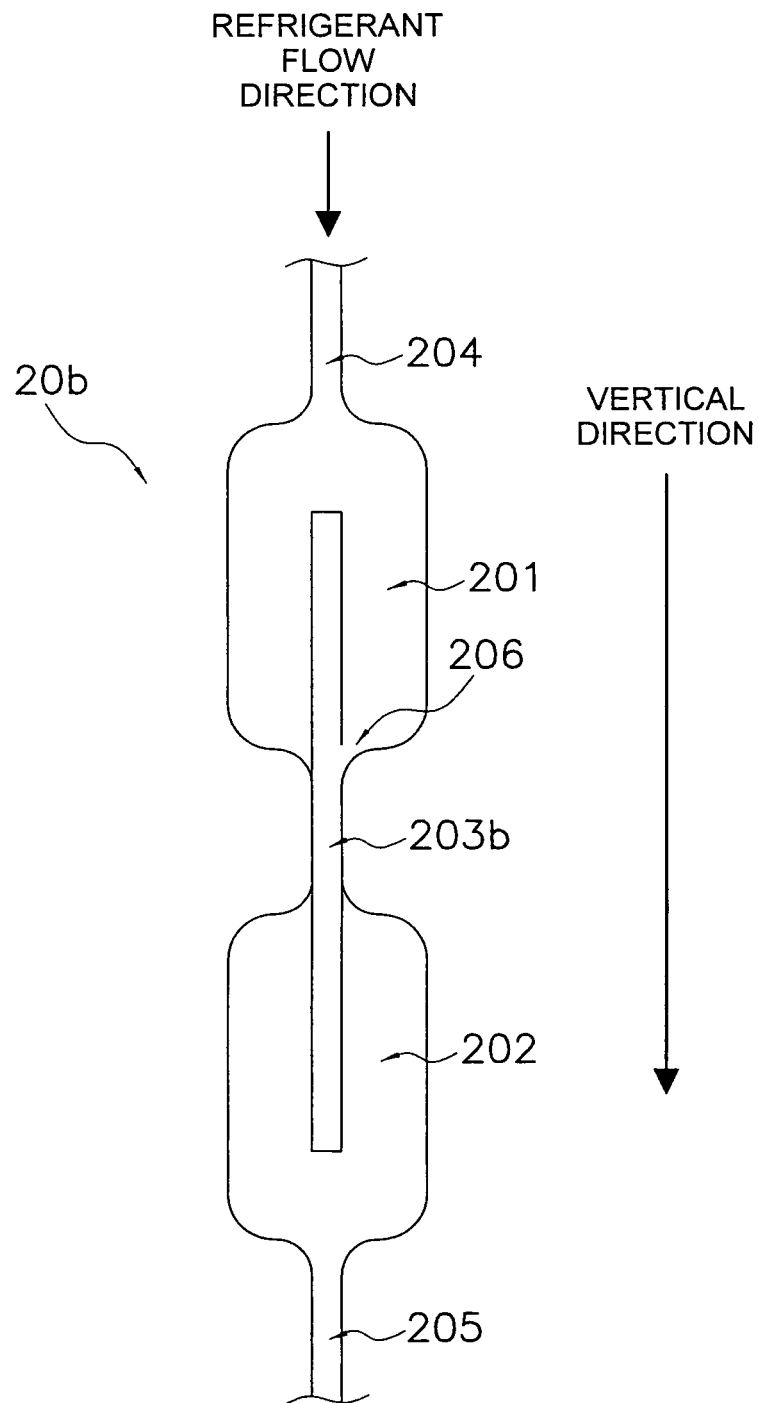


FIG. 4

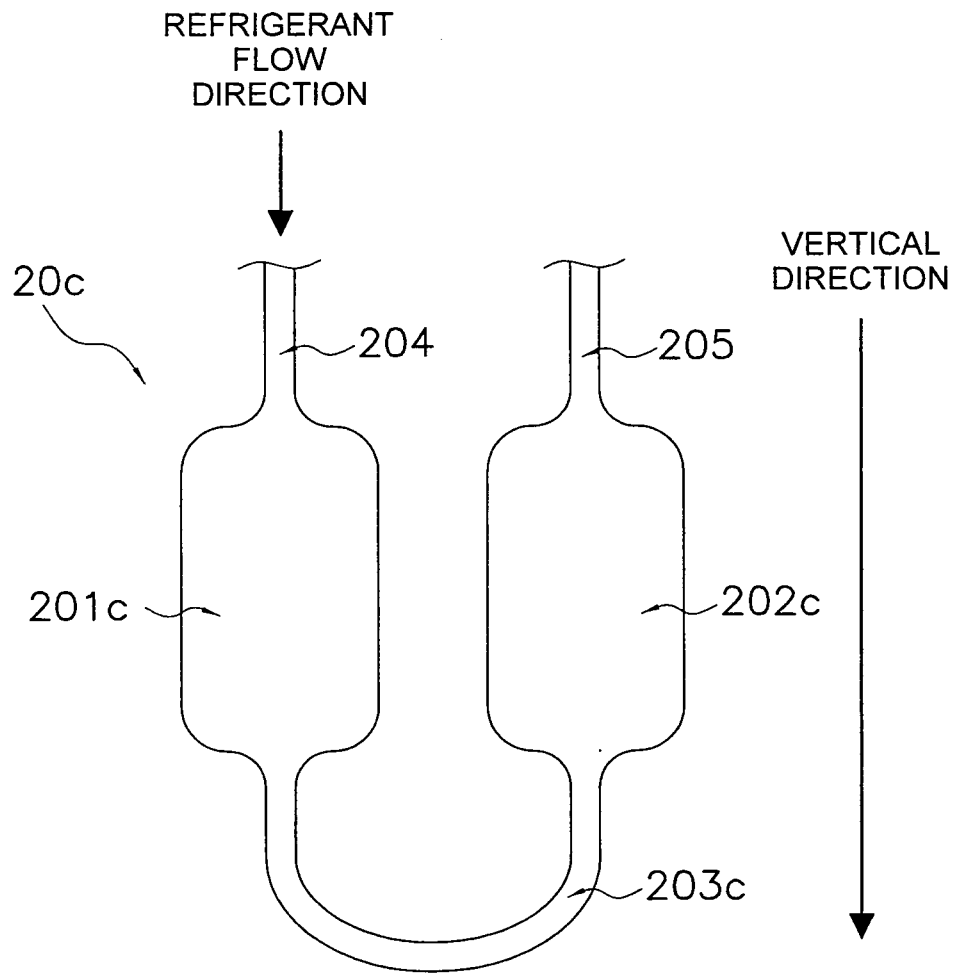


FIG. 5

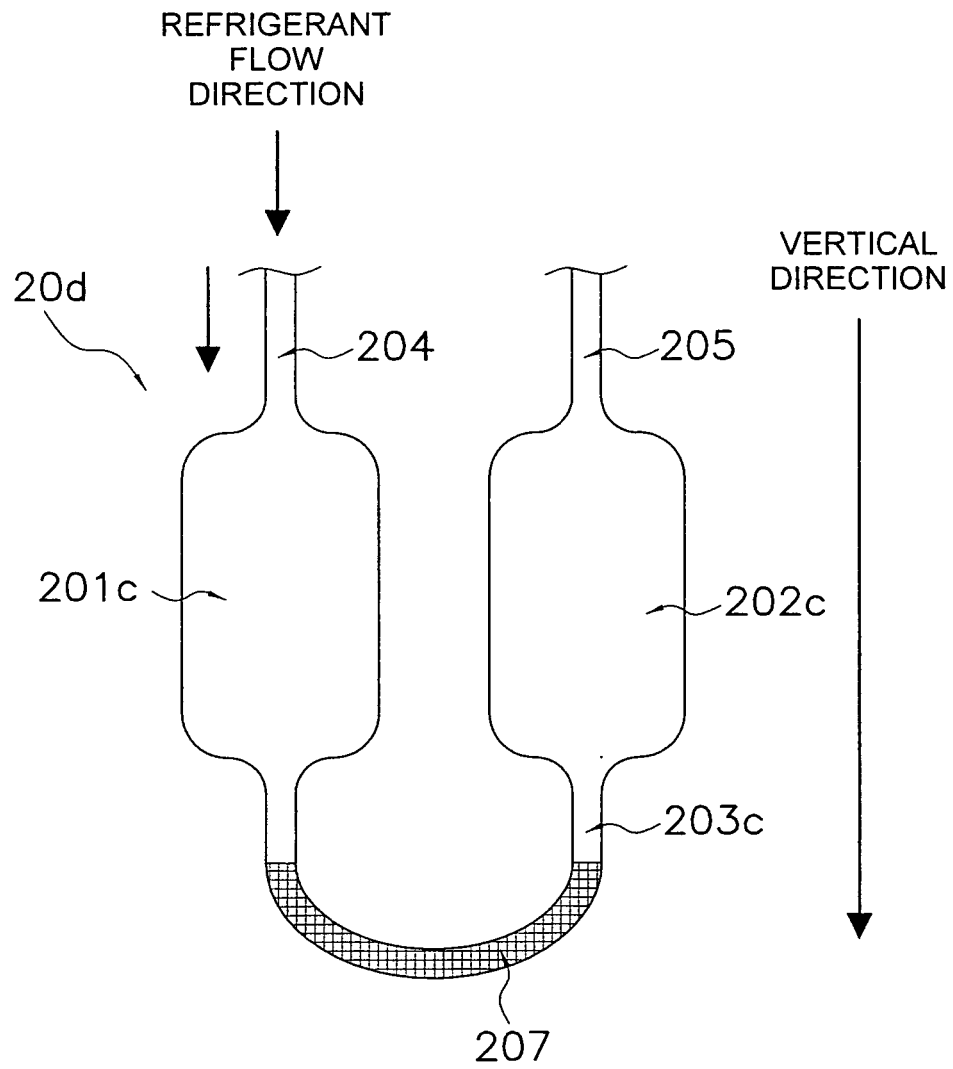


FIG. 6

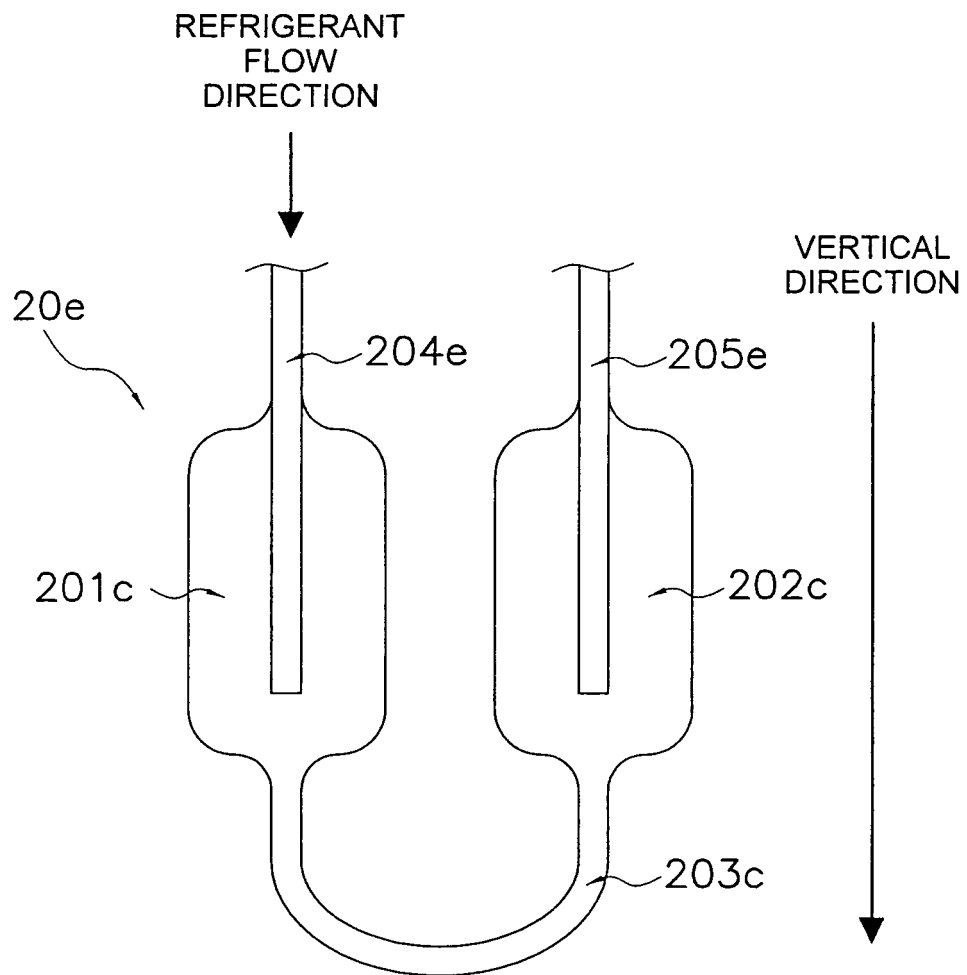


FIG. 7

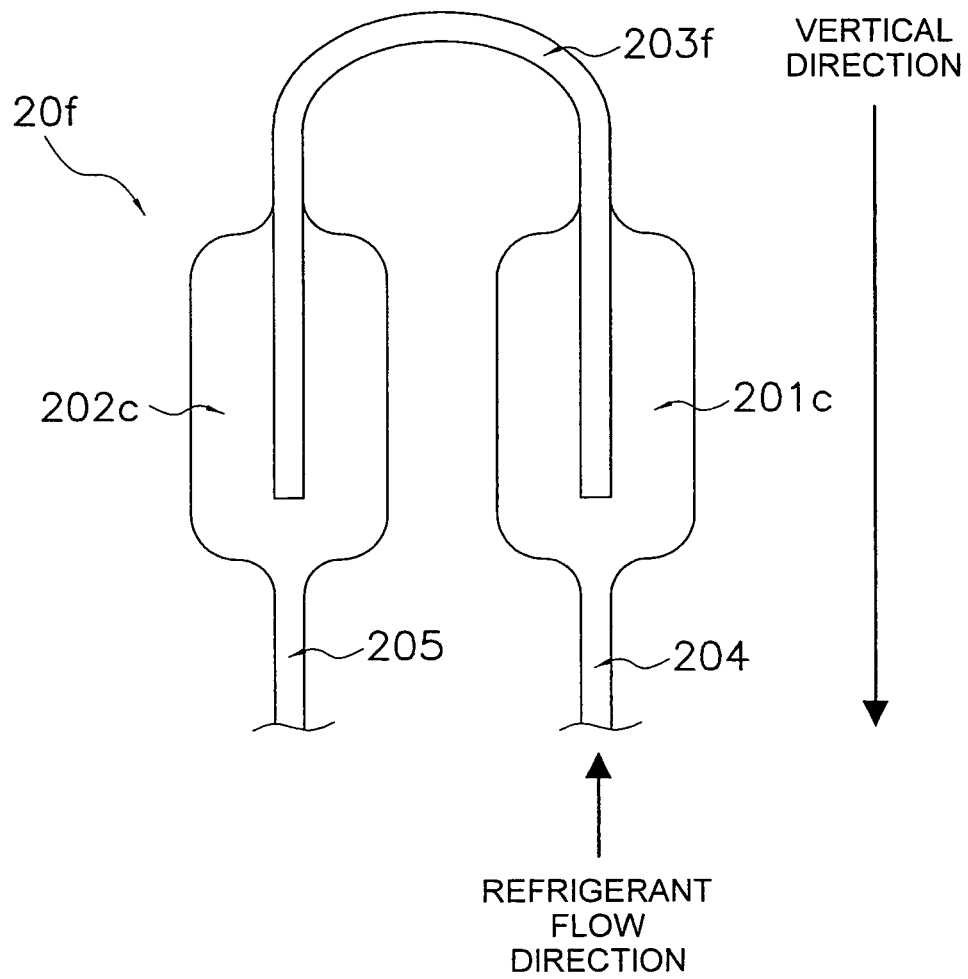


FIG. 8

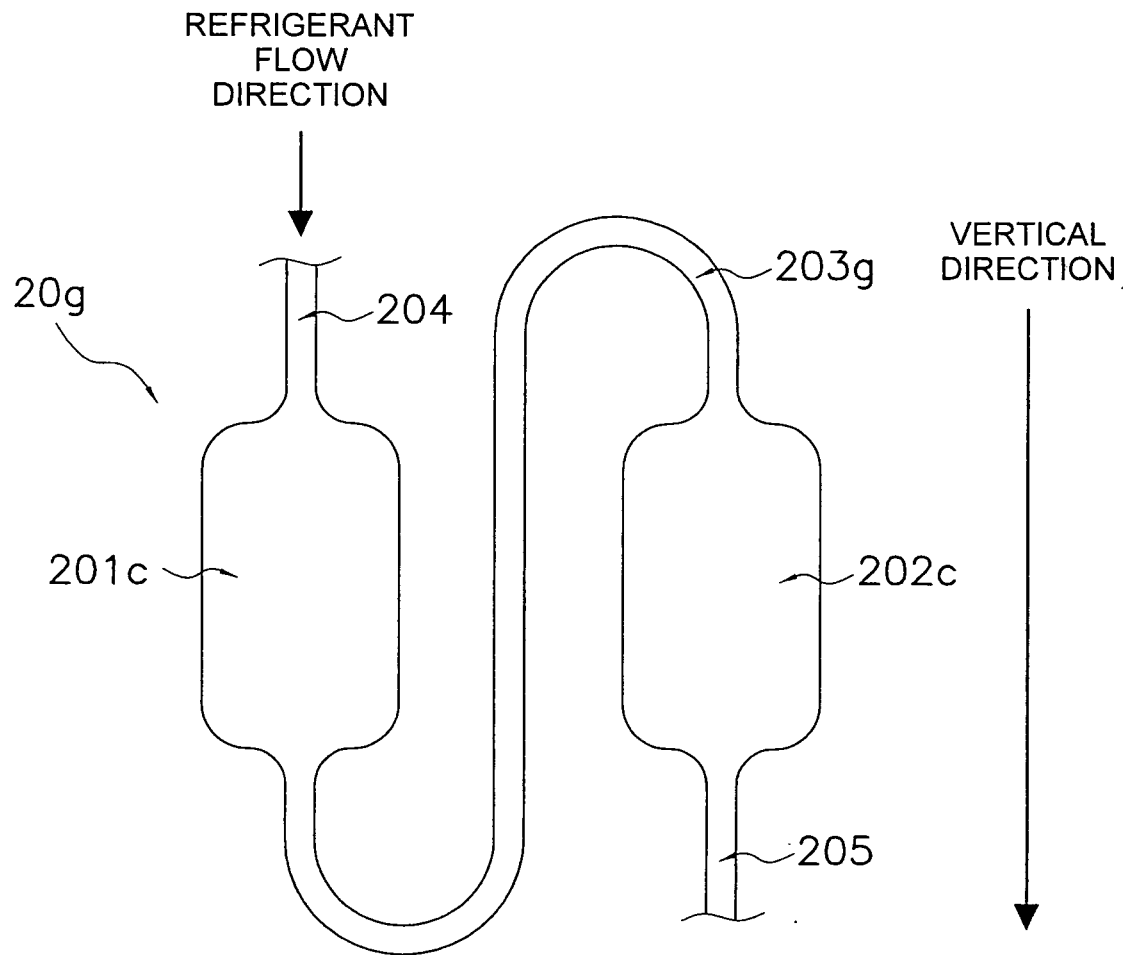


FIG. 9

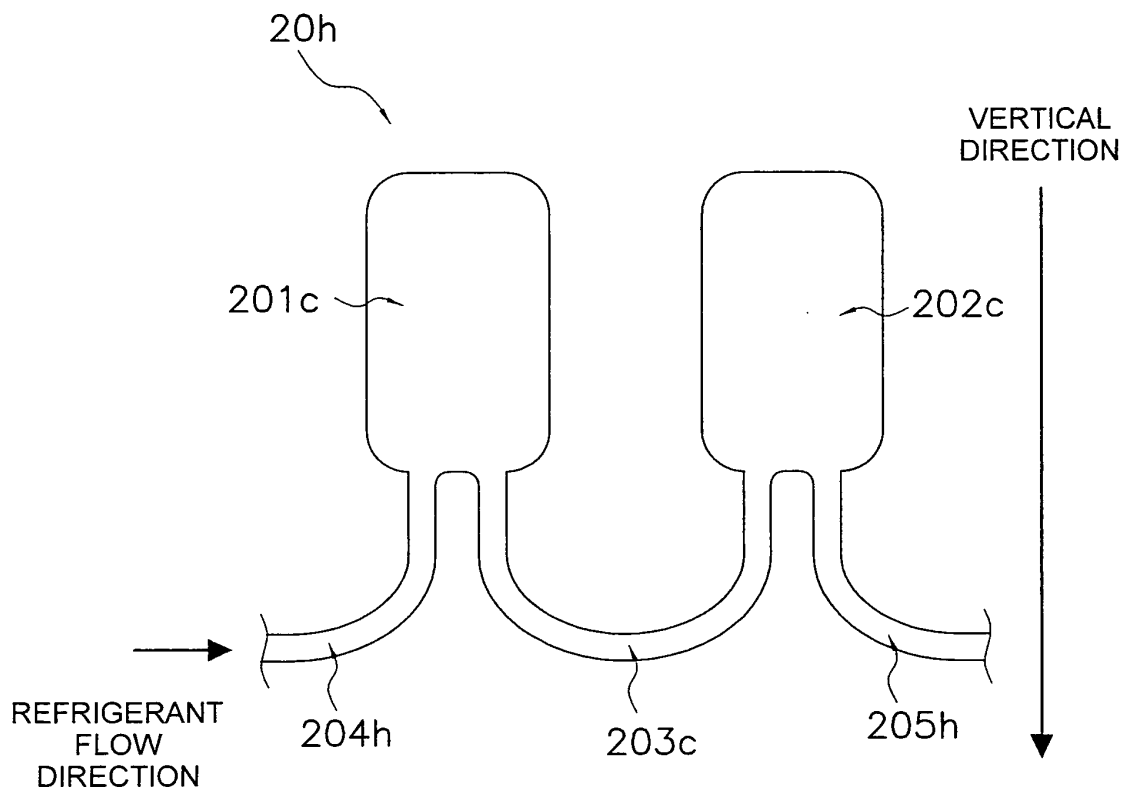


FIG. 10

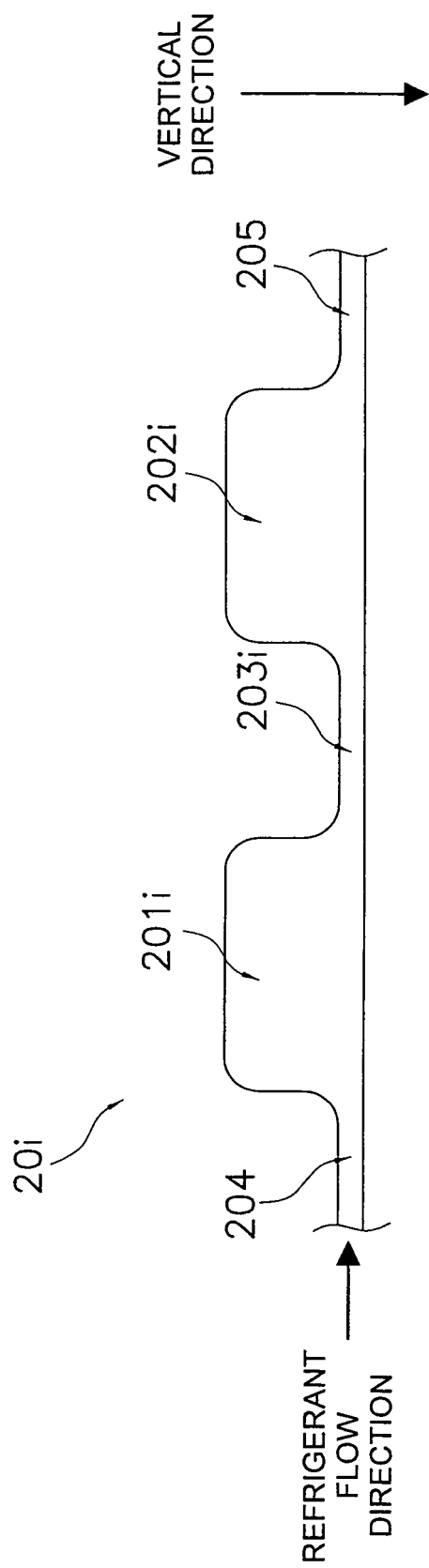


FIG. 11

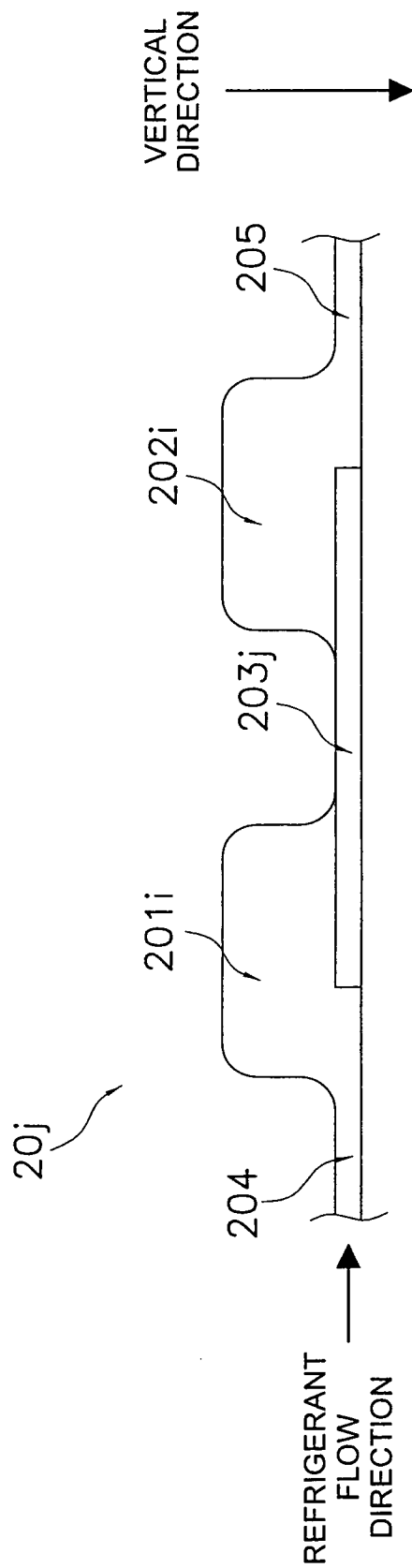


FIG. 12

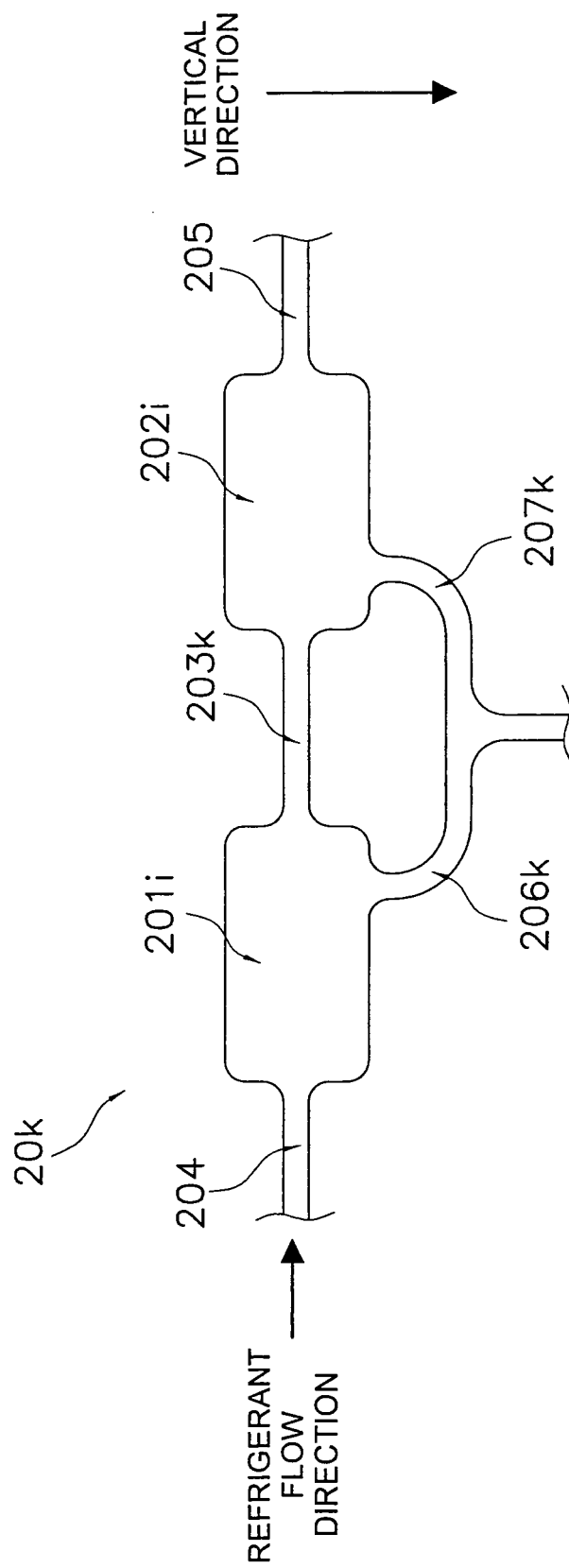


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/066616

A. CLASSIFICATION OF SUBJECT MATTER

F25B41/00(2006.01)i, F01N7/02(2006.01)i, F16L55/02(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)

F25B41/00, F01N7/02, F16L55/02

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 1996-2007

Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007

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.
X Y	JP 2005-180829 A (Toshiba Carrier Corp.), 07 July, 2005 (07.07.05), Par. No. [0004]; Figs. 3 to 5 (Family: none)	1 2-20
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 153187/1981 (Laid-open No. 57672/1983) (Mitsubishi Electric Corp.), 19 April, 1983 (19.04.83), Page 3, lines 2 to 10; Fig. 2 (Family: none)	2, 4



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

04 October, 2007 (04.10.07)

Date of mailing of the international search report

16 October, 2007 (16.10.07)

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/066616

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 99352/1973 (Laid-open No. 44959/1975) (Mitsubishi Electric Corp.), 07 May, 1975 (07.05.75), Figs. 2, 3 (Family: none)	3, 19, 20
Y	JP 6-280553 A (Honda Motor Co., Ltd.), 04 October, 1994 (04.10.94), Fig. 1 (Family: none)	5-20
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 95150/1978 (Laid-open No. 14021/1980) (Nippon Radiator Kabushiki Kaisha), 29 January, 1980 (29.01.80), Figs. 1 to 3 (Family: none)	10
A	JP 6-123525 A (Matsushita Refrigeration Co.), 06 May, 1994 (06.05.94), Figs. 1 to 4 (Family: none)	1-20
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 178356/1981 (Laid-open No. 83067/1983) (Nippon Radiator Kabushiki Kaisha), 04 June, 1983 (04.06.83), Fig. 2 (Family: none)	10
A	JP 2000-192808 A (Honda Motor Co., Ltd.), 11 July, 2000 (11.07.00), Fig. 1 (Family: none)	5-20
A	JP 2005-98663 A (Sanyo Electric Co., Ltd.), 14 April, 2005 (14.04.05), Par. Nos. [0001], [0007]; Figs. 1 to 3 (Family: none)	1-20
A	JP 6-273002 A (Toshiba Corp.), 30 September, 1994 (30.09.94), Figs. 1, 4 (Family: none)	5-20

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2004218934 A [0002]

Non-patent literature cited in the description

- **SAKAE YAMADA ; IWAO ÔTANI.** Orifisu oyobi π -gata hairetsu kûkisô ni yoru myakudô jokyô. *Transactions of the Japan Society of Mechanical Engineers (Second Part)*, 1968, vol. 34 (268), 2139-2145 [0002]
- Jirei ni manabu ryûtai kanren shindo. Gihodo Shuppan Co., Ltd, 20 September 2003, 190-193 [0002]