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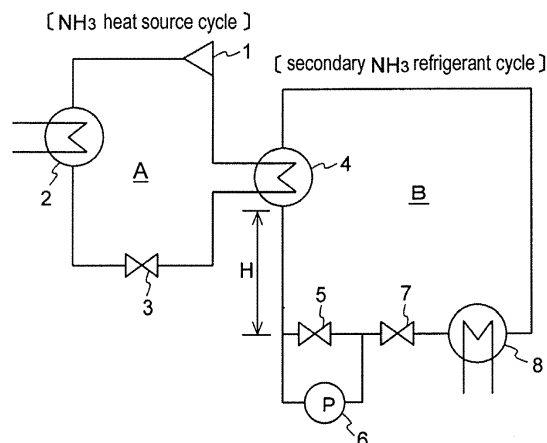
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(54) **HEAT PUMP SYSTEM**

(57) Disclosed is a heat pump system comprising a heat source cycle (A) and an NH₃ secondary coolant cycle (B). The heat cycle (A) includes a compressor (1), a condenser (2), an expansion means (3) and a cascade condenser (endothermic unit) (4), and employs an NH₃ coolant as a heat source. The NH₃ secondary coolant cycle (B) is connected to the heat source cycle (A), and cools an object load with an NH₃ secondary coolant, which is heat-absorbed by the cascade condenser (4) of the heat source cycle (A) so that the coolant is condensed. The NH₃ secondary coolant cycle (B) includes

the cascade condenser (4), which is heat-absorbed by the cascade condenser (4) of the heat source cycle (A) so that the NH₃ secondary coolant is condensed, an evaporator (8) for cooling the object coolant with the NH₃ secondary coolant condensed in the cascade condenser (4), a head difference unit (H) and a circulating pump (6) arranged between the cascade condenser (4) and the evaporator (8) so as to circulate the NH₃ secondary coolant, a bypass conduit for bypassing the circulating pump (6), and a flow control valve (5) arranged in the bypass conduit.

Fig.1



Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a multistage heat pump system using NH_3 cooling medium (heat carrier) as a refrigerant at least on a certain lower stage side of the multistage heat pump system.

Description of the Related Art

[0002] In a multistage cooling/heating system, a series of heat cycles is formed. Each heat cycle corresponds to a stage of the system. When the system forms two stages, the stages are called the higher stage (higher temperature side) and the lower stage (lower temperature side); thus, in a multistage cooling/heating system, a sequence structure is defined. In a similar way, the sequence structure is defined also in a case where the number of the stages is more than two. Further, a heat cycle of a higher stage is connected to the heat cycle of the adjacent lower stage via a cascade connection (i.e. a cascade condenser as a heat exchanger). Further, a certain heat cycle comprises a compressor that compresses and feeds the refrigerant (heat carrier) of the heat cycle. Hence, it is inevitable that lubricating oil indispensable for the operation of the compressor gets mixed with the refrigerant, whatever little the amount of the oil is.

[0003] For the sake of improving the above-described technology (heat pump system), a patent reference JP2005-140349 discloses a heat exchange system being provided with:

a heat pump system source (a higher stage) that includes a compressor, a condenser, and an evaporator; and
a heat cycle system (a lower stage) that performs an objective heat transfer,
whereby a relay heat exchanger, i.e. a cascade condenser performs heat transfer from the heat cycle system to the heat pump system source, and a heat carrier fluid head and/or a circulating pump feeds the heat carrier, while the heat cycle system is not provided with a compressor.

SUMMARY OF THE INVENTION

Subjects to be solved

[0004] However, the mentioned patent reference does not refer to any specific heat carrier (refrigerant). This point, on the contrary, makes a skilled person in the field be puzzled about how the technology can be applied to actual subjects.

[0005] In other words, in the patent reference, there is

neither teaching nor indication regarding concrete examples of heat carriers or system applications. On the other hand, in this application, a practical heat pump system of a multi-stage type will be disclosed; thereby, for instance, NH_3 is used for the higher (temperature) stage and CO_2 is used for the lower (temperature) stage, each of the NH_3 and CO_2 being a natural heat-carrying medium. By applying the heat pump system of two stages where NH_3 is used for the higher (temperature) stage so as to cool and liquefy the heat carrier in the adjacent lower stage and CO_2 is used for the lower (temperature) stage (e.g. secondary or lower stage) so as to cool the objective space or material, the load on the environment can be reduced and a high degree of safety can be achieved. Hereby, to cool the objective space or material means to absorb the heat to be cooled (i.e. to absorb the heat corresponding to the objective heat load or the cooling demand load). Further, in applying the heat pump system just described, there is another advantage that the heat carrier NH_3 in the higher stage is prevented from entering the heat carrier CO_2 in the lower stage, thanks to the adoption of the indirect cooling approach by use of the a relay e heat exchanger (the cascade condenser). In this way, only after concrete heat carriers for the multi-medium (heat carrier) and multi-stage heat pump system are determined, the practical system such as a NH_3 - CO_2 (brine) heat pump system as described above can be discussed and planned so as to apply the heat pump system to refrigerating facility and the like.

[0006] In making use of CO_2 refrigerant (as a brine heat carrier), however, the pressure of the CO_2 refrigerant in the temperature range of the heat exchange process of the CO_2 refrigerant cycle is higher than the pressure of the general refrigerant in the temperature range of a heat exchange process of the general refrigerant cycle; accordingly, if the general refrigerant in existing refrigerant facility is planned to be exchanged into CO_2 refrigerant, it is needed that the existing piping system corresponding to the existing refrigerant be replaced by a newly build piping system corresponding to CO_2 refrigerant. Thus, in this situation, the renewal work is not easily promoted because of high expenditure as to equipment replacement, even though the natural refrigerant such as CO_2 is socially desired, in view of environment load reduction.

[0007] Further, in making use of CO_2 refrigerant instead of a conventional refrigerant used in the existing facility, there may be a case where the CO_2 refrigerant causes a cooling capacity shortage in dealing with a large cooling capacity (refrigeration load).

[0008] Further, in the conventional NH_3 refrigeration system (of a multi-stage type) that uses a natural refrigerant such as NH_3 refrigerant, the refrigeration device (system) adopts a liquid pump approach or a direct expansion approach (system) in a stage of the multi-stage system; and, it is unavoidable that there remains a very small amount of refrigerator oil in the NH_3 refrigerant. The very small amount of refrigerator oil included in the

NH₃ refrigerant remains in the evaporator, the oil causing performance degradation due to aging deterioration. Thus, the control of the oil becomes a prerequisite matter in order to evade the performance degradation. And, the oil control accompanies complicated procedures or troublesome maintenance work.

[0009] In view of the above-described background, the present invention aims at providing a heat pump system; whereby, a superior level of safety can be offered; high heat-transfer efficiency can be achieved; the existing facility can be effectively made use of; the lubricating oil for the system can be easily maintained and managed; the amount of the refrigerant can be restrained to a minimal level.

Means to solve the Subjects

[0010] In order to achieve the above-described objectives, the present invention discloses a heat pump system, being provided with:

a heat source cycle that comprises a compressor, a condenser, an expansion means, and a cascade condenser, thereby NH₃ refrigerant is used as a heat carrier of the heat source cycle;

a secondary NH₃ refrigerant cycle that is directly or indirectly connected to the heat source cycle via the cascade condenser of the heat source cycle, thereby the heat in the secondary NH₃ refrigerant cycle is directly or indirectly absorbed through the cascade condenser, the heat in the secondary NH₃ refrigerant cycle absorbing an objective heat load;

wherein, the secondary NH₃ refrigerant cycle comprises:

a heat absorption part in which the heat in the secondary NH₃ refrigerant cycle is directly or indirectly absorbed through the cascade condenser of the heat source cycle, and the secondary NH₃ refrigerant is condensed;

an evaporator that absorbs the objective heat load by the evaporation of the secondary NH₃ refrigerant which is condensed through the heat absorption part; a head difference part and a circulating pump that are placed between the heat absorption part and the evaporator, so that the head difference part and the circulating pump circulate the secondary NH₃ refrigerant;

a by-pass conduit line that bypasses the circulating pump;

a flow rate control valve that is placed on the by-pass conduit line.

[0011] In general, the refrigerant NH₃ has the properties superior to those of the other general refrigerants. For instance, the evaporative latent heat of the refrigerant NH₃ is higher than that of other general refrigerant. According to the heat pump system as described above,

the refrigerant NH₃ is applied to the heat source cycle and the secondary NH₃ refrigerant cycle; therefore, the power consumption required for circulating the refrigerant NH₃ can be smaller than that required for circulating other brine refrigerant; thus, the performance of the cycle using the refrigerant NH₃ can be enhanced.

[0012] Further, in a case where an existing heat pump system is modernized (improved) with the secondary refrigerant cycle using CO₂ refrigerant, namely, in a case where refrigerant CO₂ is used instead of the refrigerant NH₃ of the secondary NH₃ refrigerant cycle from which the heat to be cooled (i.e. the objective heat load or the cooling demand load) is absorbed, the reuse of the components in the existing secondary NH₃ refrigerant cycle has to be given up. However, according to the heat pump system of the present invention as described above, the refrigerant NH₃ is used for the secondary refrigerant cycle; thus, the existing components in the heat pump system can be reused as they are.

[0013] Further, according to the present invention, the secondary NH₃ refrigerant circulated in the secondary NH₃ refrigerant cycle absorbs the objective heat load (or absorbs the refrigeration load through the evaporator), by the head difference part or by both the head difference part and the circulating pump; in addition, the line system of the NH₃ refrigerant in the heat source cycle and the line system of the NH₃ refrigerant in the secondary NH₃ refrigerant cycle are completely separated from each other by the cascade condenser between the NH₃ heat source cycle and the secondary NH₃ refrigerant cycle; thus, the lubricating oil associated with the compressor in the NH₃ heat source cycle can be prevented from entering the secondary NH₃ refrigerant cycle. Accordingly, the maintenance work in relation to the lubricating oil can be confined within the machine room (the NH₃ heat source cycle), and the safety of the heat pump system can be ensured with simple maintenance.

[0014] Further, according to the present invention, the cascade condenser separates the secondary NH₃ refrigerant cycle from the NH₃ heat source cycle; and the NH₃ refrigerant in a clean condition is used in the secondary NH₃ refrigerant cycle, being free from contamination and aged deterioration; thus, the efficiency of the evaporator can be kept high.

[0015] Moreover, according to the present invention as described above, the cascade condenser completely separates the line system of the secondary NH₃ refrigerant cycle from the line system of the NH₃ heat source cycle; thus, the amount of the refrigerant in the secondary NH₃ refrigerant cycle can be pertinently established in response to the objective heat load (the cooling demand load) to be cooled; accordingly, the amount of the refrigerant in the secondary NH₃ refrigerant cycle can be restrained to a minimum level.

[0016] A preferable embodiment according to the present invention as described above is the heat pump system whereby secondary NH₃ refrigerant cycle that is directly connected to the heat source cycle via the cas-

cade condenser of the heat source cycle; and, the NH₃ refrigerant in the heat source cycle and the NH₃ refrigerant in the secondary NH₃ refrigerant cycle are separated from each other at the cascade condenser.

[0017] Another preferable embodiment according to the present invention as described above is the heat pump system whereby the secondary NH₃ refrigerant cycle that is indirectly connected to the heat source cycle via a second secondary refrigerant cycle. In other words, the second secondary refrigerant cycle is provided between the heat source cycle and the secondary NH₃ refrigerant cycle.

[0018] Further, another preferable embodiment according to the present invention as described above is the heat pump system whereby the refrigerant of the heat source cycle is NH₃ and the configuration of the heat source cycle is replaced by a configuration of a liquid pump approach or a direct expansion system.

[0019] As described above, the existing liquid pump approach or a direct expansion system can be used as a configuration of the heat source cycle; further, the secondary NH₃ refrigerant cycle that absorbs the objective load can be additionally provided. Thus, the components of the existing facility can be made best use of.

Effects of the Invention

[0020] In general, the refrigerant NH₃ has the properties superior to those of the other general refrigerants. For instance, the evaporative latent heat of the refrigerant NH₃ is higher than that of other general refrigerant. According to the heat pump system of the present invention, the refrigerant NH₃ is applied to the heat source cycle and the secondary NH₃ refrigerant cycle; therefore, the power consumption required for circulating the refrigerant NH₃ can be smaller than that required for circulating other brine refrigerant; thus, the performance of the cycle using the refrigerant NH₃ can be enhanced.

[0021] Further, in a case where an existing heat pump system is modernized (improved) with the secondary refrigerant cycle using CO₂ refrigerant, namely, in a case where refrigerant CO₂ is used instead of the refrigerant NH₃ of the secondary NH₃ refrigerant cycle from which the heat to be cooled (i.e. the objective heat load or the cooling demand load) is absorbed, the reuse of the components in the existing secondary NH₃ refrigerant cycle has to be given up. However, according to the heat pump system of the present invention as described above, the refrigerant NH₃ is used for the secondary refrigerant cycle; thus, the existing components in the heat pump system can be reused as they are.

[0022] Further, according to the present invention, the secondary NH₃ refrigerant circulated in the secondary NH₃ refrigerant cycle absorbs the objective heat load (or absorbs the refrigeration load through the evaporator), by the head difference part or by both the head difference part and the circulating pump; in addition, the line system of the NH₃ refrigerant in the heat source cycle and the

line system of the NH₃ refrigerant in the secondary NH₃ refrigerant cycle are completely separated from each other by the cascade condenser between the NH₃ heat source cycle and the secondary NH₃ refrigerant cycle; thus, the lubricating oil associated with the compressor in the NH₃ heat source cycle can be prevented from entering the secondary NH₃ refrigerant cycle. Accordingly, the maintenance work in relation to the lubricating oil can be confined within the machine room (the NH₃ heat source cycle), and the safety of the heat pump system can be ensured with simple maintenance.

[0023] Further, according to the present invention, the cascade condenser separates the secondary NH₃ refrigerant cycle from the NH₃ heat source cycle; and the NH₃ refrigerant in a clean condition is used in the secondary NH₃ refrigerant cycle, being free from contamination and aged deterioration; thus, the efficiency of the evaporator can be kept high.

[0024] Moreover, according to the present invention as described above, the cascade condenser completely separates the line system of the secondary NH₃ refrigerant cycle from the line system of the NH₃ heat source cycle; thus, the amount of the refrigerant in the secondary NH₃ refrigerant cycle can be pertinently established in response to the objective heat load (the cooling demand load) to be cooled; accordingly, the amount of the refrigerant in the secondary NH₃ refrigerant cycle can be restrained to a minimum level.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The present invention will now be described in greater detail with reference to the preferred embodiments of the invention and the accompanying drawings, wherein:

Fig. 1 shows a configuration example regarding the heat pump system in which a heat source cycle using NH₃ refrigerant and a secondary NH₃ refrigerant cycle using NH₃ refrigerant are combined;

Fig. 2 shows a configuration example regarding the heat pump system in which a second secondary refrigerant cycle is arranged between the heat source cycle using NH₃ refrigerant and the secondary NH₃ refrigerant cycle using NH₃ refrigerant.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] Hereafter, the present invention will be described in detail with reference to the embodiments shown in the figures. However, the dimensions, materials, shape, the relative placement and so on of a component described in these embodiments shall not be construed as limiting the scope of the invention thereto, unless especially specific mention is made.

[0027] Fig. 1 shows a configuration example regarding the heat pump system in which a heat source cycle using

NH₃ refrigerant and a secondary NH₃ refrigerant cycle using NH₃ refrigerant are combined.

[0028] In Fig. 1, the symbol A denotes a heat source cycle using NH₃ refrigerant as the heat source; the symbol B denotes a secondary NH₃ refrigerant cycle using NH₃ refrigerant, the secondary NH₃ refrigerant cycle including an evaporator 8 that generates an output (an absorption heat amount) corresponding to the objective heat load (the cooling demand load) to be cooled. The heat source cycle A and the secondary NH₃ refrigerant cycle B are connected to each other so as to perform heat transfer via a cascade condenser 4; namely, the heat source cycle A and the secondary NH₃ refrigerant cycle B are directly connected to each other via the cascade condenser 4.

[0029] The heat source cycle A comprises a compressor 1, a condenser 2, an expansion means 3 (an expansion valve, a capillary tube, etc.), and a cascade condenser 4; thereby, the cascade condenser 4 functions as an evaporator in the heat source cycle A. Further, the heat source cycle A comprises the compression process, the condensation process, the expansion process, and the evaporation process regarding the NH₃ refrigerant cycle; thereby, the heat source cycle A absorbs heat from the secondary NH₃ refrigerant cycle B, via the cascade condenser 4.

[0030] The secondary NH₃ refrigerant cycle B comprises the cascade condenser 4 and an evaporator 8; thereby, the cascade condenser 4 functions as a heat absorbing device in the cycle B, and the evaporator 8 functions as a cooling device that absorbs the heat corresponding to the cooling demand load. A head (liquid head) difference part H and a circulating pump 6 are provided between the evaporator 8 and the heat absorbing part (namely, the cascade condenser 4 in the example of Fig. 1) on the upstream side of the evaporator, in the cycle B.

[0031] Further, a by-pass conduit line is provided in the cycle B so as to bypass the circulating pump 6; a flow rate control valve 5 is provided on the by-pass conduit line so as to be placed parallel to the circulating pump 6. By use of the flow rate control valve 5, the NH₃ refrigerant in the secondary NH₃ refrigerant cycle B can be circulated only with the liquid head of the head difference part H; or, the NH₃ refrigerant in the cycle B can be circulated with both the liquid head and the head of the pump 6. In other words, by setting the opening of the flow rate control valve 5, it can be chosen whether the liquid in the cycle B can be circulated by only the liquid head H or by both the liquid head and the pump head. Thus, in a case where the liquid head cannot afford to feed a sufficient flow rate of the NH₃ refrigerant streaming through the evaporator 8, a necessary flow rate required from the side of the evaporator 8 can be ensured by the pressure transport with not only the liquid head but also the pump head.

[0032] Further, on the downstream side of the circulating pump 6 as well as the flow rate control valve 5, a flow rate control valve 7 is arranged.

[0033] The flow rate control valves 5 and 7 are controlled either manually or automatically; thereby, the opening of each valve 5 or 7 is regulated so that the flow rate of the NH₃ refrigerant streaming into the evaporator 8 is maintained within an appropriate range; in addition, the flow rate may be measured by a flow meter or estimated on the basis of the temperatures of the NH₃ refrigerant at the inlet and the outlet of the evaporator 8.

[0034] Further, as described above, the heat source cycle A may be configured according to a NH₃ liquid pump approach or a NH₃ direct expansion system; thereby, the heat source cycle (to be modernized) can be configured with the existing liquid pump system or the existing NH₃ direct expansion system; further, the secondary NH₃ refrigerant cycle that absorbs the objective load can be additionally provided. Thus, the components of the existing facility can be made best use of.

[0035] Fig. 2 shows a heat pump system in which a second secondary refrigerant cycle is arranged between the heat source cycle using NH₃ refrigerant and the secondary NH₃ refrigerant cycle using NH₃ refrigerant; hereby, the configurations of the heat source cycle and the secondary NH₃ refrigerant cycle are the same as those in Fig. 1; and the second secondary refrigerant used in the second secondary refrigerant cycle C may be, for instance, NH₃ and CO₂.

[0036] In Fig. 2, the symbol A denotes the heat source cycle (of Fig. 2) using NH₃ refrigerant as the heat carrier in the heat source cycle, as is the case with the heat source cycle A in Fig. 1; the symbol B denotes a secondary NH₃ refrigerant cycle (of Fig. 2) using NH₃ refrigerant; the secondary NH₃ refrigerant cycle is connected to the heat source cycle A (of Fig. 2) via the second secondary refrigerant cycle C.

[0037] The heat of second secondary refrigerant cycle C is absorbed in (transferred to) the heat source cycle A via the cascade condenser 4 thereof; the second secondary refrigerant circulates in the second secondary refrigerant cycle C that comprises: the cascade condenser 4 that functions as the heat absorbing device which absorbs heat from the cycle C and transfers the heat to the cycle A; and, a cascade condenser 9 (an evaporator) that functions as a cooling heat supplying device which absorbs heat from the cycle B and transfers the heat to the cycle C.

[0038] The refrigerant to be circulated in the second secondary refrigerant cycle C is not limited to, for instance, NH₃ or CO₂; however, natural refrigerants such as NH₃ or CO₂ are preferably used.

[0039] A head (liquid head) difference part H and a circulating pump 10 are provided between the cascade condenser (an evaporator) 9 and the heat absorbing part (namely, the cascade condenser 4 in the example of Fig. 2) on the upstream side of the cascade condenser 4, in the cycle B.

[0040] Further, a by-pass conduit line is provided in the second secondary refrigerant cycle C so as to bypass the circulating pump 10; a flow rate control valve 11 is

provided on the by-pass conduit line so as to be placed parallel to the circulating pump 10. By setting the opening of the flow rate control valve 11, it can be chosen whether the liquid in the cycle C can be circulated by only the liquid head or by both the liquid head and the pump head.

[0041] Further, on the downstream side of the circulating pump 10 as well as the flow rate control valve 11, a flow rate control valve 12 is arranged; by controlling the opening of the flow rate control valve 12, the flow rate regarding the second secondary refrigerant streaming into the cascade condenser (the evaporator) 9 is controlled so that the second secondary refrigerant circulates in the second secondary refrigerant cycle C, with a necessary flow rate in response to the required refrigeration load.

[0042] Thus, according to the heat pump system (sometimes called a diversified system or approach) depicted in Fig. 2, the refrigerant cycle that supplies refrigeration heat to (or absorbs the refrigeration load from) the secondary NH₃ refrigerant cycle B is diversified into multi-stages (i.e. the cycles A and C); thus, the heat pump system as described can easily optimize the amount of refrigerants in contrast to the lumped (single) stage approach. Accordingly, the saving (or minimization) of the refrigerants can be further promoted.

[0043] As a principle, the refrigerant NH₃ has the properties superior to those of the other general refrigerants; for instance, the evaporative latent heat of the refrigerant NH₃ is higher than that of other general refrigerant. According to the heat pump systems described on the basis of the examples in Figs. 1 and 2, the refrigerant NH₃ is applied to the heat source cycle A and the secondary NH₃ refrigerant cycle B; therefore, the power consumption required for circulating the refrigerant NH₃ can be smaller than that required for circulating other brine refrigerant; thus, the performance of the cycle using the refrigerant NH₃ can be enhanced.

[0044] Further, when refrigerant CO₂ is used instead of the refrigerant NH₃ of the secondary NH₃ refrigerant cycle B from which the refrigeration load is absorbed, then the reuse of the components in the existing secondary NH₃ refrigerant cycle B has to be given up. According to the heat pump systems described on the basis of the examples in Figs. 1 and 2, however, the refrigerant NH₃ is used for the secondary refrigerant cycle B; thus, the existing components in the heat pump system can be reused as they are.

[0045] Further, according to the present invention, the secondary NH₃ refrigerant is circulated in the secondary NH₃ refrigerant cycle B absorbs the objective heat load (or absorbs the refrigeration load through the evaporator 8), by the head difference part H or by both the head difference part H and the circulating pump 6; in addition, the line system of the NH₃ refrigerant in the cycle A and the line system of the NH₃ refrigerant in the cycle B are completely separated from each other by the cascade condenser 4 (as well as the cascade condenser 9) between the NH₃ heat source cycle A and the secondary

NH₃ refrigerant cycle B; thus, the lubricating oil associated with the compressor 1 in the NH₃ heat source cycle A can be prevented from entering the secondary NH₃ refrigerant cycle B. Accordingly, the maintenance work in relation to the lubricating oil can be confined within the machine room (the NH₃ heat source cycle A), and the safety of the heat pump system can be ensured with simple maintenance.

[0046] Further, as described above, the cascade condenser 4 (as well as the cascade condenser 9) separates the secondary NH₃ refrigerant cycle B from the NH₃ heat source cycle A; and the NH₃ refrigerant in a clean condition can be used in the cycle B, being free from contamination and aged deterioration; thus, the efficiency of the evaporator 8 can be kept high.

[0047] Further, as described above, the cascade condenser 4 (as well as the cascade condenser 9) completely separates the line system of the secondary NH₃ refrigerant cycle B from the line system of the NH₃ heat source cycle A; thus, the amount of the refrigerant in the secondary NH₃ refrigerant cycle B can be pertinently established in response to the objective heat load (the cooling demand load) to be cooled; accordingly, the amount of the refrigerant in the secondary NH₃ refrigerant cycle B can be restrained to a minimum level.

[0048] Thus far, the explanation in relation to the embodiments according to the present invention is given in detail; incidentally, the present invention shall not be construed as limiting the scope thereof to the embodiments as is described above; it is needless to say that there may be various kinds of modified embodiments within the bounds of the features of the present invention.

[0049] For instance, the NH₃ heat source cycle A and the secondary NH₃ refrigerant cycle B may be connected via a pair (a series pair) of second secondary refrigerant cycles in two stage, although the NH₃ heat source cycle A and the secondary NH₃ refrigerant cycle B in Fig. 2 are connected via the second secondary refrigerant cycle C that itself forms a single stage.

[0050] In addition, in the examples of Figs. 1 and 2, the flow rate control valves 5 and 11 as well as the circulating pumps 6 and 10 are arranged on the downstream side of the cascade condensers 4 and 9, respectively; thereby, no special apparatus other than pipes are placed between the cascade condenser and the flow rate control valve (or the circulating pump). However, a liquid refrigerant reservoir may be provided just on the downstream side of the cascade condenser 4 or 9. In this way, a stable liquid level regarding the refrigerant is ensured so that the liquid head of the head difference part H can be accurately controlled.

Claims

1. A heat pump system, being provided with:

a heat source cycle that comprises a compres-

sor, a condenser, an expansion means, and a cascade condenser, thereby NH_3 refrigerant is used as a heat carrier of the heat source cycle; a secondary NH_3 refrigerant cycle that is directly or indirectly connected to the heat source cycle via the cascade condenser of the heat source cycle, thereby the heat in the secondary NH_3 refrigerant cycle is directly or indirectly absorbed through the cascade condenser, the heat in the secondary NH_3 refrigerant cycle absorbing an objective heat load;

wherein, the secondary NH_3 refrigerant cycle comprises:

a heat absorption part in which the heat in the secondary NH_3 refrigerant cycle is directly or indirectly absorbed through the cascade condenser of the heat source cycle, and the secondary NH_3 refrigerant is condensed;

an evaporator that absorbs the objective heat load by the evaporation of the secondary NH_3 refrigerant which is condensed through the heat absorption part;

a head difference part and a circulating pump that are placed between the heat absorption part and the evaporator, so that the head difference part and the circulating pump circulate the secondary NH_3 refrigerant;

a by-pass conduit line that bypasses the circulating pump; a flow rate control valve that is placed on the by-pass conduit line.

2. The heat pump system according to claim 1, whereby the secondary NH_3 refrigerant cycle that is directly connected to the heat source cycle via the cascade condenser of the heat source cycle; and, the NH_3 refrigerant in the heat source cycle and the NH_3 refrigerant in the secondary NH_3 refrigerant cycle are separated from each other at the cascade condenser.
3. The heat pump system according to claim 1, whereby the secondary NH_3 refrigerant cycle that is indirectly connected to the heat source cycle via a second secondary refrigerant cycle.
4. The heat pump system according to any one of claims 1 to 3, whereby the refrigerant of the heat source cycle is NH_3 and the configuration of the heat source cycle is replaced by a configuration of a liquid pump approach or a direct expansion system.

Fig.1

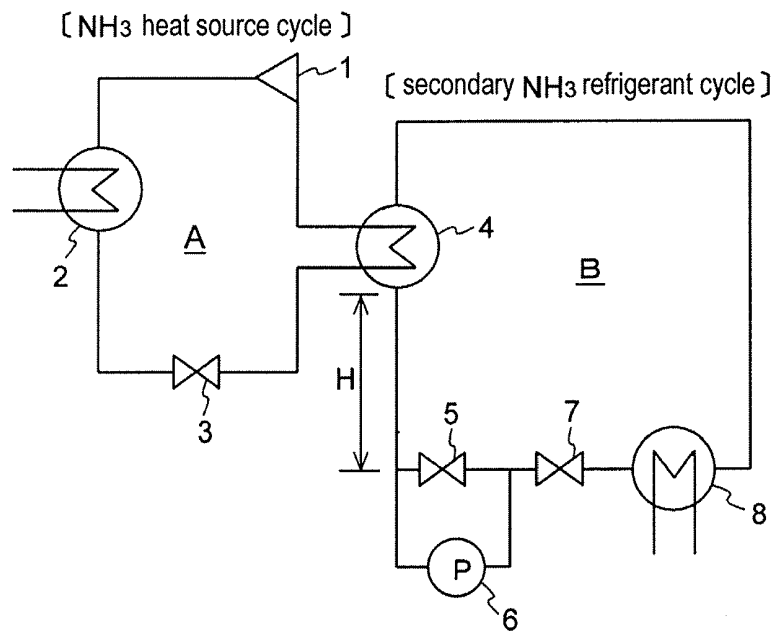
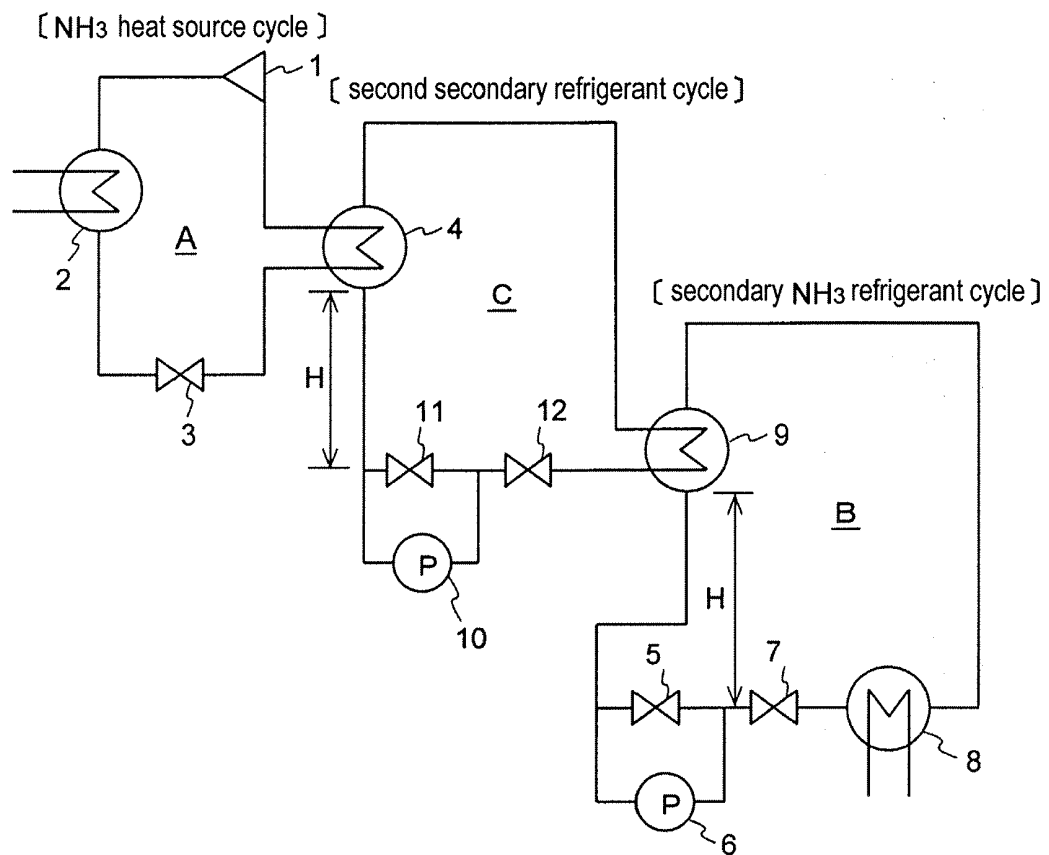


Fig.2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/062469

A. CLASSIFICATION OF SUBJECT MATTER

F25B1/00 (2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B1/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009

Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-30622 A (Mayekawa Mfg., Co., Ltd.), 03 February, 2005 (03.02.05), Par. Nos. [0019] to [0022]; Fig. 2	1-3
Y	WO 2006/038354 A1 (Mayekawa Mfg., Co., Ltd.), 13 April, 2006 (13.04.06), Par. Nos. [0003] to [0006]; Fig. 11(B)	1-3
A	JP 2006-214611 A (Nissin Refrigeration & Engineering Ltd.), 17 August, 2006 (17.08.06), Claim 1; Fig. 1	1-3
A	JP 5-39963 A (Sanki Engineering Co., Ltd.), 19 February, 1993 (19.02.93), Figs. 1 to 3; Par. Nos. [0012] to [0027]	1-3



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"I"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

Date of the actual completion of the international search
09 September, 2009 (09.09.09)Date of mailing of the international search report
29 September, 2009 (29.09.09)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

EP 2 320 158 A1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/JP2009/062469

JP 2005-30622 A	2005.02.03	(Family: none)
WO 2006/038354 A1	2006.04.13	JP 2005-172416 A JP 2008-209111 A JP 4188971 B US 2007/0234753 A1 US 2006/0266058 A1 EP 1795831 A1 EP 1688685 A1 WO 2005/050104 A1 CA 2602536 A KR 10-2007-0055579 A CN 101031761 A CA 2545370 A KR 10-2006-0116009 A CN 1902448 A BRA PI0416759
JP 2006-214611 A	2006.08.17	CN 1815108 A
JP 5-39963 A	1993.02.19	(Family: none)

Form PCT/ISA/210 (patent family annex) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/062469

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 4
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
It is unclear that what constitution is indicated by "an NH₃ liquid pump system" and "an NH₃ direct expansion system" described in claim 4.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest
the

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005140349 A [0003]