

明 細 書

二元冷凍装置

〔 技術分野 〕

本発明は、二元冷凍装置に関する。

〔 背景技術 〕

二元冷凍装置は、低温側と高温側とで別個のサイクルを行なう二つの冷凍機を一つに組み合わせたものであり、マイナス数十度の低い温度を得るために使用されている。この装置は、高圧縮比から低圧縮比まで効率の良いところで使用することができるため、省エネルギーの点で有利である。その一例については、特開平5-5567号公報に記載されている。この二元冷凍装置は、組付け、配管接続に高度の精密技術ならびに品質管理が要求される低温側の冷却ユニットをファクトリ・アセンブリ化した一体構造のものとし、これに構造が簡単な高温側ユニットであるセパレート型の室外機を組み合わせている。この結果、現地工事の簡単化ならびに装置の信頼性の向上を図っている。

－解決課題－

しかし、上記二元冷凍装置は、省エネルギー化が図れるとはいっても、外気温が低い場合には、高圧縮比を生かすことはできず、かえって室外機の運転を常時行なう必要があるため、エネルギー的に不利になることがある。

すなわち、本発明の課題は、上記二元冷凍装置において、その省エネルギー化をより一層図ることができるようにすることにある。

〔 発明の開示 〕

本発明者は、上記課題について種々の実験・検討を行ない、上述の如き外気温が低い場合には、高温側ユニットの冷媒を圧縮せずに自然循環させるだけでも低温側ユニットからの廃熱を吸収して室外に放出するに充分であることを見出し、本発明を完成するに至ったものである。

－発明の特定事項－

すなわち、特許請求の範囲の請求項 1 に係る発明が講じた手段は、先ず、低温側圧縮機（3）、カスケードコンデンサ（4）の凝縮部、膨張手段（5）及び蒸発器（6）が順に接続されて低温側冷凍サイクルを構成している低温側ユニット（1）を備えている。更に、高温側圧縮機（15）と、外気を利用して冷媒を凝縮させる凝縮器（16）とを有し、該高温側圧縮機（15）及び凝縮器（16）が高温側冷凍サイクルを構成するように膨張手段（9）を介して上記カスケードコンデンサ（4）の蒸発部に接続された高温側ユニット（2）を備えている二元冷凍装置を前提としている。

そして、上記高温側ユニット（2）が低温側ユニット（1）よりも高位置に設けられている。加えて、外気温を検出する外気温センサ（21）と、該外気温センサ（21）によって検出された外気温が所定温度よりも低いときに上記高温側冷凍サイクルにおいて冷媒を自然循環させる自然循環手段とを備えている。

また、請求項 2 に係る発明が講じた手段は、上記請求項 1 に記載の発明において、自然循環手段が、高温側圧縮機（15）をバイパスするバイパス通路（19）と、該バイパス通路（19）を開閉する開閉弁（20）と、外気温センサ（21）によって検出される外気温が所定温度よりも低いときに、上記高温側圧縮機（15）を停止させるとともに、上記開閉弁（20）を開にする制御手段（22）とを備えた構成としている。

また、請求項 3 に係る発明が講じた手段は、上記請求項 1 に記載の発明において、自然循環手段が、高温側冷凍サイクルの膨張手段 (9) をバイパスするバイパス通路 (10) と、該バイパス通路 (10) を開閉する開閉弁 (11) と、外気温センサ (21) によって検出される外気温が所定温度よりも低いときに、高温側圧縮機 (15) を停止させるとともに、上記開閉弁 (11) を開にする制御手段 (22) とを備えた構成としている。

—作用—

上記の発明特定事項により、請求項 1 に係る発明では、外気温が高いときに、高温側圧縮機 (15) が運転される。これにより、当該高温側ユニット (2) の冷媒は高い圧縮比で圧縮されるため、外気温が高くとも冷媒を凝縮器 (16) で液化し、カスケードコンデンサ (4) において低温側ユニット (1) の冷媒と熱交換をさせることができる。

外気温が低いときには、上記高温側圧縮機 (15) はその運転が停止されるが、カスケードコンデンサ (4) での熱交換によって温度が高くなった高温側ユニット (2) の冷媒は、外気温が低いために凝縮器 (16) において外気との熱交換によって液化する。この場合、高温側ユニット (2) は低温側ユニット (1) よりも高位置にあるため、液化した当該冷媒は重力でカスケードコンデンサ (4) の蒸発部に流れる。そして、低温側ユニット (1) の冷媒との間で熱交換を行ない、気化・膨張して再び高位置にある凝縮器 (16) まで上昇する。このように自然循環 (重力循環) を行なうことになる。

また、請求項 2 に係る発明では、外気温が低いときに、高温側圧縮機 (15) の運転は停止され、バイパス通路 (19) が開となる。従って、カスケードコンデンサ (4) での熱交換によって温度が高くなった高温側ユニット (2) の冷媒は、高温側圧縮機

(15) をバイパスして凝縮器 (16) に流れる、という自然循環を行なうことになる。このため、当該自然循環において高温側圧縮機 (15) が通路抵抗となることを避けることができ、冷媒循環量を多くすることができる。

また、請求項 3 に係る発明では、外気温が低いときに冷媒が高温側冷凍サイクルの膨張手段 (9) をバイパスして循環するため、通路抵抗が少なくなり、所期の冷媒循環量を確保する上で有利になる。

－発明の効果－

したがって、請求項 1 に係る発明は、二元冷凍装置において、高温側ユニット (2) を低温側ユニット (1) よりも高位置に設けるとともに、外気温を検出する外気温センサ (21) を設け、該外気温センサ (21) によって検出された外気温が所定温度よりも低いときに高温側冷凍サイクルにおいて冷媒を自然循環させるようにしている。この結果、冷却能力の大きな低下を招くことなく、高温側圧縮機 (15) が無駄に運転されることを防止することができ、省エネルギー化を図ることができる。

また、請求項 2 に係る発明は、高温側冷凍サイクルの冷媒を自然循環させる手段が、高温側圧縮機 (15) をバイパスするバイパス通路 (19) と、該バイパス通路 (19) を開閉する開閉弁 (20) と、外気温センサ (21) によって検出される外気温が所定温度よりも低いときに、上記高温側圧縮機 (15) を停止させるとともに、上記開閉弁 (20) を開にする制御手段 (22) とを備えている。この結果、当該自然循環において高温側圧縮機 (15) が通路抵抗となることを避けて冷媒の自然循環量を多くすることができ、所期の冷却能力を確保する上で有利になる。

また、請求項 3 に係る発明は、外気温が低いときに冷媒が高温側冷凍サイクルの

膨張手段（９）をバイパスして循環するようにしている。この結果、通路抵抗が少なくして冷媒の自然循環量を多くすることができ、所期の冷却能力を確保する上で有利になる。

〔図面の簡単な説明〕

図１は、本発明の実施形態を示す二元冷凍装置の冷媒回路図である。

図２は、制御のフロー図である。

図３は、二元冷凍サイクルの $p-i$ 線図である。

図４は、自然循環における $p-i$ 線図である。

〔 発明を実施するための最良の形態 〕

以下、本発明の実施形態を図面に基づいて説明する。

図１は、二元冷凍装置の冷媒回路を示し、屋内の冷凍庫に設けられる低温側ユニット（１）と、屋上に設けられる高温側ユニット（２）とを備えている。そして、本実施形態における高温側ユニット（２）は低温側ユニット（１）よりも１０ｍ以上高い位置に設けられている。

上記低温側ユニット（１）は、低温側圧縮機（３）と、カスケードコンデンサ（４）と、低温側の膨張手段である感温膨張弁（５）と、冷凍庫（７）の内部に設けられる蒸発器（６）とを備え、蒸発器（６）には庫内ファン（８）が設けられている。そして、上記低温側圧縮機（３）、カスケードコンデンサ（４）の凝縮部、感温膨張弁（５）及び蒸発器（６）は順に接続されて低温側冷凍サイクルを構成している。

上記カスケードコンデンサ（４）の蒸発部の流入ポート側には、後述する高温側冷凍サイクルを構成する高温側の膨張手段である感温膨張弁（９）が接続されるとともに、該膨張弁（９）をバイパスする通路（１０）及び該バイパス通路（１０）を開

閉する電磁開閉弁（11）が設けられている。

また、上記蒸発器（6）の流出ポート側及び上記カスケードコンデンサ（4）の蒸発部の流出ポート側には、上記感温膨張弁（5, 9）のための感温筒（12, 13）がそれぞれ付設されている。

上記低温側ユニット（1）は、その各機器の組付け、冷媒配管の接続を含む一切の組立が専門工場において行なわれ、つまり、ファクトリ・アセンブリ化されたものである。そして、現地においては、この低温側ユニット（1）の据付とカスケードコンデンサ（4）の蒸発部に対する配管接続だけが行なわれる。

次に、高温側ユニット（2）は、高温側圧縮機（15）と、外気を利用して冷媒を凝縮させる凝縮器（16）と、逆止弁（17）とを備え、凝縮器（16）には室外ファン（18）が設けられている。そして、上記高温側圧縮機（15）、逆止弁（17）、凝縮器（16）、低温側ユニット（1）の高温側感温膨張弁（9）及び上記カスケードコンデンサ（4）の蒸発部が順に接続されて高温側冷凍サイクルを構成している。

上記高温側ユニット（2）には、上記高温側圧縮機（15）及び逆止弁（17）をバイパスして上記カスケードコンデンサ（4）の蒸発部の流出側ポートを上記凝縮器（16）に結ぶバイパス通路（19）が設けられていて、該バイパス通路（19）には該通路を開閉する電磁開閉弁（20）が設けられている。

更に、当該二元冷凍装置は、上記高温側ユニット（2）が配設された屋上に外気温を検出する外気温センサ（21）を備えているとともに、該外気温センサ（21）によって検出される外気温に基づいて上記低温側圧縮機（3）、庫内ファン（8）、電磁開閉弁（11, 20）、高温側圧縮機（15）、及び室外ファン（18）の作動を制御する制御手段（22）を備えている。

すなわち、上記制御手段（22）は、図2に示すように、ステップS1において、

外気温が5℃以上か否かを判定し、外気温が5℃以上のときにステップS 2に移り、二元冷凍サイクル運転モードとなり、また、外気温が5℃未満のときに上記ステップS 1からステップS 3に移り、自然循環運転モードとなるように、上記各機器を制御するものである。各運転モードにおける各機器の作動状態は表1に示す通りである。

表 1

		二元冷凍サイクル 運転モード	自然循環 運転モード
高温側 ユニット	圧縮機	O N	O F F
	ファン	O N	O N
	開閉弁	O F F	O N
低温側 ユニット	圧縮機	O N	O N
	ファン	O N	O N
	開閉弁	O F F	O N

従って、例えば、外気温が30℃のときは、電磁開閉弁(11, 20)がバイパス通路(10, 19)を閉じ、二元冷凍サイクル運転モードとなる。この運転モードでは、例えば、庫内温度を-20℃にするときは、図3のp-i線図に示すように、蒸発器(6)での蒸発温度が-30℃、カスケードコンデンサ(4)の一次側が10℃、その2次側が5℃、凝縮器(16)での凝縮温度が45℃となるように設計される。

よって、低温側冷凍サイクルでは、低温側圧縮機(3)によって圧縮された冷媒は、カスケードコンデンサ(4)の一次側の凝縮部において10℃で液化し、感温膨張弁(5)において減圧膨張し、蒸発器(6)において-30℃で蒸発し周囲から蒸発熱を奪うことによって庫内温度を-20℃に保ち、低温側圧縮機(3)において再び圧縮される。

高温側冷凍サイクルでは、高温側圧縮機（15）によって圧縮された冷媒は、凝縮器（16）において外気との熱交換によって45℃で液化し、感温膨張弁（9）において減圧膨張し、カスケードコンデンサ（4）の二次側の蒸発部において低温側冷凍サイクルの冷媒との熱交換によって5℃で蒸発し、該低温側冷凍サイクルの冷媒を液化させた後、高温側圧縮機（15）で再び圧縮される。

一方、例えば、外気温が0℃のときは、上記電磁開閉弁（11, 20）がバイパス通路（10, 19）を開くとともに、高温側圧縮機（15）の運転が停止されて自然循環運転モードとなる。この運転モードの場合は、図4に示すように、上記カスケードコンデンサ（4）の一次側が20℃、その二次側の温度が15℃、凝縮器（16）での凝縮温度が10℃となる。

すなわち、高温側冷凍サイクルでは、高温側ユニット（2）の高温側圧縮機（15）をバイパスした冷媒は凝縮器（16）において外気との熱交換により10℃で液化し、重力によって低温側ユニット（1）に降下し、感温膨張弁（9）をバイパスしてカスケードコンデンサ（4）の二次側の蒸発部に至る。この蒸発部において、当該冷媒は低温側冷凍サイクルの冷媒との熱交換によって15℃で蒸発・膨張し、該低温側冷凍サイクルの冷媒を液化させた後、高温側ユニット（2）へ上昇する。

上記自然循環サイクルにおいては、冷媒が高温側圧縮機（15）、逆止弁（17）及び感温膨張弁（9）をバイパスして流れるため、通路抵抗が少なくなって自然循環量が多くなり、所期の冷却効率を得る上で有利に働く。また、室外ファン（18）は自然循環においても運転されるから、凝縮器（16）における冷媒の凝縮に有利である。

高温側ユニット（2）を5馬力、低温側ユニット（1）を3馬力とし、外気温が0℃、庫内温度-20℃の条件のときに、上記2つの運転モードのエネルギー使用効率（EER）を比較すると次のようになる。

二元冷凍サイクル運転モードの場合は、例えば冷却能力が 6150 kcal/h 、消費電力は低温側ユニット(1)が 2.64 KW 、高温側ユニット(2)が 2.6 KW となり、エネルギー使用効率は 1.17 となる。

これに対して、自然循環運転モードの場合は、低温側冷凍サイクルでの圧縮比が大きくなる分、冷媒の循環量が減るため冷却能力が、例えば、 5550 kcal/h となり、低温側ユニット(1)の消費電力が 3.24 KW と大きくなるが、エネルギー使用効率は 1.71 となる。

[産業上の利用分野]

以上のように、本発明による二元冷凍装置によれば、マイナス数十度の低い温度の冷凍庫に有用であり、冷却能力の大きな低下を招くことなく、省エネルギー化を図るのに適している。



請 求 の 範 囲

1. 低温側圧縮機（3）、カスケードコンデンサ（4）の凝縮部、膨張手段（5）及び蒸発器（6）が順に接続されて低温側冷凍サイクルを構成している低温側ユニット（1）と、

高温側圧縮機（15）と、外気を利用して冷媒を凝縮させる凝縮器（16）とを有し、該高温側圧縮機（15）及び凝縮器（16）が高温側冷凍サイクルを構成するように膨張手段（9）を介してして上記カスケードコンデンサ（4）の蒸発部に接続された高温側ユニット（2）とを備えている二元冷凍装置において、

上記高温側ユニット（2）が低温側ユニット（1）よりも高位置に設けられており、

外気温を検出する外気温センサ（21）と、

該外気温センサ（21）によって検出された外気温が所定温度よりも低いときに上記高温側冷凍サイクルにおいて冷媒を自然循環させる自然循環手段とを備えていることを特徴とする二元冷凍装置。

2. 請求項1に記載されている二元冷凍装置において、

自然循環手段が、

高温側圧縮機（15）をバイパスするバイパス通路（19）と、

該バイパス通路（19）を開閉する開閉弁（20）と、

外気温センサ（21）によって検出される外気温が所定温度よりも低いときに、上記高温側圧縮機（15）を停止させるとともに、上記開閉弁（20）を開にする制御手段（22）とを備えてなることを特徴とする二元冷凍装置。



3. 請求項1に記載されている二元冷凍装置において、
自然循環手段が、
高温側冷凍サイクルの膨張手段（9）をバイパスするバイパス通路（10）と、
該バイパス通路（10）を開閉する開閉弁（11）と、
外気温センサ（21）によって検出される外気温が所定温度よりも低いときに、高
温側圧縮機（15）を停止させるとともに、上記開閉弁（11）を開にする制御手段（22）
とを備えてなる
ことを特徴とする二元冷凍装置。

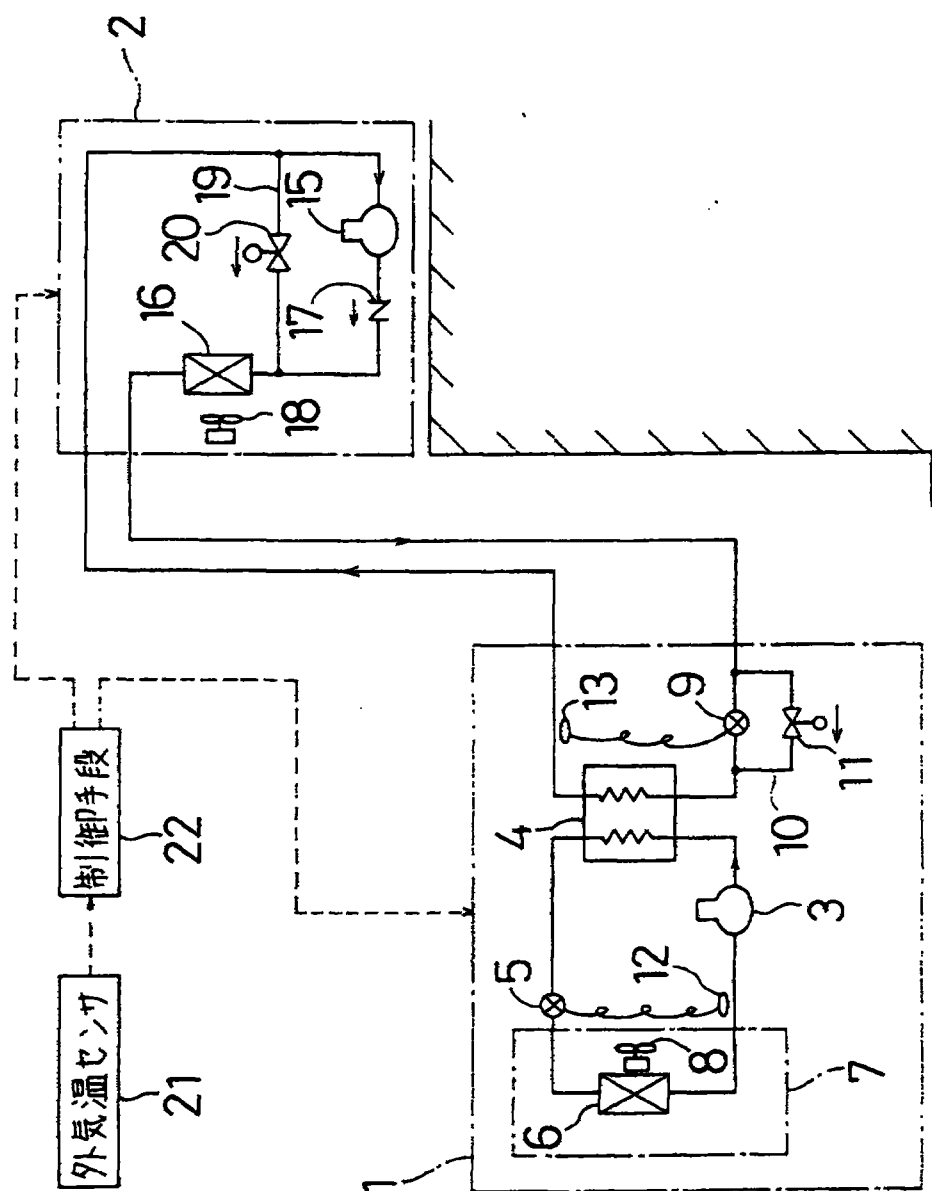


Fig.1

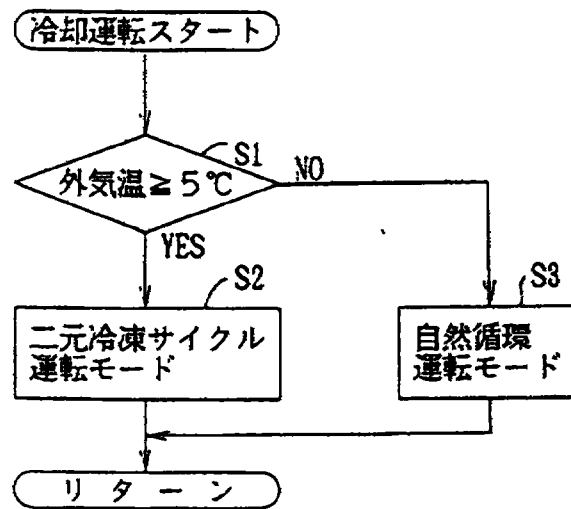


Fig.2

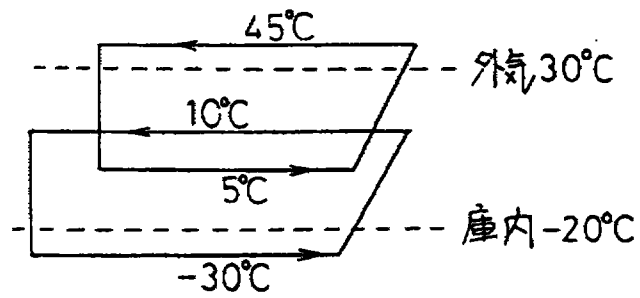


Fig.3

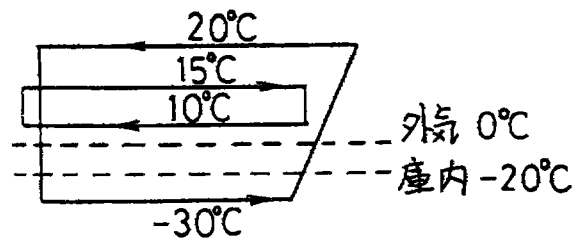


Fig.4

SPECIFICATION

BINARY REFRIGERATING APPARATUS

5

[Technical Field]

This invention relates to a binary refrigerating apparatus.

[Background Art]

10

A binary refrigerating apparatus is a combination of two types of refrigerating machines which carry out lower temperature cycle and higher temperature cycle respectively and is used for reaching a low temperature of minus several ten degrees. Since such an apparatus can be used with high efficiency from a large compression ratio to a small compression ratio, it has an advantage of excellent energy conservation. An example of such apparatus is disclosed in Japanese Patent Application Laid-Open Gazette No. 5-5567. In this binary refrigerating apparatus, a refrigerating unit of lower temperature side which requires high-precise techniques for assembly and pipe connection and strict quality control is factory-assembled so as to be formed into single-piece construction. The refrigerating unit is combined with a separate-type outdoor unit as a higher temperature side unit which has a simple structure. This results in easy on-site installation and enhanced reliability of the apparatus.

15

20

25

-Problem to be solved-

Even though the above binary refrigerating apparatus can save energy, however, it cannot effectively use its high compression ratio when an open-air temperature is low. At the time, on the contrary, it is necessary to continuously operate
5 the outdoor unit. Thereby, the apparatus may have a disadvantage in energy conservation.

An object of the present invention is to attain enhanced energy conservation in a binary refrigerating apparatus.

10

[Disclosure of Invention]

Inventors have conducted various experiments and investigations on the above problem and found that at the time of a low open-air temperature, even if refrigerant in a higher
15 temperature side unit is only naturally circulated without being compressed, this sufficiently makes it possible to absorb exhaust heat from a lower temperature side unit and discharge it outside the room. Thus, Inventors have completed the present invention.

20

-Features of the Invention-

A measure taken in claim 1 of the present invention premises a binary refrigerating apparatus comprising a lower temperature side unit (1) in which a lower temperature side
25 compressor (3), a condensation part of a cascade condenser (4), expansion means (5) and an evaporator (6) are sequentially connected thereby forming a lower temperature refrigeration cycle. The binary refrigerating apparatus also



comprises a higher temperature side unit (2) which has a higher temperature side compressor (15) and a condenser (16) for condensing refrigerant by using the air and which is connected to an evaporation part of the cascade condenser (4) through
5 expansion means (9) so that the higher temperature side compressor (15) and the condenser (16) form a higher temperature refrigeration cycle.

Further, the higher temperature side unit (2) is disposed at a position higher than a position where the lower
10 temperature side unit (1) is disposed. In addition, the binary refrigerating apparatus further comprises an open-air thermometric sensor (21) for sensing an open-air temperature, and natural circulation means for naturally circulating refrigerant in the higher temperature refrigeration cycle
15 when an open-air temperature sensed by the open-air thermometric sensor (21) is below a specific temperature.

A measure taken in claim 2 of the present invention is so composed that in claim 1 of the present invention, the natural circulation means includes a bypass passage (19) which
20 allows refrigerant to bypass the higher temperature side compressor (15), a shut-off valve (20) for opening and closing the bypass passage (19), and control means (22) for deactivating the higher temperature side compressor (15) while opening the shut-off valve (20) when an open-air
25 temperature sensed by the open-air thermometric sensor (21) is below the specific temperature.

A measure taken in claim 3 of the present invention is so composed that in claim 1 of the present invention, the



natural circulation means includes a bypass passage (10) which allows refrigerant to bypass the expansion means (9) in the higher temperature refrigeration cycle, a shut-off valve (11) for opening and closing the bypass passage (10), and control
5 means (22) for deactivating the higher temperature side compressor (15) while opening the shut-off valve (11) when an open-air temperature sensed by the open-air thermometric sensor (21) is below the specific temperature.

10 -Operation-

Under the above-mentioned features of the present invention, in the apparatus according to claim 1, when an open-air temperature is high, the higher temperature side compressor (15) is operated. Thereby, refrigerant in the
15 higher temperature side unit (2) is compressed at a high compression ratio, so that the refrigerant is liquefied in the condenser (16) even if the open-air temperature is high. This allows the refrigerant from the higher temperature side unit (2) to heat-exchange, at the cascade condenser (4), with
20 refrigerant in the lower temperature side unit (1).

When an open-air temperature is low, the higher temperature side compressor (15) is deactivated, and refrigerant in the higher temperature side unit (2), whose temperature has risen due to heat exchange at the cascade
25 condenser (4), is heat-exchanged at the condenser (16) with the air due to the low open-air temperature thereby liquefying. In this case, since the higher temperature side unit (2) is at a position higher than a position where the lower



temperature side unit (1) is, the liquefied refrigerant flows into the evaporation part of the cascade condenser (4) due to gravitation. Then, the liquefied refrigerant is heat-exchanged with refrigerant in the lower temperature side unit (1) thereby evaporating and expanding. The evaporated refrigerant rises to the condenser (16) located at the higher position again. In this manner, natural circulation (circulation by gravitation) of refrigerant is implemented.

In the apparatus according to claim 2, when an open-air temperature is low, the higher temperature side compressor (15) is deactivated and the bypass passage (19) is opened. Thereby, natural circulation is made in such a manner that refrigerant in the higher temperature side unit (2), whose temperature has risen due to heat exchange at the cascade condenser (4), bypasses the higher temperature side compressor (15) and then flows into the condenser (16). This avoids the higher temperature side compressor (15) from interfering with the flow of the refrigerant during natural circulation, thereby increasing a circulation flow rate of refrigerant.

In the apparatus according to claim 3, when an open-air temperature is low, refrigerant circulates in such a manner as to bypass the expansion means (9) in the higher temperature refrigeration cycle, so that flow resistance of refrigerant can be decreased. This provides an advantage of being able to secure a desired circulation flow rate of refrigerant.

-Effects of Invention-



As mentioned so far, in the binary refrigerating apparatus according to claim 1 of the present invention, a higher temperature side unit (2) is disposed at a position higher than a position where a lower temperature side unit (1) is disposed and an open-air thermometric sensor (21) is provided for sensing an open-air temperature. The refrigerating apparatus naturally circulates refrigerant in a higher temperature refrigeration cycle when an open-air temperature sensed by the open-air thermometric sensor (21) is below a specific temperature. Accordingly, this prevents the higher temperature side compressor (15) from being inefficiently operated while eliminating great reduction in cooling performance, thereby resulting in great energy conservation.

In the apparatus according to claim 2, means for naturally circulating refrigerant in a higher temperature refrigeration cycle includes a bypass passage (19) which allows refrigerant to bypass the higher temperature side compressor (15), a shut-off valve (20) for opening and closing the bypass passage (19), and control means (22) for deactivating the higher temperature side compressor (15) while opening the shut-off valve (20) when an open-air temperature sensed by the open-air thermometric sensor (21) is below the specific temperature. Accordingly, it is avoided that the higher temperature side compressor (15) interferes with the flow of the refrigerant during natural circulation, thereby increasing a circulation flow rate of refrigerant. This provides an advantage of being able to secure desired



cooling performance.

In the apparatus according to claim 3, when an open-air temperature is low, refrigerant circulates in such a manner as to bypass the expansion means (9) in the higher temperature refrigeration cycle. Accordingly, flow resistance of refrigerant can be decreased, so that a natural circulation flow rate of refrigerant can be increased. This provides an advantage of being able to secure desired cooling performance.

10 [Brief Description of Drawings]

Fig. 1 is a refrigerant circuit diagram of a binary refrigerating apparatus showing an embodiment of the present invention.

Fig. 2 is a control flow chart.

15 Fig. 3 is a p-i chart (pressure-enthalpy chart) in a binary refrigeration cycle.

Fig. 4 is a p-i chart in natural circulation.

[Best Mode for Carrying Out the Invention]

20 Below, description is made about an embodiment of the present invention with reference to the drawings.

Fig. 1 shows a refrigerant circuit of a binary refrigerating apparatus. The binary refrigerating apparatus comprises a lower temperature side unit (1) provided with an indoor deep freezer, and a higher temperature side unit (2) disposed on a rooftop. The higher temperature side unit (2) of the present embodiment is disposed at a position 10m higher than a position where the lower temperature side unit (1) is



disposed.

The lower temperature side unit (1) includes a lower temperature side compressor (3), a cascade condenser (4), a thermo-sensing expansion valve (5) as a lower temperature side expansion means, and an evaporator (6) provided inside a deep freezer (7). The evaporator (6) is provided with an in-freezer fan (8). The lower temperature side compressor (3), a condensation part of the cascade condenser (4), the thermo-sensing expansion valve (5) and the evaporator (6) are sequentially connected to form a lower temperature refrigeration cycle.

On an inlet port side of an evaporation part of the cascade condenser (4), connected is a thermo-sensing expansion valve (9) as a higher temperature side expansion means forming the below-mentioned higher temperature refrigeration cycle, and provided are a bypass passage (10) which allows refrigerant to bypass the expansion valve (9) and a solenoid shut-off valve (11) for opening and closing the bypass passage (10).

On a discharge port side of the evaporator (6) and on a discharge port side of the evaporation part of the cascade condenser (4), temperature sensing bulbs (12, 13) each for the thermo-sensing expansion valves (5, 9) are attached respectively.

For the lower temperature side unit (1), its entire assembly including attachments of all components and refrigerant pipe connection is made at a special factory. That is, the lower temperature side unit (1) is factory-assembled.

At the site of installation, only an installation of the lower temperature side unit (1) and a pipe connection to the evaporation part of the cascade condenser (4) are conducted.

Next, the higher temperature side unit (2) includes
5 a higher temperature side compressor (15), a condenser (16) for condensing refrigerant by using the air and a non-return valve (17). The condenser (16) is provided with an outdoor fan (18). The higher temperature side compressor (15), the non-return valve (17), the condenser (16), the higher
10 temperature side thermo-sensing expansion valve (9) of the lower temperature side unit (1) and the evaporation part of the cascade condenser (4) are sequentially connected to form a higher temperature refrigeration cycle.

The higher temperature side unit (2) further includes
15 a bypass passage (19) which allows refrigerant to bypass the higher temperature side compressor (15) and the non-return valve (17) and which connects the discharge port of the evaporation part of the cascade condenser (4) to the condenser (16). The bypass passage (19) is provided with a solenoid
20 shut-off valve (20) for opening and closing the bypass passage.

Further, the binary refrigerating apparatus comprises, on a rooftop where the higher temperature side unit (2) is disposed, an open-air thermometric sensor (21) for sensing
25 an open-air temperature, and comprises a control means (22) for controlling respective operations of the lower temperature side compressor (3), the in-freezer fan (8), the solenoid shut-off valves (11, 20), the higher temperature side

compressor (15) and the outdoor fan (18) based on an open-air temperature sensed by the open-air thermometric sensor (21).

In detail, the control means (22) controls the respective components in the following manner shown in Fig.

5 2: the program determines, at Step S1, if an open-air temperature is 5 °C or above; when the open-air temperature is 5 °C or above, the program proceeds to Step S2 to enter a binary refrigeration cycle operation mode; on the other hand, when the open-air temperature is below 5 °C, the program
10 proceeds from Step S1 to Step S3 to enter a naturally circulating operation mode. Operational states of the respective components in the respective operation modes are shown in the following Table 1.

15

Table 1

		Binary refrigeration cycle operation mode	Naturally circulating operation mode
Higher temp. side unit	Compressor	ON	OFF
	Fan	ON	ON
	Shut-off Valve	OFF	ON
Lower temp. side unit	Compressor	ON	ON
	Fan	ON	ON
	Shut-off Valve	OFF	ON

Accordingly, when an open-air temperature is, for example, 30°C, the solenoid shut-off valves (11, 20) close the bypass passages (10, 19) so that the refrigerating
20 apparatus turns binary refrigeration cycle operation mode. In this operation mode, if the temperature inside the deep

freezer should be set to -20°C , as shown in a p-i chart of Fig. 3, the refrigerating apparatus is designed so that an evaporation temperature in the evaporator (6) is -30°C , a temperature in the primary side of the cascade condenser (4) is 10°C , a temperature in its secondary side is 5°C and a condensation temperature in the condenser (16) is 45°C .

Thus, in the lower temperature refrigeration cycle, refrigerant compressed by the lower temperature side compressor (3) liquefies at 10°C in the condensation part of the primary side of the cascade condenser (4), reduces in pressure and expands at the thermo-sensing expansion valve (5), evaporates at -30°C in the evaporator (6) to take evaporation heat from the surrounding thereby keeping the temperature inside the deep freezer at -20°C . The refrigerant is then compressed in the lower temperature side compressor (3) again.

In the higher temperature refrigeration cycle, refrigerant compressed by the higher temperature side compressor (15) liquefies at 45°C in the condenser (16) by heat exchange with the air, reduces in pressure and expands at the thermo-sensing expansion valve (9), evaporates at 5°C in the evaporation part of the secondary side of the cascade condenser (4) by heat exchange with refrigerant in the lower temperature refrigeration cycle thereby liquefying refrigerant in the lower temperature refrigeration cycle. The refrigerant in the higher temperature refrigeration cycle is then compressed in the higher temperature side compressor (15) again.

Meanwhile, when an open-air temperature is, for example, 0°C , the solenoid shut-off valves (11, 20) open the bypass passages (10, 19) and the higher temperature side compressor (15) is deactivated, so that the refrigerating apparatus turns naturally circulating operation mode. In this operation mode, as shown in Fig. 4, a temperature of the primary side of the cascade condenser (4) is 20°C , a temperature of its secondary side is 15°C and a condensation temperature of the condenser (16) is 10°C .

In detail, in the higher temperature refrigeration cycle, refrigerant bypasses the higher temperature side compressor (15) of the higher temperature side unit (2), liquefies at 10°C in the condenser (16) by heat exchange with the air, flows downward to the lower temperature side unit (1) by gravitation, bypasses the thermo-sensing expansion valve (9) and flows into the evaporation part of the secondary side of the cascade condenser (4). In the evaporation part, the refrigerant evaporates and expands at 15°C by heat exchange with refrigerant in the lower temperature refrigeration cycle while liquefying the refrigerant in the lower temperature refrigeration cycle, and then rises to the higher temperature side unit (2).

In the naturally circulating cycle, since refrigerant bypasses the higher temperature side compressor (15), the non-return valve (17) and the thermo-sensing expansion valve (9), flow resistance of refrigerant can be reduced thereby increasing a natural circulation flow rate of refrigerant. This provides an advantage of being able to obtain a desired

cooling efficiency. Further, since the outdoor fan (18) is operated even during the natural circulation, this has an advantage in condensing refrigerant in the condenser (16).

Suppose that the higher temperature side unit (2) has 5 hp, the lower temperature side unit (1) has 3 hp, an open-air temperature is 0°C and a temperature inside the deep freezer is -20°C. Comparison was made in energy efficiency ratio (EER) between the above-mentioned two operation modes. The results are as follows.

10 In the binary refrigeration cycle operation mode, the cooling performance was 6150 kcal/h, the power draw of the lower temperature side unit (1) was 2.64 kW, the power draw of the higher temperature side unit (2) was 2.6 kW, and the EER was 1.17.

15 On the other hand, in the naturally circulating operation mode, since the circulation flow ratio of refrigerant was reduced by the increase in compression ratio in the lower temperature refrigeration cycle, the cooling performance was 5550 kcal/h and the power draw of the lower
20 temperature side unit (1) was 3.24 kW larger than that in the binary refrigeration cycle operation mode. The EER was 1.71.

[Industrial Field of Utilization]

As mentioned so far, the binary refrigerating
25 apparatus of the present invention is useful for deep freezer used at a low temperature of minus several ten degrees, and is suitable for attaining energy conservation without great degradation in cooling performance.



THIS SHEET HAS BEEN
REPLACED

CLAIMS

1. A binary refrigerating apparatus having:

5 a lower temperature side unit (1) in which a lower temperature side compressor (3), a condensation part of a cascade condenser (4), expansion means (5) and an evaporator (6) are sequentially connected thereby forming a lower temperature refrigeration cycle; and

10 a higher temperature side unit (2) which has a higher temperature side compressor (15) and a condenser (16) for condensing refrigerant by using the air and which is connected to an evaporation part of the cascade condenser (4) through expansion means (9) so that the higher temperature side compressor (15) and the condenser (16) form a higher
15 temperature refrigeration cycle,

the improvement comprising:

said higher temperature side unit (2) being disposed at a position higher than a position where said lower temperature side unit (1) is disposed,

20 an open-air thermometric sensor (21) for sensing an open-air temperature; and

natural circulation means for naturally circulating refrigerant in the higher temperature refrigeration cycle when an open-air temperature sensed by the open-air
25 thermometric sensor (21) is below a specific temperature.

2. A binary refrigerating apparatus according to claim 1, wherein

This Sheet Has Been Replaced





THIS SHEET HAS BEEN
REPLACED

said natural circulation means includes:

a bypass passage (19) which allows refrigerant to
bypass the higher temperature side compressor (15);

a shut-off valve (20) for opening and closing the
5 bypass passage (19); and

control means (22) for deactivating the higher
temperature side compressor (15) while opening the shut-off
valve (20) when an open-air temperature sensed by the open-air
thermometric sensor (21) is below the specific temperature.

10

3. A binary refrigerating apparatus according to claim 1,
wherein

said natural circulation means includes:

a bypass passage (10) which allows refrigerant to
15 bypass the expansion means (9) in the higher temperature
refrigeration cycle;

a shut-off valve (11) for opening and closing the
bypass passage (10); and

control means (22) for deactivating the higher
20 temperature side compressor (15) while opening the shut-off
valve (11) when an open-air temperature sensed by the open-air
thermometric sensor (21) is below the specific temperature.

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ABSTRACT

A higher temperature side unit (2) having a higher temperature side compressor (15) and a condenser (16) to form
5 a higher temperature refrigeration cycle is disposed at a position higher than a position where a lower temperature side unit (1) forming a lower temperature refrigeration cycle is disposed. The higher temperature side unit (2) is provided with a bypass passage (19) which allows refrigerant to bypass
10 the higher temperature side compressor (15). A shut-off valve (20) is disposed in the bypass passage (19). When an open-air temperature sensed by an open-air thermometric sensor (21) is low, the higher temperature side compressor (15) is deactivated and the bypass passage (19) is opened, so that
15 refrigerant naturally circulates in the higher temperature refrigeration cycle.

FIG. 1

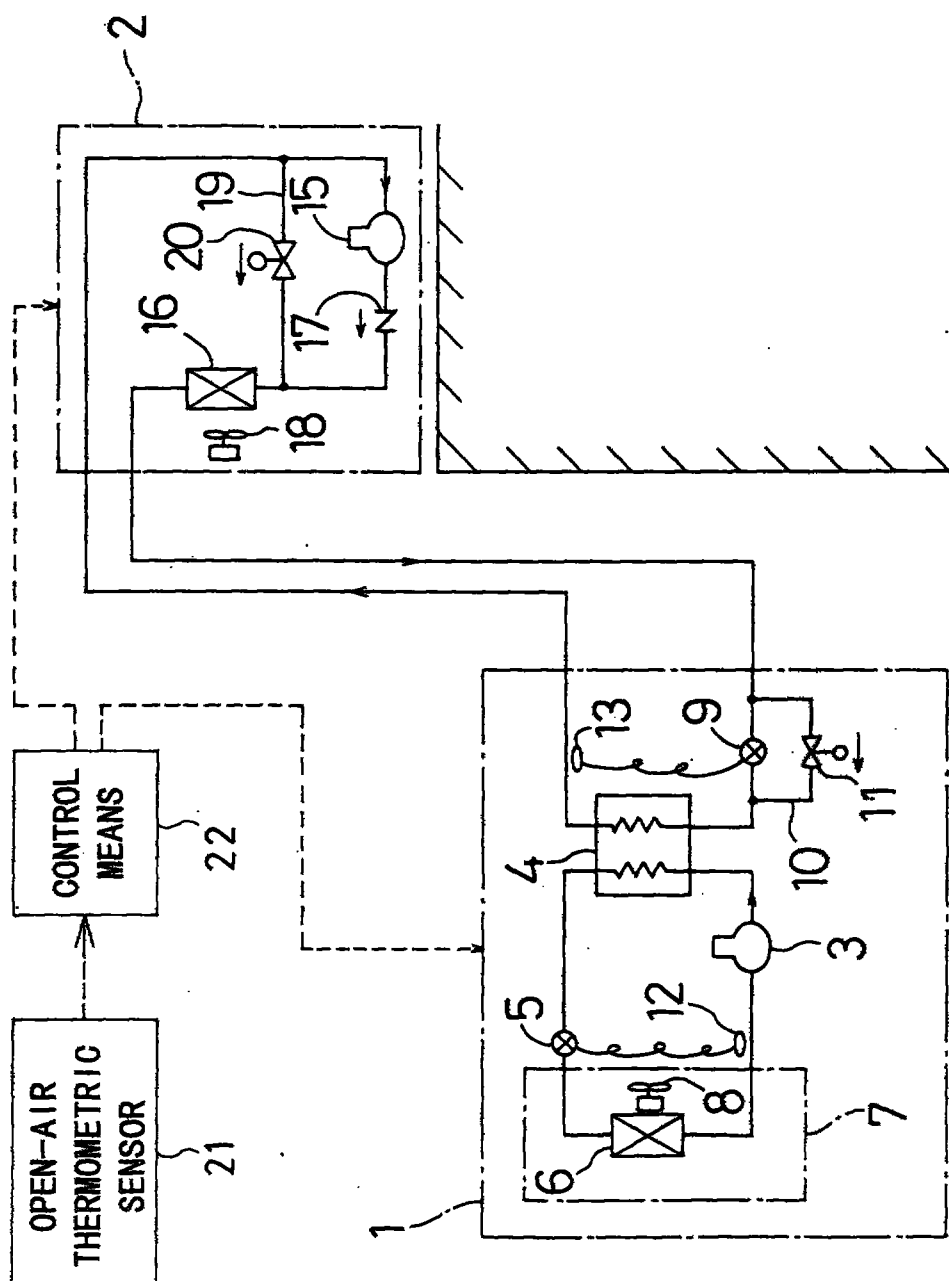


FIG. 2

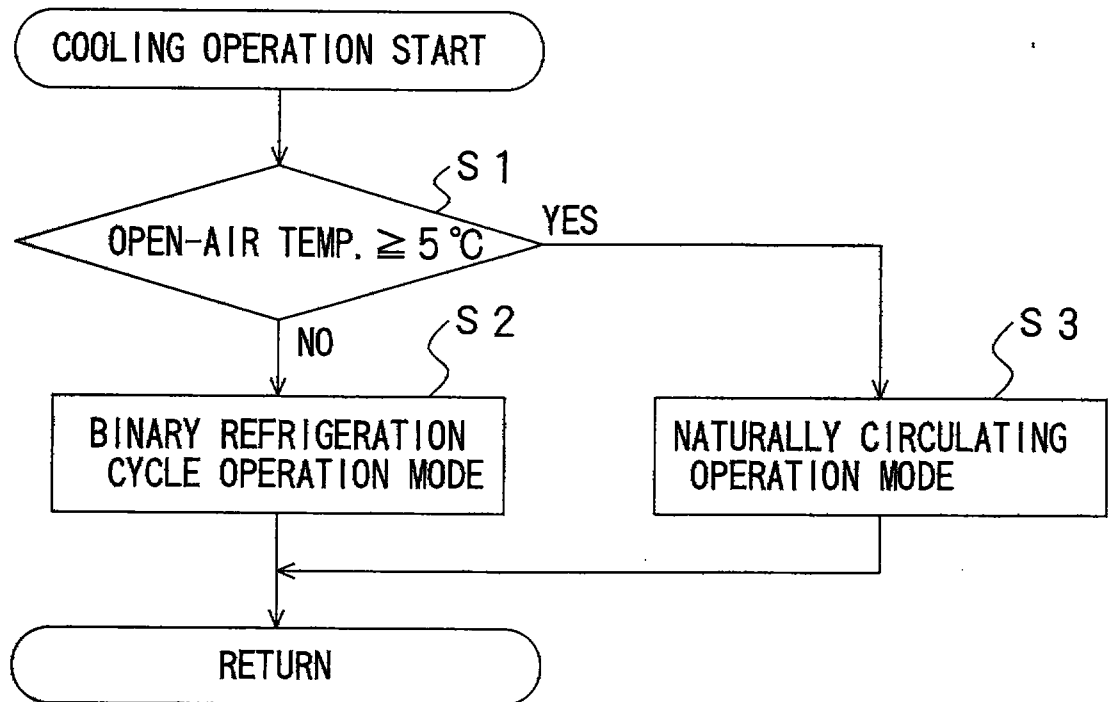


FIG. 3

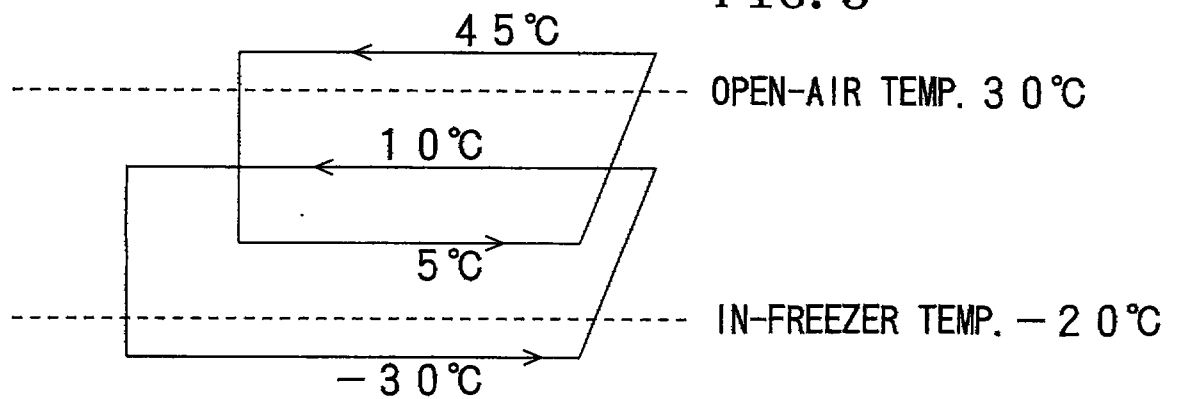
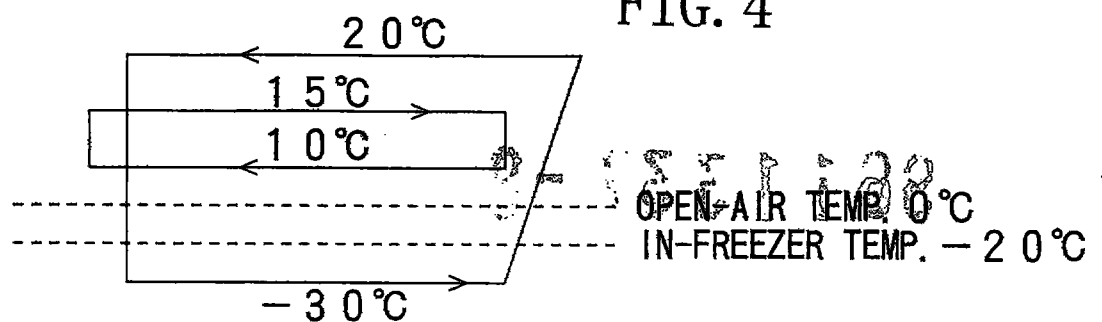


FIG. 4



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Even though the above binary refrigerating apparatus can save energy, however, it cannot effectively use its high compression ratio when an open-air temperature is low. At the time, on the contrary, it is necessary to continuously operate
5 the outdoor unit. Thereby, the apparatus may have a disadvantage in energy conservation.

An object of the present invention is to attain enhanced energy conservation in a binary refrigerating apparatus.

10

[Disclosure of Invention]

Inventors have conducted various experiments and investigations on the above problem and found that at the time of a low open-air temperature, even if refrigerant in a higher
15 temperature side unit is only naturally circulated without being compressed, this sufficiently makes it possible to absorb exhaust heat from a lower temperature side unit and discharge it outside the room. Thus, Inventors have completed the present invention.

20

-Features of the Invention-

Accordingly,

~~A measure taken in claim 1 of~~ the present invention
~~provides~~
~~premises~~ a binary refrigerating apparatus comprising a lower
temperature side unit (1) in which a lower temperature side
25 compressor (3), a condensation part of a cascade condenser
(4), expansion means (5) and an evaporator (6) are
sequentially connected thereby forming a lower temperature
refrigeration cycle. The binary refrigerating apparatus also

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comprises a higher temperature side unit (2) which has a higher temperature side compressor (15) and a condenser (16) for condensing refrigerant by using the air and which is connected to an evaporation part of the cascade condenser (4) through expansion means (9) so that the higher temperature side compressor (15) and the condenser (16) form a higher temperature refrigeration cycle.

Further, the higher temperature side unit (2) is disposed at a position higher than a position where the lower temperature side unit (1) is disposed. In addition, the binary refrigerating apparatus further comprises an open-air thermometric sensor (21) for sensing an open-air temperature, and natural circulation means for naturally circulating refrigerant in the higher temperature refrigeration cycle when an open-air temperature sensed by the open-air thermometric sensor (21) is below a specific temperature.

In one preferred form

~~A measure taken in claim 2 of the present invention is so composed that in claim 1 of the present invention,~~ the natural circulation means includes a bypass passage (19) which allows refrigerant to bypass the higher temperature side compressor (15), a shut-off valve (20) for opening and closing the bypass passage (19), and control means (22) for deactivating the higher temperature side compressor (15) while opening the shut-off valve (20) when an open-air temperature sensed by the open-air thermometric sensor (21) is below the specific temperature.

In another preferred form

~~A measure taken in claim 3 of the present invention is so composed that in claim 1 of the present invention, the~~

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natural circulation means includes a bypass passage (10) which allows refrigerant to bypass the expansion means (9) in the higher temperature refrigeration cycle, a shut-off valve (11) for opening and closing the bypass passage (10), and control means (22) for deactivating the higher temperature side compressor (15) while opening the shut-off valve (11) when an open-air temperature sensed by the open-air thermometric sensor (21) is below the specific temperature.

10

-Operation-

Under the above-mentioned features of the present invention, ~~in the apparatus according to claim 1,~~ when an open-air temperature is high, the higher temperature side compressor (15) is operated. Thereby, refrigerant in the higher temperature side unit (2) is compressed at a high compression ratio, so that the refrigerant is liquefied in the condenser (16) even if the open-air temperature is high. This allows the refrigerant from the higher temperature side unit (2) to heat-exchange, at the cascade condenser (4), with refrigerant in the lower temperature side unit (1).

When an open-air temperature is low, the higher temperature side compressor (15) is deactivated, and refrigerant in the higher temperature side unit (2), whose temperature has risen due to heat exchange at the cascade condenser (4), is heat-exchanged at the condenser (16) with the air due to the low open-air temperature thereby liquefying. In this case, since the higher temperature side unit (2) is at a position higher than a position where the lower

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temperature side unit (1) is, the liquefied refrigerant flows into the evaporation part of the cascade condenser (4) due to gravitation. Then, the liquefied refrigerant is heat-exchanged with refrigerant in the lower temperature side unit (1) thereby evaporating and expanding. The evaporated refrigerant rises to the condenser (16) located at the higher position again. In this manner, natural circulation (circulation by gravitation) of refrigerant is implemented.

first preferred form of the invention.
~~In the apparatus according to claim 2,~~

10 temperature is low, the higher temperature side compressor (15) is deactivated and the bypass passage (19) is opened. Thereby, natural circulation is made in such a manner that refrigerant in the higher temperature side unit (2), whose temperature has risen due to heat exchange at the cascade
15 condenser (4), bypasses the higher temperature side compressor (15) and then flows into the condenser (16). This avoids the higher temperature side compressor (15) from interfering with the flow of the refrigerant during natural circulation, thereby increasing a circulation flow rate of
20 refrigerant.

second preferred form of the invention.

In the ~~apparatus according to claim 3,~~ when an open-air temperature is low, refrigerant circulates in such a manner as to bypass the expansion means (9) in the higher temperature refrigeration cycle, so that flow resistance of refrigerant
25 can be decreased. This provides an advantage of being able to secure a desired circulation flow rate of refrigerant.

-Effects of Invention-

As mentioned so far, in the binary refrigerating apparatus according to ~~claim 1 of~~ the present invention, a higher temperature side unit (2) is disposed at a position higher than a position where a lower temperature side unit (1) is disposed and an open-air thermometric sensor (21) is provided for sensing an open-air temperature. The refrigerating apparatus naturally circulates refrigerant in a higher temperature refrigeration cycle when an open-air temperature sensed by the open-air thermometric sensor (21) is below a specific temperature. Accordingly, this prevents the higher temperature side compressor (15) from being inefficiently operated while eliminating great reduction in cooling performance, thereby resulting in great energy conservation. first preferred form of the apparatus.

15 In the ~~apparatus according to claim 2,~~ means for naturally circulating refrigerant in a higher temperature refrigeration cycle includes a bypass passage (19) which allows refrigerant to bypass the higher temperature side compressor (15), a shut-off valve (20) for opening and closing
20 the bypass passage (19), and control means (22) for deactivating the higher temperature side compressor (15) while opening the shut-off valve (20) when an open-air temperature sensed by the open-air thermometric sensor (21) is below the specific temperature. Accordingly, it is avoided
25 that the higher temperature side compressor (15) interferes with the flow of the refrigerant during natural circulation, thereby increasing a circulation flow rate of refrigerant. This provides an advantage of being able to secure desired

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cooling performance.

~~second preferred form of the apparatus~~

In the ~~apparatus according to claim 2~~, when an open-air

temperature is low, refrigerant circulates in such a manner as to bypass the expansion means (9) in the higher temperature refrigeration cycle. Accordingly, flow resistance of refrigerant can be decreased, so that a natural circulation flow rate of refrigerant can be increased. This provides an advantage of being able to secure desired cooling performance.

10

[Brief Description of Drawings]

Fig. 1 is a refrigerant circuit diagram of a binary refrigerating apparatus showing an embodiment of the present invention.

Fig. 2 is a control flow chart.

15

Fig. 3 is a p-i chart (pressure-enthalpy chart) in a binary refrigeration cycle.

Fig. 4 is a p-i chart in natural circulation.

[Best Mode for Carrying Out the Invention]

20

Below, description is made about an embodiment of the present invention with reference to the drawings.

Fig. 1 shows a refrigerant circuit of a binary refrigerating apparatus. The binary refrigerating apparatus comprises a lower temperature side unit (1) provided with an indoor deep freezer, and a higher temperature side unit (2) disposed on a rooftop. The higher temperature side unit (2) of the present embodiment is disposed at a position 10m higher than a position where the lower temperature side unit (1) is

20 FEB 1998

CLAIMS

1. A binary refrigerating apparatus having:

5 a lower temperature side unit ~~(1)~~ in which a lower temperature side compressor ~~(3)~~, a condensation part of a cascade condenser ~~(4)~~, expansion means ~~(5)~~ and an evaporator ~~(6)~~ are sequentially connected thereby forming a lower temperature refrigeration cycle; and

10 a higher temperature side unit ~~(2)~~ which has a higher temperature side compressor ~~(15)~~ and a condenser ~~(16)~~ for condensing refrigerant by using the air and which is connected to an evaporation part of the cascade condenser ~~(4)~~ through expansion means ~~(9)~~ so that the higher temperature side compressor ~~(15)~~ and the condenser ~~(16)~~ form a higher temperature refrigeration cycle,

the improvement comprising:

said higher temperature side unit ~~(2)~~ being disposed at a position higher than a position where said lower temperature side unit ~~(1)~~ is disposed,

20 an open-air thermometric sensor ~~(21)~~ for sensing an open-air temperature; and

natural circulation means for naturally circulating refrigerant in the higher temperature refrigeration cycle when an open-air temperature sensed by the open-air thermometric sensor ~~(21)~~ is below a specific temperature.

2. A binary refrigerating apparatus according to claim 1, wherein



20 FEB 1998

said natural circulation means includes:

a bypass passage ~~(19)~~ which allows refrigerant to
bypass the higher temperature side compressor ~~(15)~~;

a shut-off valve ~~(20)~~ for opening and closing the
5 bypass passage ~~(19)~~; and

control means ~~(22)~~ for deactivating the higher
temperature side compressor ~~(15)~~ while opening the shut-off
valve ~~(20)~~ when an open-air temperature sensed by the open-air
thermometric sensor ~~(21)~~ is below the specific temperature.

10

3. A binary refrigerating apparatus according to claim 1,
wherein

said natural circulation means includes:

a bypass passage ~~(10)~~ which allows refrigerant to
15 bypass the expansion means ~~(9)~~ in the higher temperature
refrigeration cycle;

a shut-off valve ~~(11)~~ for opening and closing the
bypass passage ~~(10)~~; and

control means ~~(22)~~ for deactivating the higher
20 temperature side compressor ~~(15)~~ while opening the shut-off
valve ~~(11)~~ when an open-air temperature sensed by the open-air
thermometric sensor ~~(21)~~ is below the specific temperature.



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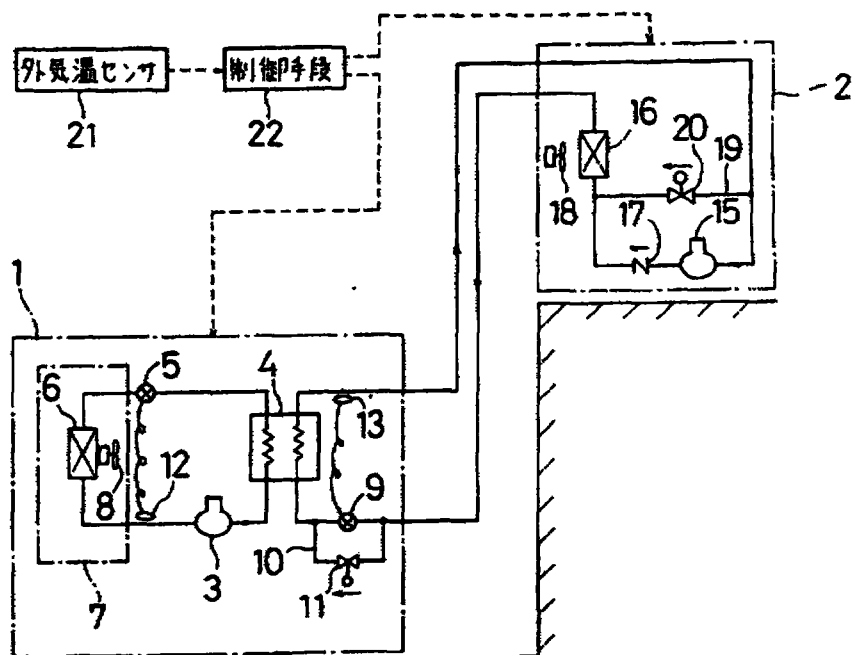
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(21) 国際出願番号 PCT/JP96/00055 (22) 国際出願日 1996年1月12日(12.01.96) (30) 優先権データ 特願平7/3890 1995年1月13日(13.01.95) JP (71) 出願人 (米国を除くすべての指定国について) ダイキン工業株式会社 (DAIKIN INDUSTRIES, LTD.)(JP/JP) 〒530 大阪府大阪市北区中崎西2丁目4番12号 梅田センタービル Osaka, (JP) (72) 発明者：および (75) 発明者／出願人 (米国についてのみ) 上野明敏(UENO, Akitoshi)(JP/JP) 藤本遊二(FUJIMOTO, Yuzo)(JP/JP) 〒591 大阪府堺市金岡町1304番地 ダイキン工業株式会社 堺製作所 金岡工場内 Osaka, (JP) (74) 代理人 弁理士 前田 弘, 外(MAEDA, Hiroshi et al.) 〒550 大阪府大阪市西区靱本町1丁目4番8号 太平ビル Osaka, (JP)		(81) 指定国 CN, NO, SG, US, 欧州特許(AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). 添付書類書類 国際調査報告書

(54) Title : TWO-DIMENSIONAL REFRIGERATING PLANT

(54) 発明の名称 二元冷凍装置

(57) Abstract

A high temperature side unit (2) equipped with a high temperature side compressor (15) and a condenser (16) for constituting a high temperature side refrigeration cycle is disposed at a higher position than a low temperature side unit (1) constituting a low temperature side refrigeration cycle. A bypass passage (19) bypassing the high temperature side compressor (15) is disposed in the high temperature side unit (2), and an open/close valve (20) is disposed in this bypass passage (19). When an outside temperature detected by an outside temperature sensor (21) is low, the operation of the high temperature side compressor (15) is stopped to open the bypass passage (19), and the high temperature side refrigeration cycle allows a refrigerant to naturally circulate.



21 ... external temperature sensor

22 ... control means

(57) 要約

低温側冷凍サイクルを構成する低温側ユニット（１）よりも、高温側冷凍サイクルを構成する高温側圧縮機（１５）及び凝縮器（１６）を備えた高温側ユニット（２）を高位置に設けている。高温側ユニット（２）は、高温側圧縮機（１５）をバイパスするバイパス通路（１９）を設けるとともに、バイパス通路（１９）に開閉弁（２０）を設けている。外気温センサ（２１）によって検出される外気温が低いときには、高温側圧縮機（１５）の運転を停止させてバイパス通路（１９）を開とし、高温側冷凍サイクルは冷媒を自然循環させる。

情報としての用途のみ

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