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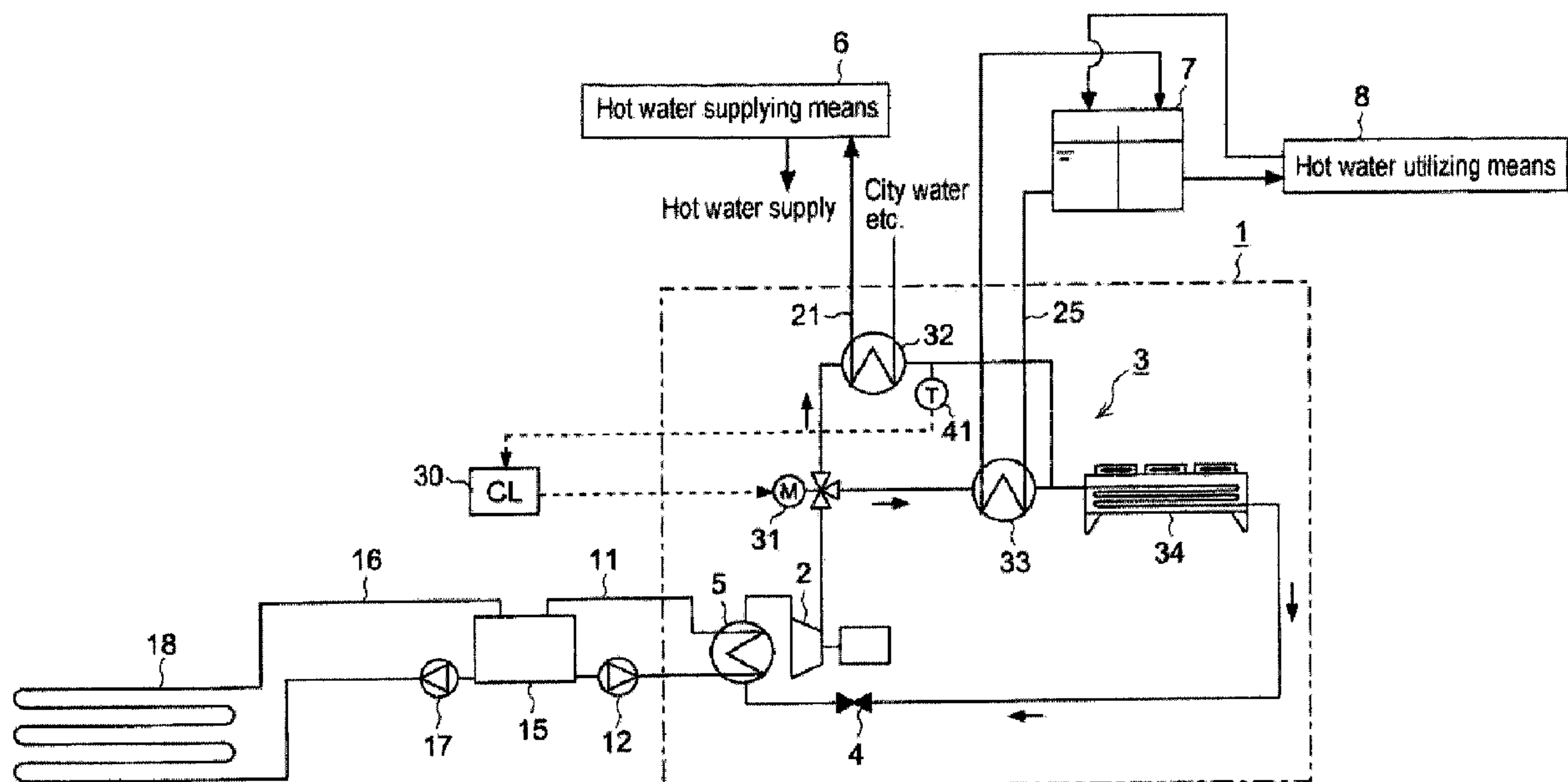
(72) Inventeurs/Inventors:
SASAKI, YASUSHI, JP;
VO, N. T., JP;
PUHACZ, LEN, JP;
INABA, NORIYASU, JP

(73) Propriétaire/Owner:
MAYEKAWA MFG. CO., LTD., JP

(74) Agent: GOWLING WLG (CANADA) LLP

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(54) Title: COOLING-HEATING DEVICE FOR ICE RINK FACILITY



(57) Abrégé/Abstract:

A cooling-heating device for an ice rink facility is described. The device supplies cold heat generated by a heat pump circuit to the ice rink and hot heat generated by the heat pump circuit to the hot heat consuming facilities annexed to the ice rink. The device includes a condensing means including heat exchangers, the heat exchangers being connected to the heat pump circuit in parallel and heating-up low-temperature water by use of condensation heat of CO₂ refrigerant; a three way valve provided at a CO₂ refrigerant branch point on upstream sides of the heat exchangers in the heat pump circuit; and a control device that controls the opening of the three way valve based on the temperature of the CO₂ refrigerant at the outlet of the heat exchangers, so that the control device controls the CO₂ refrigerant flow rate of the CO₂ refrigerant fed into the heat exchangers.



Abstract

A cooling-heating device for an ice rink facility is described. The device supplies cold heat generated by a heat pump circuit to the ice rink and hot heat generated by the heat pump circuit to the hot heat consuming facilities annexed to the ice rink. The device includes a condensing means including heat exchangers, the heat exchangers being connected to the heat pump circuit in parallel and heating-up low-temperature water by use of condensation heat of CO₂ refrigerant; a three way valve provided at a CO₂ refrigerant branch point on upstream sides of the heat exchangers in the heat pump circuit; and a control device that controls the opening of the three way valve based on the temperature of the CO₂ refrigerant at the outlet of the heat exchangers, so that the control device controls the CO₂ refrigerant flow rate of the CO₂ refrigerant fed into the heat exchangers.

COOLING-HEATING DEVICE FOR ICE RINK FACILITY

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a cooling-heating device for an ice rink facility in which the cold generated in a heat pump circuit cools the ice rink and the heat generated by the heat pump circuit supplies heat to the heating facilities annexed to the ice rink.

Background of the Invention

[0002] In the ice rink facility, it is necessary to manufacture ice and maintain the condition of the manufactured ice. The ice temperature level to maintain the ice condition is different from one facility application to another; namely, the appropriate ice-temperature levels are different among the ice link applications such as ice rinks for ice hockey game, figure skating competition, or recreation-use. It is usually necessary to maintain the ice temperature in a range approximately from -1°C to 5°C . Generally, in forming ice and maintaining the formed ice, the refrigerating pipes are constructed under the ice layer of the ice rink so that the ice is formed and the formed ice is maintained; thereby, the cooled brine that is cooled by a refrigeration device in a temperature range approximately from -12°C to -8°C is fed through the refrigerating pipes so that the ice temperature is kept in a range approximately from -5°C to -1°C .

For instance, JP1995-241363 (Patent Reference 1) discloses a technology as described above.

[0003] As described above, the ice rink facility needs the refrigeration device for manufacturing ice and maintaining the condition of the manufactured ice; in addition to the refrigeration device, the ice rink facility needs a hot-water supply system for adjusting the ice condition, melting the ice, heating-up the rink floor and so on. Further, many of skate-rink facilities are provided with annexed facilities such as a warm pool, a library and a community center; and, many of the annexed facilities need heating or hot-water supply.

The heating-cooling device that is generally and currently used is now explained based on Figs. 11 to 13.

[0004] Fig. 11 shows an outline of a general skate-rink.

An annexed facility 62 such as a library is annexed to the skate-rink 51.

In forming an ice layer 52 in the skate-rink 51, a concrete layer 53 is watered; the cooled brine is fed through the cooling pipes 54 for manufacturing ice, the cooling pipes 54 being arranged inside of the concrete layer 53; and, the water is frozen.

Further, inside of a concrete layer 55 that is located at the lower side of the concrete layer 53, a plurality of rink underside heating pipes 56 is arranged; by feeding the warm brine through the rink underside heating pipes 56, the water content included in the soil beneath the concrete layer 55 is prevented from being frozen.

Further, the surface of the rink ice is damaged by the blades of the skaters' boots so that hollows or grooves are formed on the ice surface; in order to recover the ice surface condition, a vehicle 58 for adjusting the rink ice condition flattens the surface ice so as to remove the formed hollows or grooves; then, the vehicle 58 sprinkles water on the flattened ice surface so as to manufacture the new ice surface. In sprinkling water on the ice surface, since the

damaged upper-layer of ice is melted, hot-water of approximately 70°C is used. The ice shaved (i.e. removed) by the vehicle 58 is transported to an ice melting pit 59 where hot-water of approximately 40 to 50°C melts the transported ice.

Further, warm air is obtained by performing heat exchange between the hot-water of approximately 40 to 50°C and the air; the skate-rink is provided with a heating device 60 that heats the inside of the skate rink by use of the warm air and a floor heating device 64 that performs floor heating by use of the hot-water fed through the pipes arranged beneath the spectator seats 61.

Moreover, the annexed facility 62 is provided with a shower 63 and a wash room 65 ; the hot-water is supplied to the shower 63 and the wash room 65.

It is hereby noted that the term “hot water” means the water whose temperature is higher than the ordinary temperature (15-25°C) in this specification. Further, the term “cold heat” is used as a synonym for “cold” and the term “hot heat” is used as an antonym for the “cold heat” in this specification.

[0005] As explained above, a general skate-rink is provided with heating demand (heat sinks) and cooling demand (cold sink), as depicted in Fig. 11. Fig. 12 summarizes the heat sinks and the cold sink, as well as, the heat sources and the cold source; Fig. 12 shows an example regarding what demand the high-temperature-water, the medium-temperature-water and the cooled brine are used for. For instance, the hot-temperature-water of 70°C to 80°C is used for the vehicle 58, the shower 63 and the wash room 65; the medium- temperature-water of 40°C to 50°C is used for the rink underside heating pipes 56, the ice melting pit 59, the heating device 60 and the floor heating device 64. Further, the cooled brine is used for cooling

the brine streaming through the cooling pipe 54.

[0006] Fig. 13 shows an example of a conventional system that produces high- temperature water, the medium-temperature water and the cooled brine.

In Fig. 13, a brine chiller 120 that is used for manufacturing the skate- rink ice and maintaining the ice condition is provided with a compressor 121, an electric motor 122 for driving the compressor, a vaporizing type condenser 123, a liquid receiver 124, an expansion valve 125 and an evaporator 126; thus, the brine chiller 120 forms a general refrigerating cycle. The secondary refrigerant that is accumulated in a brine tank 128 and fed to the brine chiller side in a liquid state is cooled by the evaporator 126; then, the cooled brine is returned to the brine tank 128. Further, the secondary refrigerant that has cooled and returned to the brine tank 128 is fed to the cooling pipe 54, so as to freeze the sprinkled water and cool the frozen ice.

[0007] On the other hand, a system for producing the hot water to be supplied to the annexed facilities requiring the hot water is provided with a hot water boiler 150, a primary hot water pump 151, a heat exchanger 155 for generating the medium temperature water, a heat exchanger 156 for generating the high temperature water, and a secondary hot water pump 154. The high temperature water higher than 90°C that is produced by the hot water boiler 150 is fed to the heat exchanger 155 for generating the medium temperature water and the heat exchanger 156 for generating the high temperature water, by use of the primary hot water pump 151.

In the heat exchanger 155 for generating the medium temperature, the high temperature

water higher than 90°C that is produced by the hot water boiler 150 heats up water so as to generate the medium-temperature water in a temperature range approximately from 40°C to 50°C; the secondary hot water pump 154 feeds the medium-temperature water to the rink underside heating pipe 56, the ice melting pit 59 and the heating device 60. Thereby, the heat sinks such as the rink underside heating pipe 56, the ice melting pit 59 and the heating device 60 need the medium-temperature water. The medium temperature water supplies the heat to the heat sinks; then, the temperature of the medium temperature water is reduced. The medium temperature water of the reduced temperature returns to the heat exchanger 155 for generating the medium temperature; in the heat exchanger 155, the medium temperature water of the reduced temperature is again heated up and fed to the heat sinks.

Further, in the heat exchanger 156 for generating the high temperature water, the city water supplied to the heat exchanger 156 is heated up so as to generate the high-temperature water in a temperature range approximately from 70°C to 80°C; the generated high-temperature water is fed to the locations such as the shower 63, the wash room 65 and the vehicle 58, the location needing the high-temperature water.

[0008] Incidentally, the needs of nowadays strongly requires the countermeasures against the depletion of the ozone layer as well as against global warming, in addition to the measures for enhancing energy efficiency; accordingly, it is a pressing need that the skate-rink facility uses the refrigerant other than chlorofluorocarbons; in addition, it is a pressing need that the hydro fluorocarbon (HFC) as an alternate refrigerant is efficiently recovered, and the energy efficiency of the cooling-heating device for an ice rink facility is enhanced.

Thus, in order to provide the countermeasures against the depletion of the ozone layer

as well as against global warming, as well as, in order to enhance the energy efficiency, it is considered to make use of the natural refrigerant such as ammonia, hydrocarbon, air and carbon dioxide (CO₂); in addition, it is considered to use the heat pump that makes full use of the heat dissipated from the refrigeration system.

[0009] On the other hand, in many of the refrigeration system of the skate-rinks, the ammonia refrigerant is made use of; thereby, since the temperature of the ammonia refrigerant is increased according to the ammonia properties when the ammonia refrigerant is compressed, the lubricating oil used for the compressor tends to be carbonized. Due to this carbonization, the risk of the compressor troubles may become higher. Further, in view of heat utilization, since the ammonia refrigerant is condensed in a condenser, the quantity of the usefully utilized heat is limited by the condensation temperature. In this way, using the ammonia refrigerant for the heat pump is not so widespread.

Further, utilizing a heat pump that makes use of an alternative refrigerant HFC, for instance, the refrigerant HFC404A instead of the ammonia refrigerant may emerge from the above-described background; however, the global warming potential of the refrigerant HFC404A is so high that, in a sense, the heat pump making use of the refrigerant HFC404A runs counter to the trend of the global warming gas reduction.

[0010] Hence, Patent Reference 2 (CA2599768) discloses a device for manufacturing ice for a skate-rink and maintaining the condition of the manufactured ice, the device making use of a natural refrigerant as a cooling medium. The device for manufacturing ice and maintaining the condition of the manufactured ice is provided with a heat pump that configures a

refrigeration cycle in which CO₂ refrigerant is used as the cooling medium. Thereby, the brine cooled by the heat pump cools the skate-rink, whereas the heat of the brine taken into the heat pump becomes the heat source to produce hot water. Further, the device is provided with a plurality of heat exchangers that are arranged in series on the delivery side of the compression means in the heat pump; thus, each heat exchanger can produce the hot water of a temperature range in response to each heat exchanger.

[0011] Further, in relation to the above-described technology, Patent Reference 3 (CA2724255) discloses a CO₂ refrigeration system for an ice rink. In the disclosed system, the brine is cooled by a refrigeration cycle in which CO₂ refrigerant is circulated; by use of the cooled brine, the ice rink is cooled. Further, the hot heat that is recovered by the refrigeration cycle is supplied to at least one heating apparatus annexed to the ice rink facility. In the configuration to use the hot heat, a heat exchanger and a heating apparatus are arranged in parallel to a gas cooler so that the CO₂ supply rates toward these components are controlled by use of a plurality of valves; thus, the hot heat supply rates are regulated.

[0012] [References] [Patent References]

[0013] Patent Reference 1: JP1995-241363

Patent Reference 2: CA2599769

Patent Reference 3: CA2724255

SUMMARY OF THE INVENTION

Subjects to be solved

[0014] According to Patent Reference 2 referred above, the CO₂ refrigerant to transfer cold heat to the skate-rink is used as a cooling medium; thus, the cooling medium can be easily placed in a supercritical state in the heat cycle, and the hot water whose temperature is not less than 70°C can be obtained. In this way, the cold heat and the hot heat can be effectively used. However, in producing hot water, a plurality of heat exchangers is arranged in series; and, it is difficult to maintain the heat recovery ratio at a high level.

On the other hand, according to Patent Reference 3, the heat exchanger and the heating apparatus are connected to the refrigeration device forming the refrigeration device; and, in order to make effective use of the hot heat (i.e. in order to enhance use efficiency regarding the hot heat), the supply rates (i.e. the flow rates) regarding the CO₂ refrigerant to be transferred to these components are controlled by use of a plurality of valves. However, Patent Reference 3 does not disclose what control is concretely performed in order to enhance use efficiency regarding the hot heat. Actually, Patent Reference 3 does not establish an operation control technology to enhance use efficiency regarding the hot heat.

Hence, in view of the subjects to be solved in the conventional technologies, the present invention aims at providing a cooling-heating device that can enhance the recovery ratio of the recovered hot heat to the generated heat generated by the heat pump.

Means to solve the Subjects

[0015] In order to solve the above-described subjects, the present invention discloses a cooling-heating device for an ice rink facility, the device including, but not limited to, a heat pump circuit with a refrigerant line, the heat pump circuit including, but not limited to: a condensing means, an expansion valve, and an evaporating means so as to circulate CO₂

refrigerant through the compression means, the condensing means, the expansion valve, and the evaporating means,

wherein

the cooling-heating device supplies the cold heat generated by the heat pump circuit to the ice rink as well as supplies the hot heat generated by the heat pump circuit to the hot heat consuming facilities annexed to the ice rink,

wherein

the cooling-heating device includes, but not limited to:

the condensing means that includes, but not limited to, a first heat exchanger and a second heat exchanger, the heat exchangers being connected to the heat pump circuit in parallel and heating-up low-temperature water by use of the condensation heat of the CO₂ refrigerant;

a three way valve that is provided at a CO₂ refrigerant branch point on the upstream sides of the first and second heat exchangers in the refrigerant line so that the three way valve controls the flow rate of the CO₂ refrigerant;

a first hot water circuit that is connected to the first heat exchanger and a second hot water circuit that is connected to the second heat exchanger;

at least one cold brine circuits that is connected to the evaporating means;

a temperature detecting means that detects the temperature of the CO₂ refrigerant on the outlet side of the one of the heat exchangers when the temperature of the low-temperature water on the inlet side of the one of the heat exchanger is lower than the temperature of the low-temperature water on the inlet side of the other heat exchanger;

a control device that controls the opening of the three way valve based on the CO₂

refrigerant temperature detected by the temperature detecting means so that the control device controls the flow rate of the CO₂ refrigerant fed into the first heat exchanger as well as the second heat exchanger.

[0016] According to the present invention, the first and second heat exchangers are integrated into the heat pump circuit in parallel; thus, the recovery rate regarding the hot heat produced by the heat pump can be enhanced. Thereby, in the case where the two heat exchangers are connected to the heat pump circuit as described above, when the temperature of the low-temperature water fed into the one of the heat exchanger is different from the temperature of the low-temperature water fed into the other heat exchanger, the heat cycle efficiency regarding the heat pump circuit fluctuates in response to the flow rates of the low-temperature water fed into the heat exchangers. Hence, by controlling the opening of the three way valve based on the temperature of the CO₂ refrigerant at the outlet side of each heat exchangers, as well as, by providing the control device that controls the flow rate of the low-temperature water streaming through each heat exchanger, the heat cycle efficiency regarding the heat pump circuit can be maintained at a high level. To be more specific, the control device can control the temperature of the CO₂ refrigerant at the refrigerant confluence point on the downstream side of the first heat exchanger as well as the second heat exchanger so that the CO₂ refrigerant temperature at the refrigerant confluence point is lower as far as possible. The lower the CO₂ refrigerant temperature at the refrigerant confluence point, the higher the heat recovery rate regarding the hot heat at the first heat exchanger as well as the second heat exchanger. In this way, the heat cycle efficiency of the heat pump cycle that the heat pump circuit forms can be enhanced.

Thereby, the opening of the three way valve is controlled based on the temperature of the CO₂ refrigerant at the outlet side of one of the heat exchangers, the one of the heat exchangers being determined so that the temperature of the low-temperature water fed into the one of the heat exchangers is lower than the temperature of the low-temperature water fed into the other heat exchanger; in this way, the hot heat of the CO₂ refrigerant can be appropriately and effectively transferred to the low-temperature water streaming through the one of the heat exchangers that is determined so that the temperature of the low-temperature water fed into the one of the heat exchangers is lower than the temperature of the low-temperature water fed into the other heat exchanger.

In this way, the hot heat of the CO₂ refrigerant can be appropriately transferred to the low-temperature water streaming through the one of the heat exchangers that is determined so that the temperature of the low-temperature water fed into the one of the heat exchangers is lower than the temperature of the low-temperature water fed into the other heat exchanger.

Further, according to the present invention, the CO₂ refrigerant is used as a cooling medium of the heat pump circuit; accordingly, the heat cycle of the cooling medium can easily pass through an area of the supercritical state of the medium; thus, the heat exchanger temperature difference between the heat pump circuit and the to-be-heated-up water circuit as well as between the heat pump circuit and the to-be-cooled cold brine circuit can be easily increased. Thus, the efficiency of the heat transfer can be enhanced.

[0017] A preferable embodiment of the present invention is the cooling-heating device for an ice rink facility,

wherein

the first hot water circuit that is connected to at least one hot water supplying means that supplies hot water to the hot heat consuming facilities; and,

the second hot water circuit that is connected to at least one hot water utilizing means so as to circulate the hot water and supply the heat of the hot water to the hot heat consuming facilities via indirect heat exchange.

In general, city water or well water is used for a hot water supplying means (or a hot water consuming means at the same time); on the other hand, the water that is once stored in a water tank is circulated through a hot water utilizing means. Accordingly, there is a temperature difference between the temperature of the low-temperature water fed into the first heat exchanger and the temperature of the low-temperature water fed into the second heat exchanger; by controlling the flow rate of the CO₂ refrigerant to be fed into each heat exchanger based on the temperatures as described above, the temperature of the CO₂ refrigerant at the confluence point in the heat pump circuit can be further reduced. Thus, the heat cycle efficiency can be enhanced.

[0018] Another preferable embodiment of the present invention is the cooling- heating device for an ice rink facility,

wherein

the cooling-heating device includes, but not limited to, a spare heat exchanger on the downstream side of the first heat exchanger as well as the second heat exchanger in the heat pump circuit; and,

wherein

the water that is preliminarily heated-up by the spare heat exchanger is fed into the first

heat exchanger through the first hot water circuit, and

the first hot water fed into the first heat exchanger is heated-up therein so that hot water is produced.

As described above, the first heat exchanger produces the hot water by heating the water that is preliminarily heated-up in the spare heat exchanger; accordingly, the heat recovery rate can be enhanced, and the cooling capacity of the heat pump can be increased.

[0019] Another preferable embodiment of the present invention is the cooling- heating device for an ice rink facility,

wherein

the cooling-heating device includes, but not limited to, a gas cooler provided on the downstream side of the first heat exchanger as well as the second heat exchanger in the heat pump circuit, the gas cooler being arranged in series with the first heat exchanger as well as the second heat exchanger.

As described above, by providing the gas cooler so that the gas cooler is arranged in the heat pump circuit in series with the first heat exchanger as well as the second heat exchanger, the recovery rate of the hot heat and the cooling capacity for cooling the ice rink can be enhanced.

[0020] Another preferable embodiment of the present invention is the cooling- heating device for an ice rink facility, the cooling- heating device including, but not limited to:

a temperature detecting means that detects the temperature of the refrigerant at the inlet side of the gas cooler;

a temperature detecting means that detects the temperature of the refrigerant at the outlet side of the gas cooler; and,

a controller in which the temperatures detected by the temperature detecting means are inputted,

wherein

the controller controls the delivery pressure of the compression means in the heat pump circuit based on the difference between the temperature at the inlet side of the gas cooler and the temperature at the outlet side of the gas cooler so that the operation of the heat pump formed by the heat pump circuit can be changed-over from the trans-critical operation mode to the subcritical operation mode and vice versa, the trans-critical operation mode being an operation mode in which the heat pump cycle of the CO₂ refrigerant passes through the range of the super-critical state regarding the CO₂ refrigerant, whereas the subcritical operation mode is an operation mode in which the heat pump cycle of the CO₂ refrigerant does not pass through the range of the super-critical state regarding the CO₂ refrigerant.

[0021] According to the configuration as described above, the operation of the heat pump (circuit) can be changed-over from the trans-critical operation mode to the subcritical operation mode and vice versa, based on the difference between the temperature of the CO₂ refrigerant on the inlet side of the gas cooler and the temperature of the CO₂ refrigerant on the outlet side of the gas cooler. In other words, the operation mode is changed over from one mode to the other mode in response to the heating demand at the heat exchangers. For instance, when the heating demand is low, the subcritical operation mode where the delivery pressure of the compression means is low is adopted; when the heating demand is high, the

trans-critical operation mode where the delivery pressure of the compression means is high is adopted. In this way, the power for driving the compression means can be reduced in comparison with the case where the trans-critical operation mode is always adopted. Thus, energy saving can be achieved.

[0022] Another preferable embodiment of the present invention is the cooling- heating device including, but not limited to:

a first temperature detecting means that detects the temperature of the low-temperature water at the inlet side of the first heat exchanger; and,

a second temperature detecting means that detects the temperature of the low-temperature water at the inlet side of the second heat exchanger,

wherein

the controller compares a first detected temperature detected by the first temperature detecting means with a second detected temperature detected by the second temperature detecting means so that the CO₂ refrigerant is fed preferentially to the second heat exchanger, in a case where the first detected temperature is higher than the second detected temperature; and,

the controller compares a first detected temperature detected by the first temperature detecting means with a second detected temperature detected by the second temperature detecting means so that the CO₂ refrigerant is fed preferentially to the first heat exchanger, in a case where the second detected temperature is higher than the first detected temperature.

As described above, the temperature of the CO₂ refrigerant at the CO₂ refrigerant confluence point can be surely reduced, regardless of the temperature levels regarding the

low-temperature water fed into the first heat exchanger or the second heat exchanger; thus, the heat cycle efficiency regarding the heat pump circuit can be enhanced.

Effects of the Invention

[0023] According to the present invention as described above, the first and second heat exchangers are integrated into the heat pump circuit in parallel; thus, the recovery rate regarding the hot heat produced by the heat pump can be enhanced. Further, in the present invention, the opening of the three way valve is controlled based on the temperature of the CO₂ refrigerant at the outlet side of one of the heat exchangers, so that the CO₂ refrigerant flow rate of the CO₂ refrigerant fed into the first heat exchanger as well as the second heat exchanger is controlled. On the basis of the above-described configuration, the temperature of the CO₂ refrigerant at the refrigerant confluence point on the downstream side of the first heat exchanger as well as the second heat exchanger is controlled so that the CO₂ refrigerant temperature at the refrigerant confluence point is lower as far as possible. The lower the CO₂ refrigerant temperature at the refrigerant confluence point, the higher the heat recovery rate regarding the hot heat at the first heat exchanger as well as the second heat exchanger.

Thereby, the opening of the three way valve is controlled based on the temperature of the CO₂ refrigerant at the outlet side of one of the heat exchangers, the one of the heat exchangers being determined so that the temperature of the low-temperature water fed into the one of the heat exchangers is lower than the temperature of the low-temperature water fed into the other heat exchanger; in this way, the hot heat of the CO₂ refrigerant can be appropriately and effectively transferred to the low-temperature water streaming through the one of the heat exchangers that is determined so that the temperature of the low-temperature water fed into

the one of the heat exchangers is lower than the temperature of the low-temperature water fed into the other heat exchanger.

In this way, the hot heat of the CO₂ refrigerant can be appropriately transferred to the low-temperature water streaming through the one of the heat exchangers that is determined so that the temperature of the low-temperature water fed into the one of the heat exchangers is lower than the temperature of the low-temperature water fed into the other heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The present invention will now be described in greater detail with reference to the modes of the present invention, the preferred embodiments of the present invention and the accompanying drawings, wherein:

Fig. 1 shows the configuration of a cooling-heating device according to a first mode of the present invention;

Fig. 2 shows the variables (state variables) regarding the periphery of the heat exchangers in the first mode of the present invention, the variables being represented with specific numerical examples;

Fig. 3 shows a Mollier chart in which a heat cycle process, namely, the change of state regarding the refrigerant used for a heat pump according the first mode of the present invention is depicted;

Fig. 4 shows how a heat cycle process changes in the Mollier chart, when an operation mode of the heat pump is changed into another operation mode of the heat pump in the first mode of the present invention;

Fig. 5 shows the configuration of a cooling-heating device according to a second

mode of the present invention;

Fig. 6 shows the variables regarding the periphery of a spare heater in the second mode of the present invention, the variables being represented with specific numerical examples;

Fig. 7 shows a Mollier chart in which a heat cycle process, namely, the change of state regarding the refrigerant used for a heat pump according the second mode of the present invention is depicted;

Fig. 8 shows the variables regarding the periphery of the heat exchangers in a comparison example, the variables being represented with specific numerical examples;

Fig. 9 shows a Mollier chart in which a heat cycle process, namely, the change of state regarding the refrigerant used for a heat pump in the comparison example is depicted;

Fig. 10 shows the configuration of a cooling-heating device according to a third mode of the present invention; and, Fig. 10 shows the variables regarding the periphery of the heat exchangers in the third mode of the present invention, the variables being represented with specific numerical examples;

Fig. 11 shows an outline of a general skate-rink;

Fig. 12 explains how the high-temperature water, the intermediate- temperature water and the cooled brine are used for the heat demand or the cold demand in a general ice rink;

Fig. 13 shows an example of a conventional system that produces high- temperature water, the medium-temperature water and the cooled brine.

DETAILED DESCRIPTION OF THE MODES AND THE PREFERRED EMBODIMENTS

[0025] Hereafter, the present invention will be described in detail with reference to the

modes or embodiments shown in the figures. However, the dimensions, materials, shape, the relative placement and so on of a component described in these modes or embodiments shall not be construed as limiting the scope of the invention thereto, unless especially specific mention is made.

(First Mode)

[0026] On the basis of Fig. 1, the configuration of a cooling-heating device for an ice rink facility is now explained, according to a first mode of the present invention.

This cooling-heating device supplies the cold heat to the ice rink, and the hot heat to the heating-warming devices that are annexed to the ice rink; the main components (hereby, the main circuits) of the heating-cooling device are a heat pump circuit 1, a first cold brine circuit 11, a second brine circuit 16, a hot water circuit 21 as a first hot water circuit for supplying hot water, and a hot water circuit 25 as a second hot water circuit for circulating hot water.

[0027] The heat pump circuit includes, but not limited to, a CO₂ refrigerant which is a natural cooling medium that circulates in the heat pump circuit, a compressor 2 as a compressing means, a condensing means 3, an expansion valve 4 and an evaporator 5 as an evaporating means.

The compressor 2 is driven by an electric motor and compresses the CO₂ refrigerant. Incidentally, the flow rate of the CO₂ refrigerant delivered from the compressor 2 is to be variable in response to the speed of the electric motor.

The condensing means 3 indirectly (i.e. without mixing) performs the heat exchange between the CO₂ refrigerant compressed by the compressor 2 and a warm brine such as low

temperature water, so that the warm brine is heated up via the heat exchange. The concrete configuration regarding the condensing means 3 is described later.

The expansion valve 4 is provided between the condensing means 3 and the evaporator 5; the CO₂ refrigerant is cooled in the condensing means 3, and the temperature of the CO₂ refrigerant is reduced; the CO₂ refrigerant of the reduced temperature is depressurized through the expansion valve 4.

In the evaporator 5, the heat exchange between the CO₂ refrigerant and the cooled brine is indirectly performed so that the brine is cooled. In other words, the cold brine absorbs the heat from the water or ice of the ice rink, and the absorbed heat vaporizes the CO₂ refrigerant.

Incidentally, in this mode of the invention, the example of the brine is a liquid refrigerant such as ethylene glycol water and propylene glycol water.

[0028] In the heat pump circuit 1 of the above-described configuration, the CO₂ refrigerant compressed by the compressor 2 is transferred to the condensing means 3, where the heat exchange between the CO₂ refrigerant and the warm brine is performed; and, the brine is heated up and the CO₂ refrigerant is cooled so that the temperature of the CO₂ refrigerant is reduced. Further, the cooled CO₂ refrigerant is depressurized in the expansion valve 4 and enters the evaporator 5. In the evaporator 5, the CO₂ refrigerant cools the brine and the CO₂ refrigerant itself is heated up.

[0029] On the other hand, the brine cooled in the evaporator 5 circulates through the first cold brine circuit 11 and the second brine circuit 16; the cold heat produced in the heat pump circuit is supplied to the ice rink via the cooled brine. To be more concretely, the cold brine

cooled by the evaporator 5 circulates in the first cold brine circuit 11 by use of a first brine pump 12 so as to return to a brine tank 15. The cold brine that has been cooled and returned to the brine tank 15 is transferred to the cooling pipe 18 by a second brine pump 17. The cooling pipe 18 is constructed at the bottom part of the ice rink; in manufacturing the rink ice, water is sprinkled over the cooling pipe, and the cold brine transferred to the cooling pipe 18 freezes the sprinkled water or cools the manufactured ice. In addition, the heat recovered by cold brine at the cooling pipe 18 is transferred to the evaporator 5, where the heat conveyed via the brine is transferred to the CO₂ refrigerant.

[0030] In the next place, the above-described condensing means 3 is concretely explained.

In this mode of the invention, the condensing means 3 includes, but not limited to: a heat exchanger 32 as a first heat exchanger for supplying hot water and a heat exchanger 33 as a second heat exchanger for circulating hot water, the heat exchanger 32 and the heat exchanger 33 being integrated into the line of the heat pump circuit 1, in parallel. The temperature of the (low-temperature) water fed into the heat exchanger 32 is different from the temperature of the (low-temperature) water fed into the heat exchanger 33.

In the heat pump circuit 1 that is provided with the heat exchanger 32 and the heat exchanger 33 in parallel, a three way valve 31 is arranged at the branch point where the heat pump circuit route (refrigerant passage route) is branched, the branch point being on the upstream side of the heat exchanger 32 as well as the heat exchanger 33. The three way valve 31 is configured so that the flow rates of the CO₂ refrigerant streaming the heat exchangers 32 and 33 are controlled; and, for instance, a servo valve of a proportionally activated type or a solenoid valve of a proportionally activated type is used as the three way valve. By use of this

three way valve 31, the flow rate of the CO₂ refrigerant fed to the heat exchanger 32 as well as the heat exchanger 33 is controlled. A controller 30 controls the opening of the three way valve 31.

[0031] The heat exchanger 32 for supplying hot water is connected to the hot water circuit 21 for supplying hot water; a low-temperature water fed into the hot water circuit 21 for supplying hot water is heated up by the condensation heat of the CO₂ refrigerant. Hereby, the low temperature water fed into the heat exchanger 32 for supplying hot water is, for instance, city water or well water. Further, the hot water circuit 21 for supplying hot water is connected to a hot water supplying means 6. Thus, the low temperature water fed into the heat exchanger 32 for supplying hot water is heated up thereby; then, the heated-up low-temperature water is supplied to the hot water supplying means 6 through the hot water circuit 21 for supplying hot water so as to be used as the hot water. Incidentally, the examples of the hot water supplying means 6 are a hot water supplying device for a warm pool, a faucet, a hot-water shower and so on. Hereby, the temperature of the hot water to be supplied is preferably not less than 70°C.

[0032] The heat exchanger 33 for circulating hot water is connected to the hot water circuit 25 for circulating hot water; a low-temperature water fed into the hot water circuit 25 for circulating hot water is heated up by the condensation heat of the CO₂ refrigerant. Hereby, the low temperature water fed into the heat exchanger 33 for circulating hot water is the water stored in a hot water tank 7. The low temperature water fed into the heat exchanger 33 for circulating hot water is heated-up thereby; then, the heated-up low-temperature water is returned to the hot water tank 7 through the hot water circuit 25 for circulating hot water.

Thus, the temperature of the hot water in the hot water tank 7 increases. Further, the hot water is conveyed to a hot water utilizing means 8 so as to transfer the hot heat to the hot water utilizing means 8 via the indirect heat exchange; then, the warm water is returned to the hot water tank 7. Incidentally, the examples of the hot water utilizing means 8 are a spectator stand, a library annexed to the ice rink, an indoor heating device for a public facility such as a community center, a heating device for heating soil, a device for melting ice and so on.

[0033] Further, a gas cooler 34 may be provided on the downstream side of the heat exchanger 32 for supplying hot water as well as the heat exchanger 33 for circulating hot water, in the heat pump circuit 1. The CO₂ refrigerant is indirectly cooled by the air that circulates inside of the gas cooler 34.

The controller 30 controls the opening of the three way valve 31 based on the temperature on the CO₂ refrigerant outlet side of one of the heat exchangers 32 and 33; thereby, the heat exchanger 32 for supplying hot water is selected out of the heat exchangers 32 and 33 in a case where the inlet side temperature of the low temperature water in the heat exchangers 32 is lower than the inlet side temperature of the low temperature water in the heat exchangers 33, whereas the heat exchanger 33 for circulating hot water is selected out of the heat exchangers 32 and 33 in a case where the inlet side temperature of the low temperature water in the heat exchangers 33 is lower than the inlet side temperature of the low temperature water in the heat exchangers 32. Thus, the opening of the three way valve 31 is controlled so that the flow rate of the CO₂ refrigerant fed to the heat exchanger 32 for supplying hot water as well as the heat exchanger 33 for circulating hot water is controlled. As shown in Fig. 1, it is preferable that a temperature detecting means 41 is provided so as to detect the temperature

of the CO₂ refrigerant on the outlet side of the h heat exchanger 32 for supplying hot water; and, the controller 30 may control the opening of the three way valve 31 on the basis of the CO₂ refrigerant temperature detected by the temperature detecting means 7. The reason of the above-described control manner is as follows.

City water or well water is usually used in the heat exchanger 32 for supplying hot water; the temperature of the city water or the well water is usually in the normal temperature range. On the other hand, the water stored in the hot water tank 7 circulates through the heat exchanger 33 for circulating hot water; the temperature of the circulating water is higher than the normal temperature. Accordingly, it is the heat exchanger 32 for supplying hot water that is more frequently supplied with the low temperature water whose temperature is lower than the temperature of the low temperature water circulating through the heat exchanger 33 for circulating hot water. However, the temperature of the low temperature water circulating through the heat exchanger 33 for circulating hot water sometimes lower than the temperature of the low temperature water fed into the heat exchanger 32 for supplying hot water. In these events, a temperature detecting means may be provided with each of the heat exchangers, as described later.

[0034] Fig. 2 shows the variables regarding the periphery of the heat exchangers in this first mode of the present invention, the variables being represented with specific numerical examples. Incidentally, the numerical values described in the drawings are only preferable examples. This cooling-heating device produces the hot water whose temperature is not less than 70°C, by use of the heat exchanger 32 for supplying hot water; and, the cooling- heating device recovers the remaining to-be-recovered heat , by use of the heat exchanger 33 for

circulating hot water so as to produce the hot water to be circulated and utilized.

As described above, in the heat pump circuit 1, the heat exchanger 32 for supplying hot water and the heat exchanger 33 for circulating hot water are arranged in parallel; the three way valve 31b is provided at the branch point on the upstream side of the heat exchangers. The controller 30 controls the opening of the three way valve 31. Further, the temperature (signal) regarding the CO₂ refrigerant at the downstream side of the heat exchanger 32 for supplying hot water is inputted into the controller 30; based on the refrigerant temperature, the opening of the three way valve 31 is controlled; the temperature regarding the CO₂ refrigerant at the downstream side of the heat exchanger 32 for supplying hot water is detected by the temperature detecting means 41.

[0035] As shown in Fig. 2, for instance, in a case where the temperature of the CO₂ refrigerant fed from the compressor 2 is 110°C and the flow rate of the CO₂ refrigerant is 4000 kg/h, the CO₂ refrigerant of the flow rate 996 kg/h is fed into the heat exchanger 32 for supplying hot water via the three way valve, and the CO₂ refrigerant of the flow rate 3004 kg/h is fed into the heat exchanger 33 for circulating hot water. Thereby, the exchanged heat flow rate at the heat exchanger 32 for supplying hot water is 80.9 kW, and the exchanged heat flow rate at the heat exchanger 33 for circulating hot water is 103 kW. The city water of the temperature 13°C and the flow rate 20 L/min is fed to the heat exchanger 32 for supplying hot water; in the heat exchanger 32, the heat exchange is performed between the water and the CO₂ refrigerant so that the hot water of the temperature 71°C is produced so as to be delivered to the hot water supplying means 6. On the other hand, the hot water of the temperature 39°C and the flow rate 246.2 L/min is fed to the heat exchanger 33 for circulating hot water, from

the hot water tank 7; in the heat exchanger 33, the heat exchange is performed between the water and the CO₂ refrigerant so that the hot water of the temperature 45°C is produced. The produced hot water is returned to the hot water tank 7 and the hot water in the hot water tank 7 is appropriately transferred to the hot water utilizing means 8.

[0036] Fig. 3 shows a Mollier chart in which a heat cycle process, namely, the change of state regarding the refrigerant used for the heat pump according the first mode of the invention is depicted. As shown in Fig. 3, the temperature of the CO₂ refrigerant is increased to the temperature at the point e1 (a state point) by the compressor 2; while the state of the CO₂ refrigerant moves from the point e1 to the point f1, a part of the heat included in the CO₂ refrigerant is recovered by the heat exchanger 33 for circulating hot water. Further, while the state of the CO₂ refrigerant moves from the point e1 to the point g1, a part of the heat included in the CO₂ refrigerant is recovered by the heat exchanger 32 for supplying hot water.

Further, a part of the heat included in the CO₂ refrigerant at the point h1 (the confluence point regarding the refrigerant flow) is released into the atmosphere via the gas cooler 34 arranged at the downstream side of the heat exchanger 32 as well as the heat exchanger 33, while the state of the CO₂ refrigerant changes from the point h1 to the point i1.

In relation to the above-described context, in the Mollier chart of Fig. 3, the confluence point h1 regarding the flow of the CO₂ refrigerant passing through the heat exchanger 32 for supplying hot water and the flow of the CO₂ refrigerant passing through the heat exchanger 33 for circulating hot water is located between the point f1 and the point g1; and, the location (i.e. the condition of the CO₂ refrigerant) of the point h1 depends on the opening of the three way valve 31. Thereby, when the opening of the three way valve 31 is set so as to feed the CO₂

refrigerant preferentially to the heat exchanger whose low-temperature-water inlet temperature is lower (i.e. to the heat exchanger 32 in this case), the point h1 gets closer to the point g1. As a result, the heat released at the gas cooler 34 is reduced, and the thermal efficiency of the heat cycle which the heat pump circuit forms can be enhanced.

[0037] As described above, according to this mode of the invention, the heat exchanger 32 for supplying hot water and the heat exchanger 33 for circulating hot water are arranged in parallel in the heat pump circuit 1; thus, the hot heat recovery ratio (efficiency percentage) regarding the hot water produced by the heat pump circuit can be enhanced. Hereby, in arranging the heat exchanger 32 for supplying hot water and the heat exchanger 33 for circulating hot water in parallel in the heat pump circuit 1, when there is a difference between the inlet temperature of the low-temperature water streaming through the heat exchanger 32 and the inlet temperature of the low-temperature water streaming through the heat exchanger 33, the thermal efficiency of the heat pump cycle (which the heat pump circuit 1 forms) fluctuates in response to the flow rate of the low-temperature water streaming through the heat exchanger 32 as well as the flow rate of the low-temperature water streaming through the heat exchanger 33. In order to overcome this difficulty, the opening of the three way valve 31 is controlled based on the temperature of the CO₂ refrigerant at the outlet side of one of the heat exchangers 32 and 33; and, the controller 30 is provided so as to control the flow rate of the low-temperature water streaming through each heat exchanger. In this way, the thermal efficiency of the heat pump cycle can be maintained at a high level. To be more specific, the controller 30 can control the flow rate so that the temperature of the CO₂ refrigerant is kept at a lower temperature level, the temperature of the CO₂ refrigerant being the temperature at the

CO₂ refrigerant confluence point on the downstream side of the heat exchanger 32 for supplying hot water and the heat exchanger 33 for circulating hot water. The lower the temperature of the CO₂ refrigerant at the confluence point, the higher the heat recovery ratio at the heat exchanger 32 as well as the heat exchanger 33. In this way, the thermal efficiency of the heat pump cycle can be enhanced. Thereby, the control of the opening of the three way valve is performed based on the CO₂ refrigerant temperature at the CO₂ refrigerant outlet side of the heat exchanger 32 or the heat exchanger 33; thereby, whether the heat exchanger 32 or the heat exchanger 33 is selected depends on the principle that the heat exchanger whose water outlet temperature is lower is selected. In this way, the opening of the three way valve is controlled based on the temperature of the CO₂ refrigerant at the outlet side of the heat exchanger whose water outlet temperature is lower than the temperature of the other heat exchanger is selected; thus, in the selected heat exchanger, the CO₂ refrigerant appropriately transfers heat to the low-temperature water. Accordingly, the hot heat of the CO₂ refrigerant can be further effectively made use of.

Further, according to this mode of the invention, the CO₂ refrigerant is used as a cooling medium of the heat pump circuit 1; thus, the heat pump cycle of the cooling medium can easily pass through the range of the super-critical state; the temperature difference as a heat exchanger temperature difference between the heating medium and the heated medium (or between the cooling medium and the cooled medium) can be easily formed for the hot water circuit 21 for supplying hot water, a hot water circuit 25 for circulating hot water; in addition, the temperature difference is easily achieved in the heat exchange between the first cold brine circuit 11 and the second brine circuit 16. In this way, the heat transfer efficiencies can be enhanced.

[0038] Further, in a variation of this first mode of the invention, it may be considered that the operation method of the heat pump circuit is changed from one mode to another mode. In this event, as shown in Fig. 2, the heat pump circuit is provided with a temperature detecting means 42 that detects the temperature of the CO₂ refrigerant on the inlet side of the gas cooler, a temperature detecting means 43 that detects the temperature of the CO₂ refrigerant on the outlet side of the gas cooler, and the controller 30 in which the temperature information is inputted from the temperature detecting means 42 as well as 44.

Based on the difference between the temperature of the CO₂ refrigerant on the inlet side of the gas cooler and the temperature of the CO₂ refrigerant on the outlet side of the gas cooler, the controller 30 controls the delivery pressure of the compressor 2 so that the operation of the heat pump circuit can be changed-over from the trans-critical operation mode to the subcritical operation mode and vice versa; hereby, the trans-critical operation mode is an operation mode in which the heat pump cycle of the CO₂ refrigerant passes through the range of the super-critical state regarding the CO₂ refrigerant, whereas the subcritical operation mode is an operation mode in which the heat pump cycle of the CO₂ refrigerant does not pass through the range of the super-critical state regarding the CO₂ refrigerant.

[0039] Fig. 4 shows how a heat cycle process changes in the Mollier chart, when an operation mode (e.g. the trans-critical) of the heat pump is changed into another operation mode (e.g. the subcritical) of the heat pump in the first mode of the present invention.

In a case where the outdoor temperature is low and the heating demand is low, the subcritical operation mode is adopted; and, only the sensible heat included in the refrigerant

gas delivered from the compressor 2 performs the heating. Thereby, regarding the heat pump cycle in Fig. 4, the symbols QH1, P1, and (a-d) correspond to the heating capacity, the shaft driving power, and the cooling capacity, respectively.

On the other hand, in a case where the outdoor temperature is low and the heating demand is high, the trans-critical operation mode is adopted. In relation to the heat pump cycle in Fig. 4, the symbols QH2, P2, and (a-d') correspond to the heating capacity, the shaft driving power, and the cooling capacity, respectively. In this trans-critical operation mode, the shaft driving power for driving the compressor 2 somewhat increases; however, a great deal of heating capacity can be obtained, and the cooling capacity is increased.

According to the configuration as described, the trans-critical operation mode is changed over into the subcritical operation mode and vice versa in response to the heating demand at each heat exchanger; thus, the hot water of the desired temperature can be obtained regardless of the outdoor temperature. Further, the driving power for driving the compressor 2 can be reduced, and energy conservation is achieved.

(Second Mode)

[0040] Based on Fig. 5, a second mode of the present invention is now explained.

Incidentally, the same components in the second mode as in the first mode are given common numerals or symbols; and, explanation repetitions are omitted.

The cooling-heating device according to this second mode of the invention includes, but not limited to, a spare heat exchanger 35 on the downstream side of the heat exchanger 32 for supplying hot water as well as the heat exchanger 33 for circulating hot water, in the heat pump circuit 1. Further, the cooling-heating device includes, but not limited to, the hot water

circuit 21 for supplying hot water; the water that is preliminarily heated up at the spare heat exchanger 35 is transferred to the heat exchanger 32 for supplying hot water, through the hot water circuit 21; and, the water transferred to the heat exchanger 32 is heated up therein so as to produce high-temperature water as the hot water to be supplied to each hot water demand. .

[0041] Fig. 6 shows the variables regarding the periphery of a spare heater (i.e. the spare heat exchanger 35) in the second mode of the invention, the variables being represented with specific numerical examples. Incidentally, the numerical values described in Fig. 6 are only preferable examples. Hereby, the objective is that the heat exchanger 32 for supplying hot water produces the hot water whose temperature is not less than 70°C, and the heat exchanger 33 for circulating hot water recovers a part of remaining heat of the CO₂ refrigerant so as to produce the hot water to be circulated.

As shown in Fig. 6, for instance, in a case where the temperature of the CO₂ refrigerant fed from the compressor 2 is 110°C and the flow rate of the CO₂ refrigerant is 4000 kg/h, the temperature of the CO₂ refrigerant that has passed through the heat exchanger 32 or 33 and reaches the outlet of the gas cooler 34 becomes 16°C. The city water of the temperature 3°C is supplied to the spare heat exchanger 35, where the heat exchange between the city water and the CO₂ refrigerant of the temperature 16°C is performed so that the temperature of the city water is preliminarily increased up to 13°C. The water heated-up to 13°C is fed to the heat exchanger 32 for supplying hot water; on the other hand, the temperature of the CO₂ refrigerant streaming out of the spare heater 35 becomes 11°C, and the CO₂ refrigerant of the temperature 11°C is fed toward the evaporator 5.

[0042] Fig. 7 shows a Mollier chart in which a heat cycle process, namely, the change of state regarding the refrigerant used for a heat pump according the second mode of the invention is depicted. As shown in Fig. 7, in response to the difference between the temperature at the CO₂ refrigerant inlet side i5 regarding the spare heater 35 and the temperature at the CO₂ refrigerant outlet side k5 regarding the spare heater 35, the cooling capacity of the heat pump cycle increases.

In this way, by use of the water that is preliminarily heated-up by the spare heater 35, the hot water is produced at the heat exchanger 32 for supplying hot water; thus, the heat recovery efficiency can be enhanced, and the cooling capacity of the heat pump circuit 1 can be increased.

(Comparison Example)

[0043] Fig. 8 shows the variables (state variables) regarding the periphery of the heat exchangers in a comparison example, the variables being represented with specific numerical examples; Fig. 9 shows a Mollier chart in which a heat cycle process, namely, the change of state regarding the refrigerant used for a heat pump in the comparison example is depicted.

In this comparison example, the heat exchanger 32' for supplying hot water and the heat exchanger 33' for circulating hot water are integrated in the heat pump circuit 1 in series as well as in this order.

As shown in Figs. 8 and 9, for instance, in a case where the temperature of the CO₂ refrigerant fed from the compressor 2 is 110°C and the flow rate of the CO₂ refrigerant is 4000 kg/h, the exchanged heat flow rate at the heat exchanger 32' for supplying hot water becomes 80.9 kW, and the exchanged heat flow rate at the heat exchanger 33' for circulating hot water

becomes 56.3kW. The city water of the temperature 13°C is supplied to the heat exchanger 32' for supplying hot water, where the heat exchange between the city water and the CO₂ refrigerant is performed so that the hot water of the temperature 13°C is produced and the hot water is fed to the hot water supplying means (i.e. the hot water consuming means). On the other hand, the hot water of the temperature 39°C and the flow rate 134.4 L/min is fed to the heat exchanger 33' for circulating hot water, in the heat exchanger 33', the heat exchange is performed between the water and the CO₂ refrigerant so that the hot water of the temperature 45°C is produced.

[0044] In the configuration as described above, the temperature of the hot water at the inlet of the heat exchanger 33' for circulating hot water is 39°C; thus, the temperature of the CO₂ refrigerant at the outlet of the heat exchanger 33' for circulating hot water becomes 44°C. This means that the temperature of the CO₂ refrigerant at the inlet of the gas cooler 34' is increased in comparison with the corresponding CO₂ refrigerant temperature in the first mode of the invention as shown in Fig.2. Therefore, the heat that is disposed of at the gas cooler 34' is increased, and the heat that is recovered in the brine circuit is reduced.

Thus, according to the above-described modes of the present invention where a plurality of heat exchangers are arranged in parallel, the heat cycle efficiency can be enhanced in comparison with the case of the above-described comparison example where a plurality of heat exchangers are arranged in series.

(Third Mode)

[0045] Fig. 10 shows the configuration of a cooling-heating device according to a third

mode of the present invention; and, Fig. 10 shows the variables regarding the periphery of the heat exchangers in the third mode of the present invention, the variables being represented with specific numerical examples. Incidentally, the same components in this third mode as in the first or second mode are given common numerals or symbols; and, explanation repetitions are omitted.

The cooling-heating device according to this third mode of the invention includes, but not limited to:

a hot water tank 46 for supplying hot water, the tank 46 being provided on the hot water circuit 21 for supplying hot water; and,

a pump 47 for circulating the low-temperature water (or hot water) in a closed loop including, but not limited to, the heat exchanger 32 for supplying hot water, the hot water tank 46 and the hot water circuit 21, the pump 47 being arranged on the hot water circuit 21 (that is an open circuit) in Fig. 10. The pump 47 circulates the low-temperature water such as city water in the closed loop so that the hot water heated-up at the heat exchanger 32 streams from the heat exchanger 32 to the hot water tank; thus, the temperature of the hot water to be supplied is increased up to a prescribed temperature of, for instance, not less than 60°C.

[0046] Further, the cooling-heating device according to this third mode of the invention includes, but not limited to:

a first temperature detecting means 45 for detecting the temperature of the low-temperature water at the inlet side of the heat exchanger 32 for supplying hot water:

a second temperature detecting means 48 for detecting the temperature of the low-temperature water at the inlet side of the heat exchanger 33 for circulating hot water.

The controller 30 compares a first detected temperature detected by the first temperature detecting means 45 with a second detected temperature detected by the second temperature detecting means 48; in a case where the first detected temperature is higher than the second detected temperature, the controller 30 controls the opening of the three way valve 31 so that the CO₂ refrigerant is fed preferentially to the heat exchanger 33 for circulating hot water; on the other hand, in a case where the second detected temperature is higher than the first detected temperature, the controller 30 controls the opening of the three way valve 31 so that the CO₂ refrigerant is fed preferentially to the heat exchanger 32 for supplying hot water.

[0047] To be more specific, in the case where the first detected temperature is higher than the second detected temperature, a fourth temperature detecting means 49 detects the temperature (the fourth temperature) of the CO₂ refrigerant at the downstream side of the heat exchanger 33 for circulating hot water; based on the detected fourth temperature, the controller 30 controls the opening of the three way valve 31.

Further, in the case where the second detected temperature is higher than the first detected temperature, a third temperature detecting means 41 detects the temperature (the third temperature) of the CO₂ refrigerant at the downstream side of the heat exchanger 32 for supplying hot water; based on the detected third temperature, the controller 30 controls the opening of the three way valve 31.

[0048] For instance, on the premise that the city water is fed to the hot water circuit 21 for supplying hot water, in a case where the first detected temperature detected by the first temperature detecting means 45 is 45°C and the second detected-temperature detected by the

second temperature detecting means 48 is 39°C, the controller 30 controls the three way valve 31 so that the third detected temperature detected by the third temperature detecting means 41 becomes 17°C. Thereby, the CO₂ refrigerant is fed preferentially to the heat exchanger 32 for supplying hot water.

On the other hand, on the premise that the hot water is circulated in the closed loop including the heat exchanger 32, the hot water tank 46, the pump 47 and the hot water circuit 21, in a case where the first detected temperature detected by the first temperature detecting means 45 is 64°C and the second detected-temperature detected by the second temperature detecting means 48 is 39°C, the controller 30 controls the three way valve 31 so that the fourth detected temperature detected by the fourth temperature detecting means becomes 44°C. Thereby, the CO₂ refrigerant is fed preferentially to the heat exchanger 33 for circulating hot water.

[0049] According to this third mode of the present invention, the temperature of the CO₂ refrigerant at the above-described confluence point h1 regarding the CO₂ refrigerant downstream from the heat exchanger 32 and the CO₂ refrigerant downstream from the heat exchanger 33 can be surely reduced, regardless of the temperature levels regarding the low-temperature water fed into the heat exchanger 32 for supplying hot water as well as the heat exchanger 33 for circulating hot water. Thus, the thermal efficiency of the heat pump cycle can be enhanced.

(Symbols)

[0050] The items with the numerals in the figures or this specification are explained as

follows:

- 1 a heat pump circuit;
- 2 a compressor;
- 3 a condensing means;
- 4 an expansion valve;
- 5 an evaporator;
- 6 a hot water supplying means or a hot water consuming means;
- 7 a hot water tank;
- 8 a hot water utilizing means;
- 11 a first cold brine circuit;
- 15 a brine tank;
- 16 a second brine circuit;;
- 30 a controller;
- 31 a three way valve;
- 32 a heat exchanger 32 for supplying hot water;
- 33 a heat exchanger 33 for circulating hot water;
- 34 a gas cooler;
- 35 a spare heater or a spare heat exchanger.

What is claimed is:

1. A cooling-heating device for an ice rink facility, the device comprising a heat pump circuit comprising a refrigerant line, the heat pump circuit comprising: a compression means, a condensing means, an expansion valve and an evaporating means so as to circulate CO₂ refrigerant through the compression means, the condensing means, the expansion valve, and the evaporating means,

wherein the cooling-heating device supplies the cold heat generated by the heat pump circuit to the ice rink as well as supplies the hot heat generated by the heat pump circuit to the hot heat consuming facilities annexed to the ice rink,

wherein the cooling-heating device comprises:

the condensing means that comprises a first heat exchanger and a second heat exchanger, the heat exchangers being connected to the heat pump circuit in parallel and heating-up low-temperature water by use of the condensation heat of the CO₂ refrigerant;

a three way valve that is provided at a CO₂ refrigerant branch point on the upstream sides of the first and second heat exchangers in the refrigerant line so that the three way valve controls the flow rate of the CO₂ refrigerant;

a first hot water circuit that is connected to the first heat exchanger and a second hot water circuit that is connected to the second heat exchanger;

at least one cold brine circuits that is connected to the evaporating means;

a temperature detecting means that detects the temperature of the CO₂ refrigerant on the outlet side of the one of the heat exchangers when the temperature of the low-temperature water on the inlet side of the one of the heat exchanger is lower than the temperature of the low-temperature water on the inlet side of the other heat exchanger and

a control device that controls the opening of the three way valve based on the CO₂ refrigerant temperature detected by the temperature detecting means so that the control device controls the flow rate of the CO₂ refrigerant fed into the first heat exchanger as well as the second heat exchanger.

2. The cooling-heating device for an ice rink facility according to claim 1,
wherein the first hot water circuit that is connected to at least one hot water supplying means that supplies hot water to the hot heat consuming facilities and

wherein the second hot water circuit that is connected to at least one hot water utilizing means so as to circulate the hot water and supply the heat of the hot water to the hot heat consuming facilities via indirect heat exchange.

3. The cooling-heating device for an ice rink facility according to claim 1, further comprising:

a spare heat exchanger on the downstream side of the first heat exchanger as well as the second heat exchanger in the heat pump circuit,

wherein the water that is preliminarily heated-up by the spare heat exchanger is fed into the first heat exchanger through the first hot water circuit, and the first hot water fed into the first heat exchanger is heated-up therein so that hot water is produced.

4. The cooling-heating device for an ice rink facility according to claim 1, further comprising:

a gas cooler provided on the downstream side of the first heat exchanger as well as the

second heat exchanger in the heat pump circuit,

wherein the gas cooler is arranged in series with the first heat exchanger as well as the second heat exchanger.

5. The cooling-heating device for an ice rink facility according to claim 4, comprising:
a temperature detecting means that detects the temperature of the refrigerant at the inlet side of the gas cooler;

a temperature detecting means that detects the temperature of the refrigerant at the outlet side of the gas cooler and

a controller in which the temperatures detected by the temperature detecting means are inputted,

wherein the controller controls the delivery pressure of the compression means in the heat pump circuit based on the difference between the temperature at the inlet side of the gas cooler and the temperature at the outlet side of the gas cooler so that the operation of the heat pump formed by the heat pump circuit can be changed-over from the trans-critical operation mode to the subcritical operation mode and vice versa, the trans-critical operation mode being an operation mode in which the heat pump cycle of the CO₂ refrigerant passes through the range of the super-critical state regarding the CO₂ refrigerant, the subcritical operation mode is an operation mode in which the heat pump cycle of the CO₂ refrigerant does not pass through the range of the super-critical state regarding the CO₂ refrigerant.

6. The cooling-heating device for an ice rink facility according to claim 1, comprising:
a first temperature detecting means that detects the temperature of the low-temperature

water at the inlet side of the first heat exchanger and

a second temperature detecting means that detects the temperature of the low-temperature water at the inlet side of the second heat exchanger,

wherein the controller compares a first detected temperature detected by the first temperature detecting means with a second detected temperature detected by the second temperature detecting means so that the CO₂ refrigerant is fed preferentially to the second heat exchanger, in a case where the first detected temperature is higher than the second detected temperature and

wherein the controller compares a first detected temperature detected by the first temperature detecting means with a second detected temperature detected by the second temperature detecting means so that the CO₂ refrigerant is fed preferentially to the first heat exchanger, in a case where the second detected temperature is higher than the first detected temperature.

Fig.1

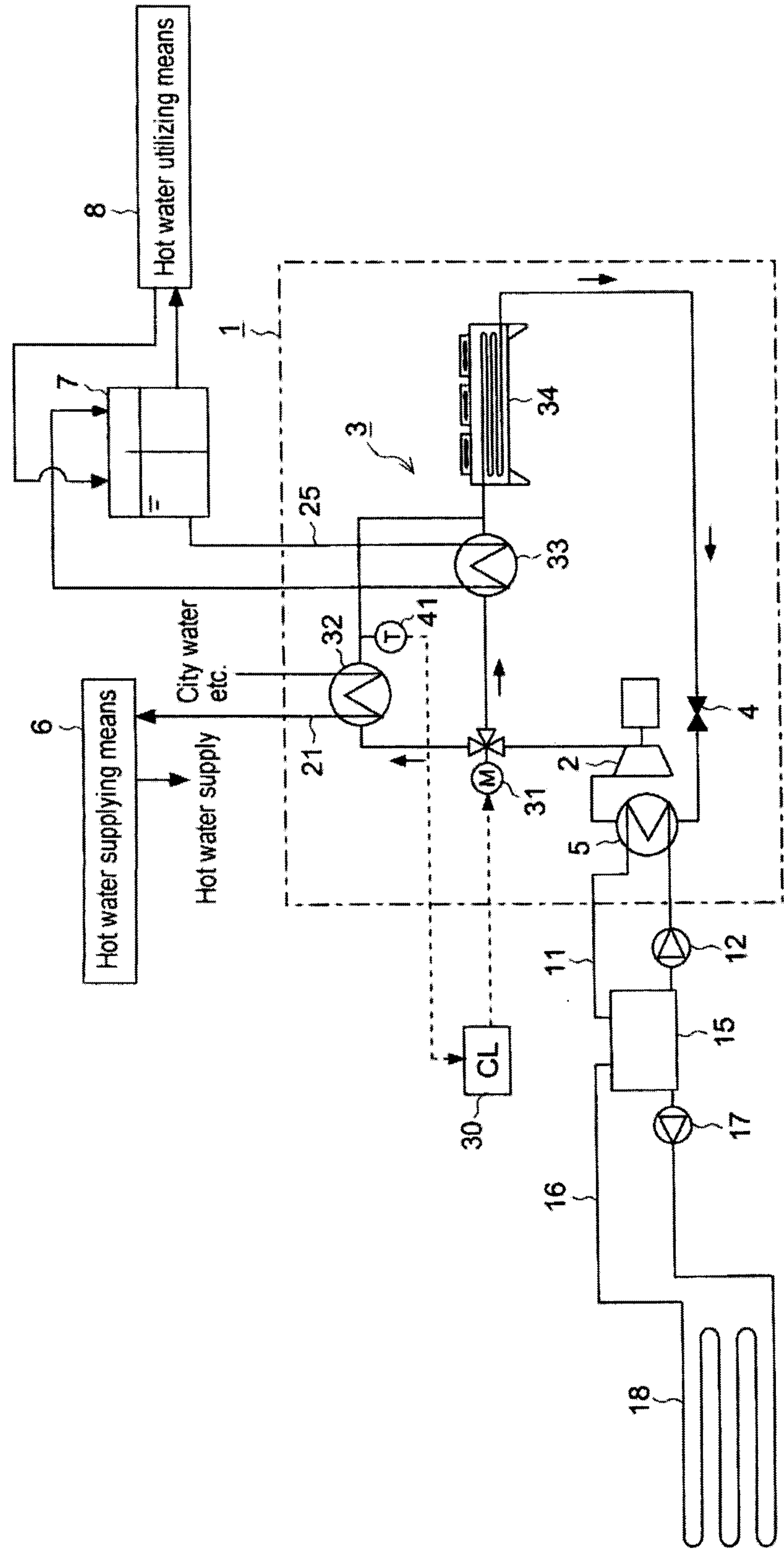


Fig.2

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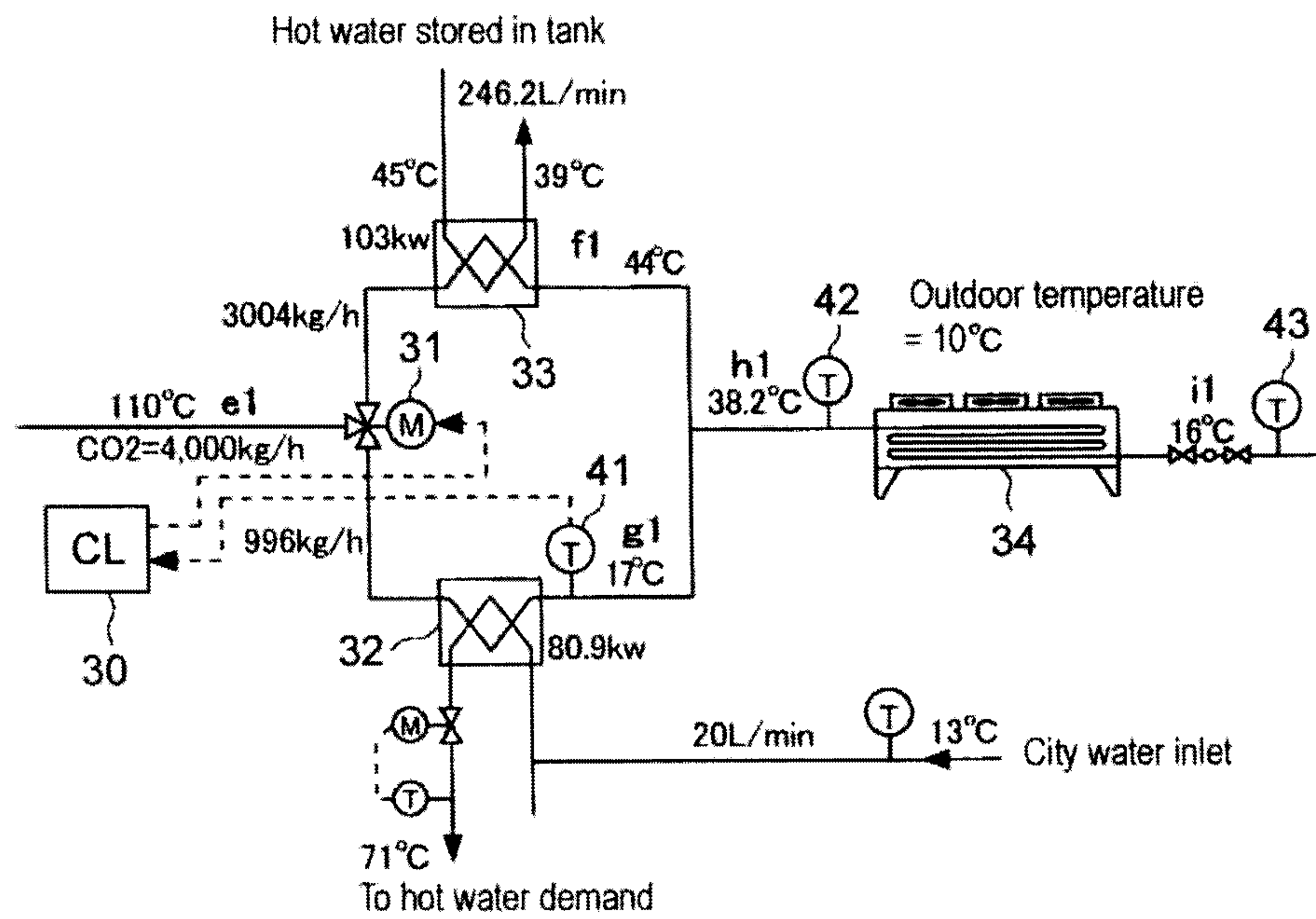


Fig.3

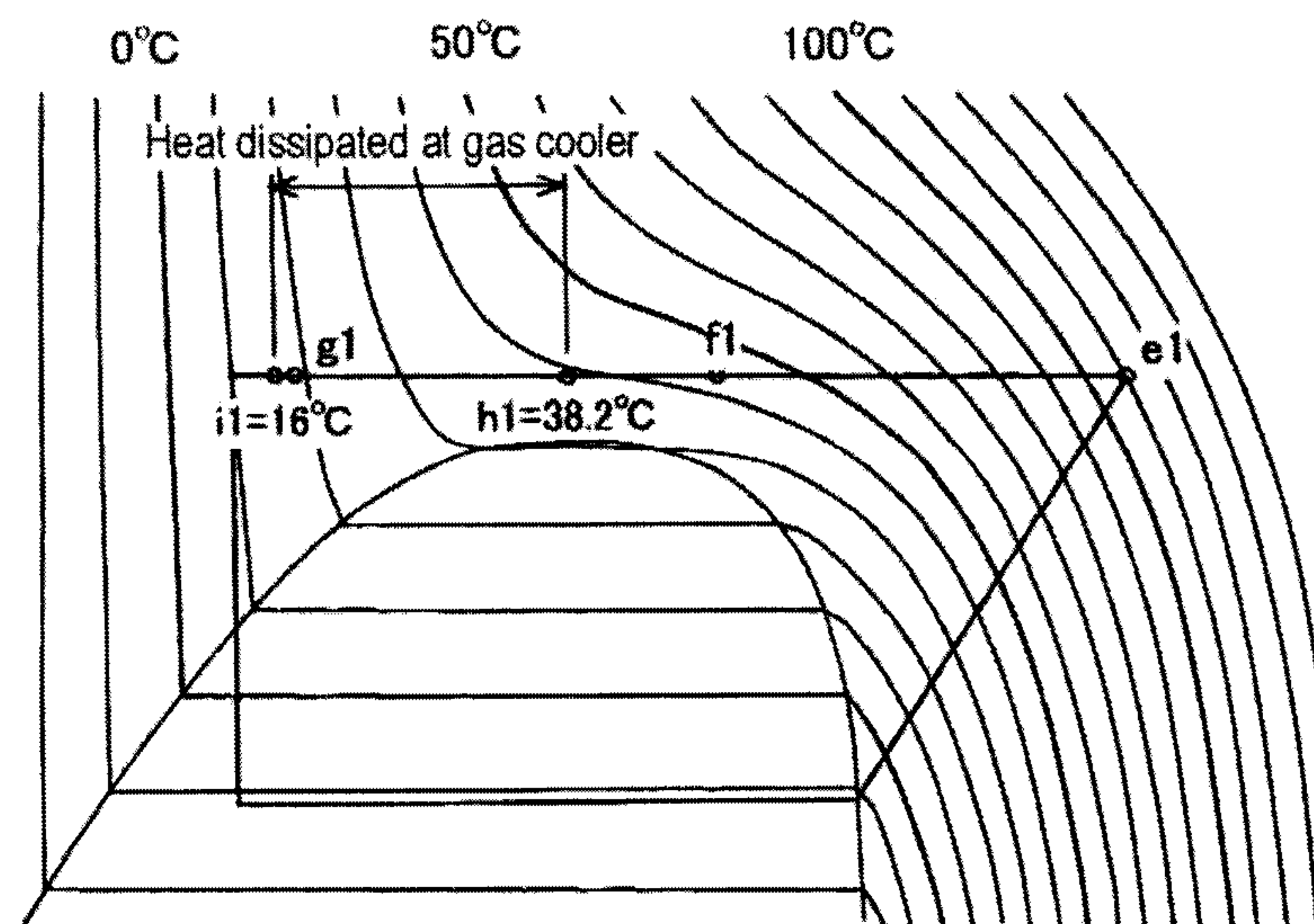


Fig.4

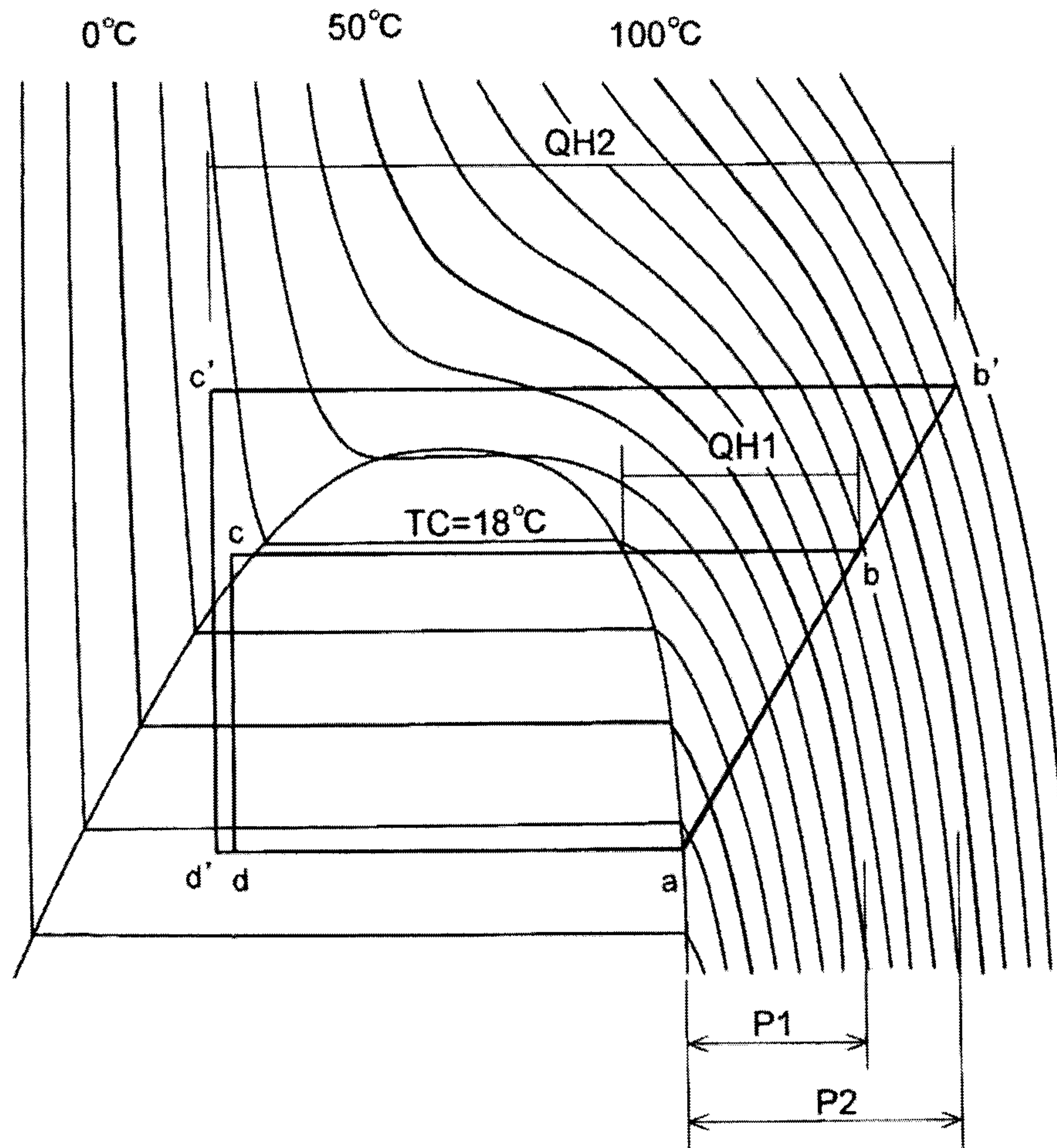


Fig.6

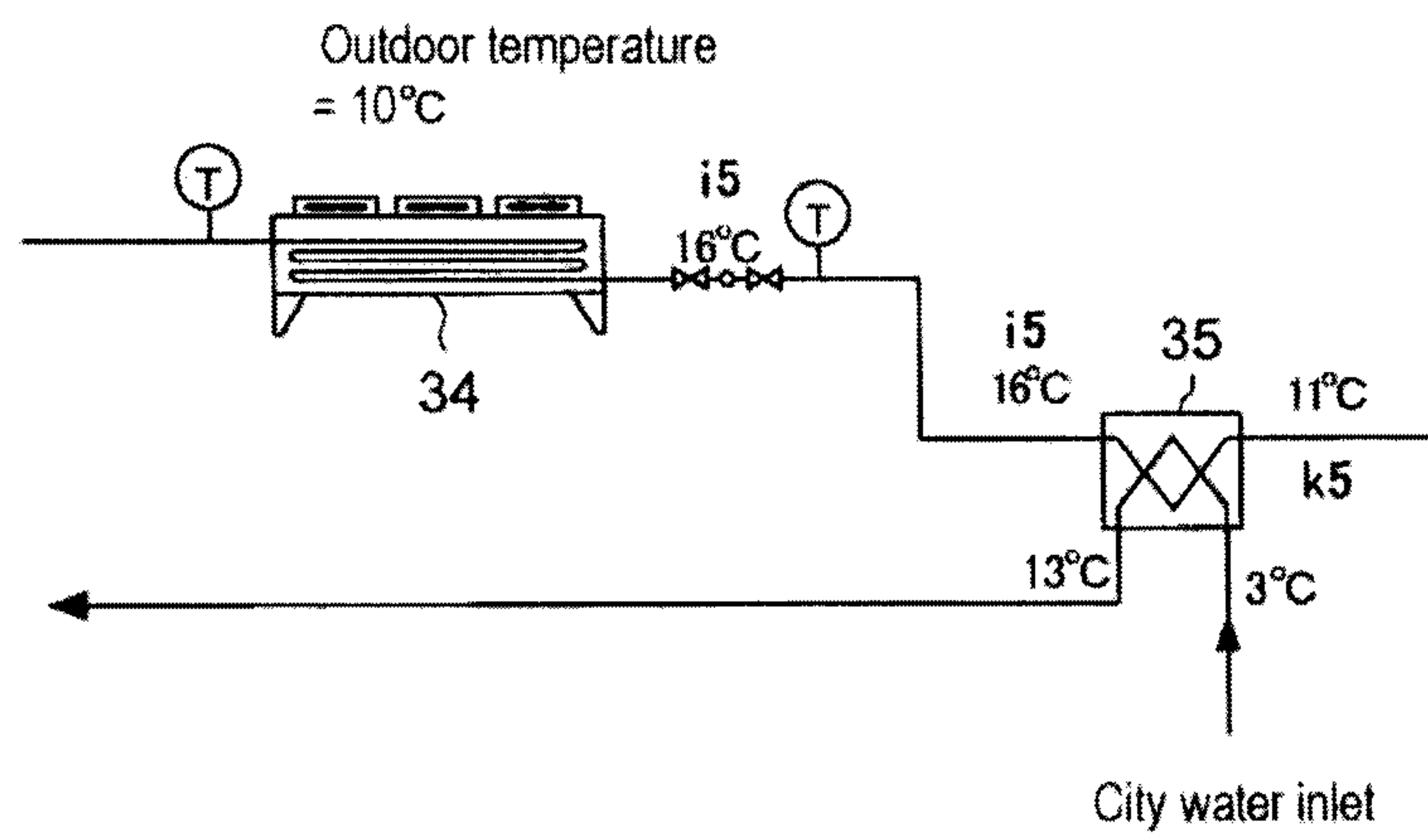


Fig.7

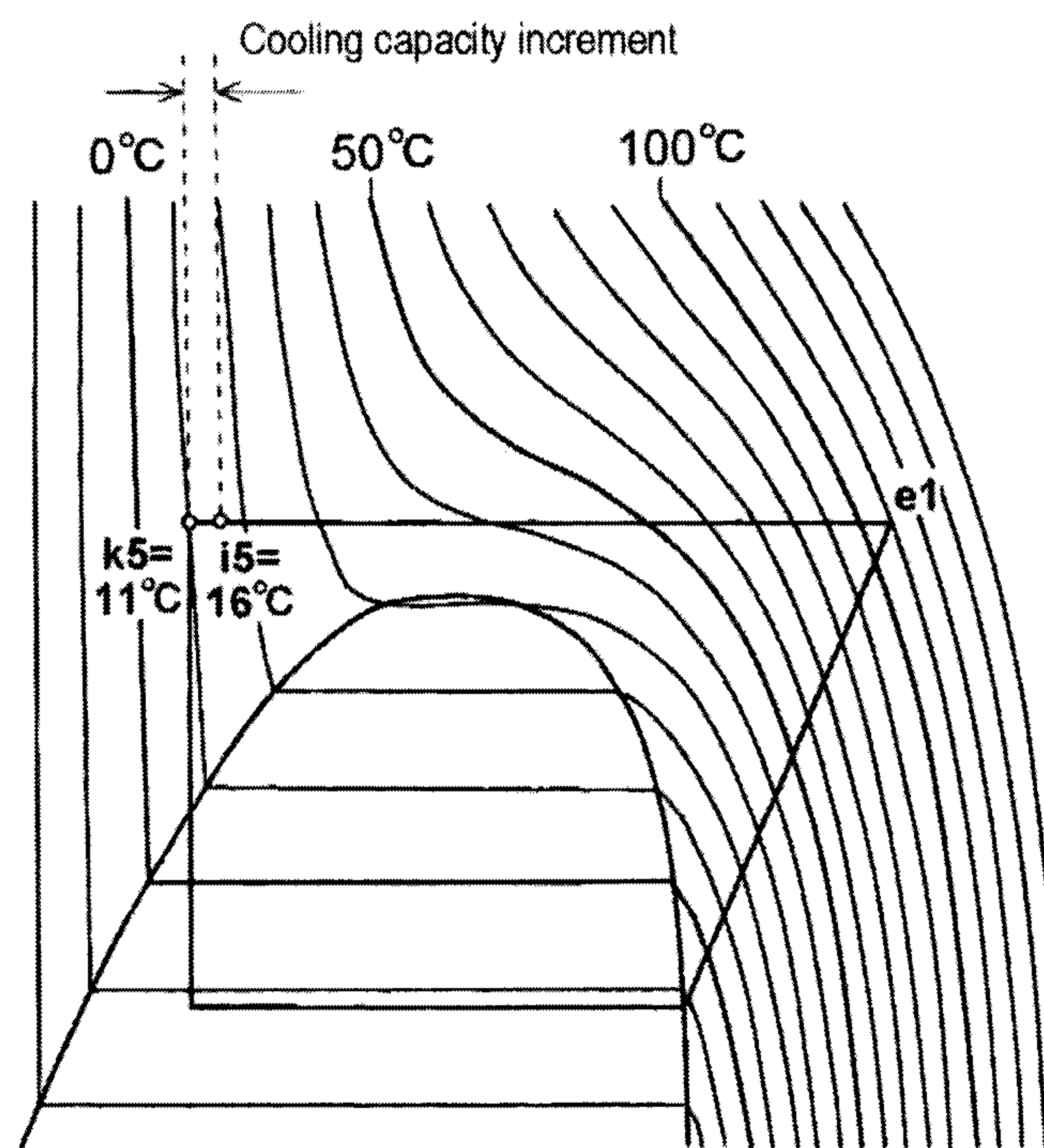


Fig.8

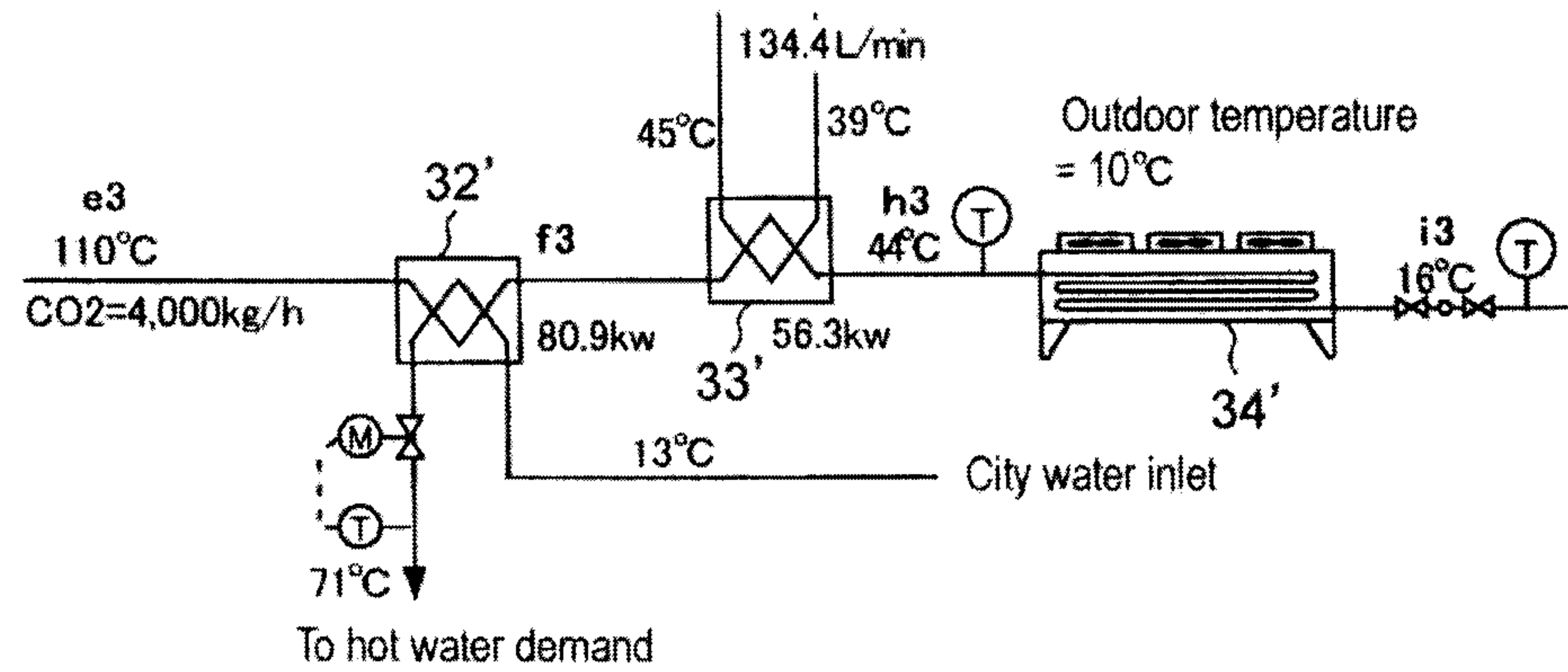


Fig.9

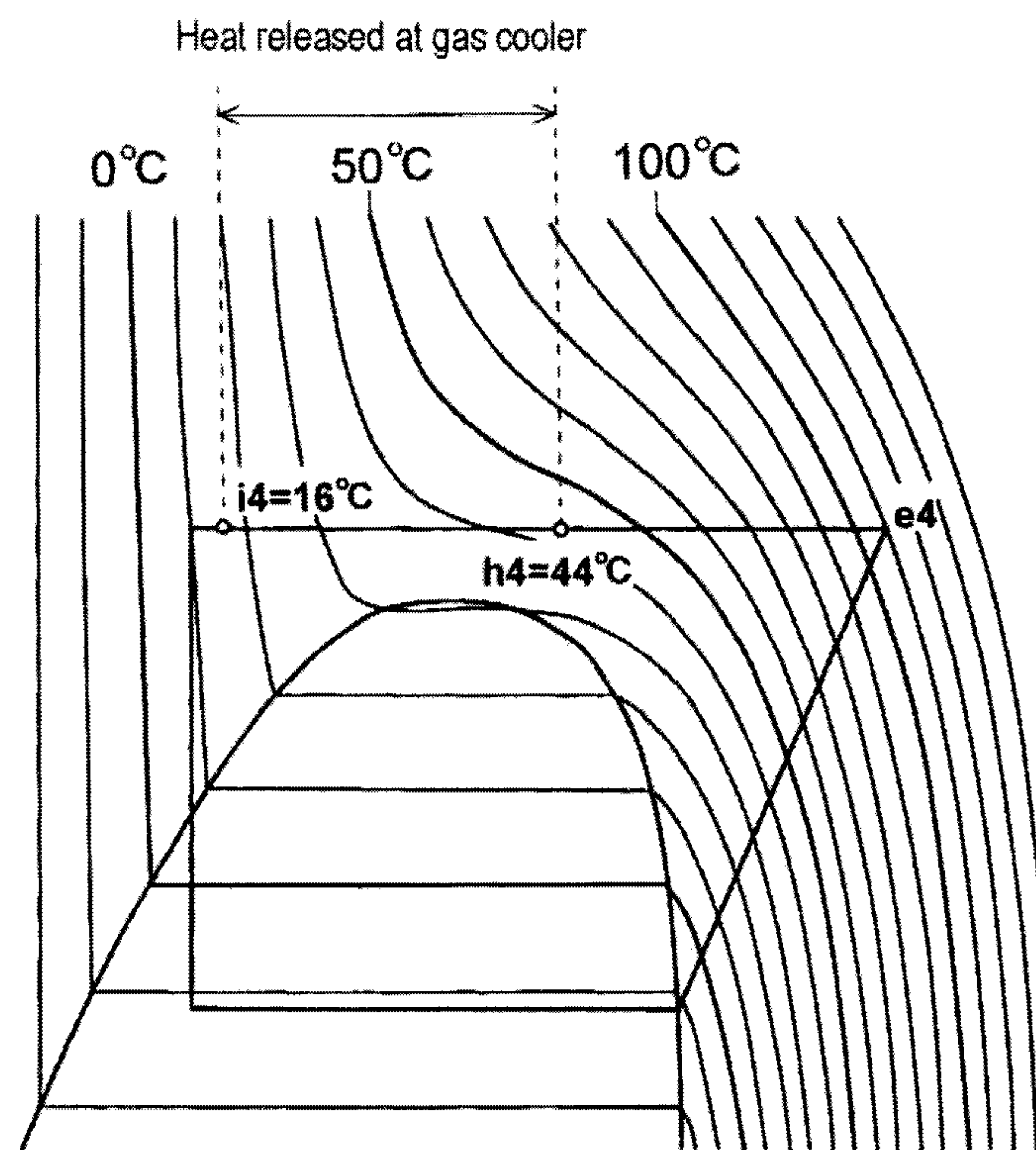


Fig.10

(7 / 10)

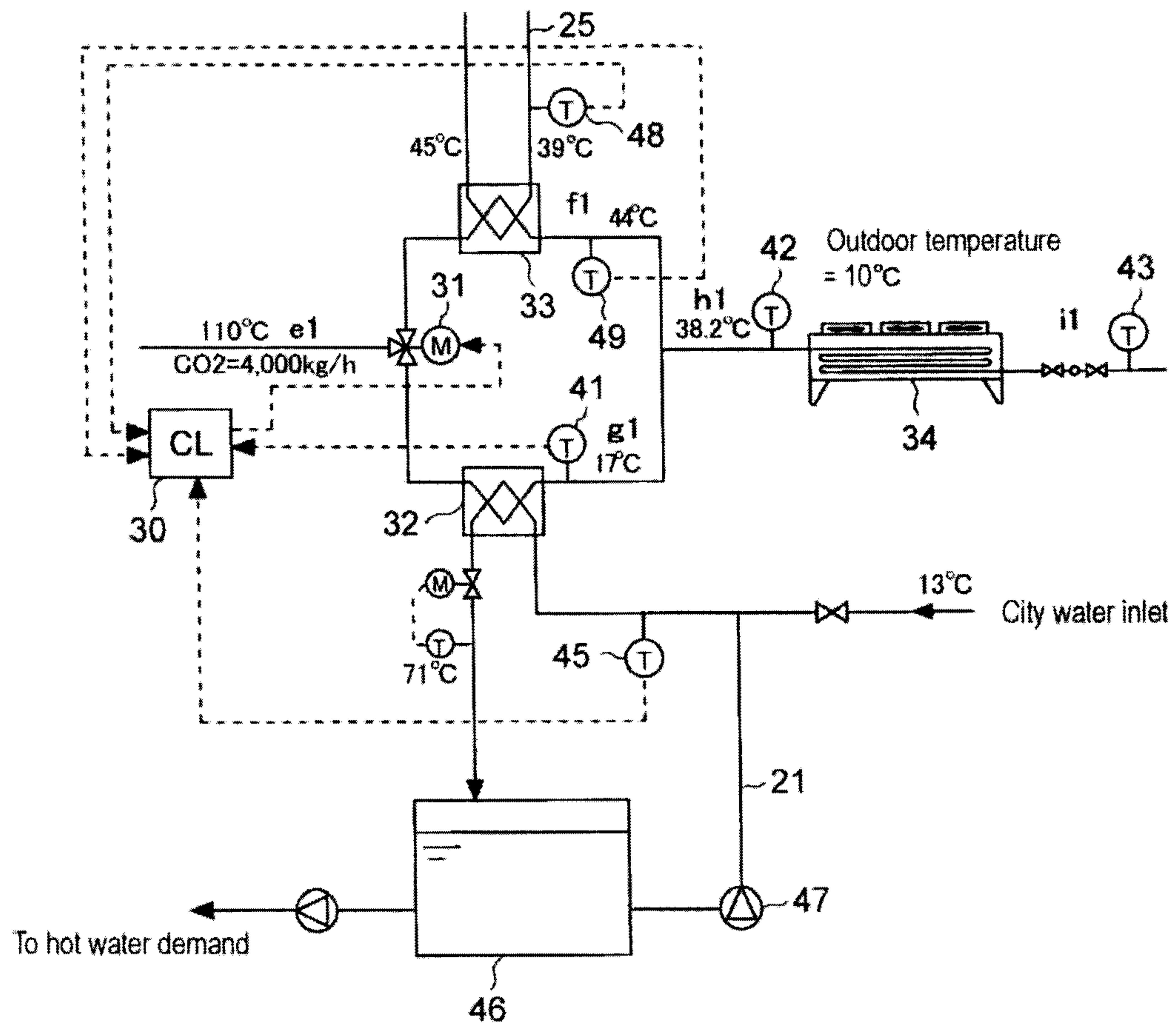


Fig.11

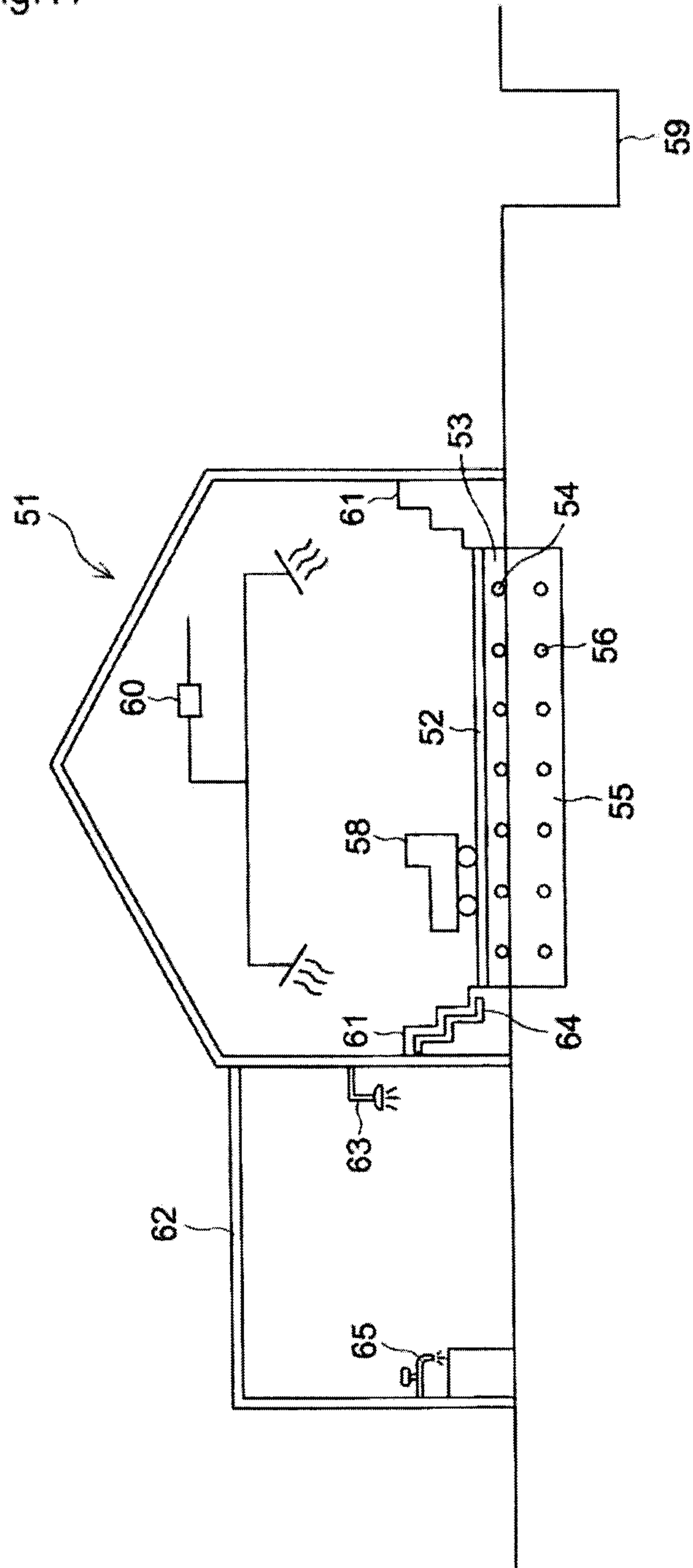


Fig.12

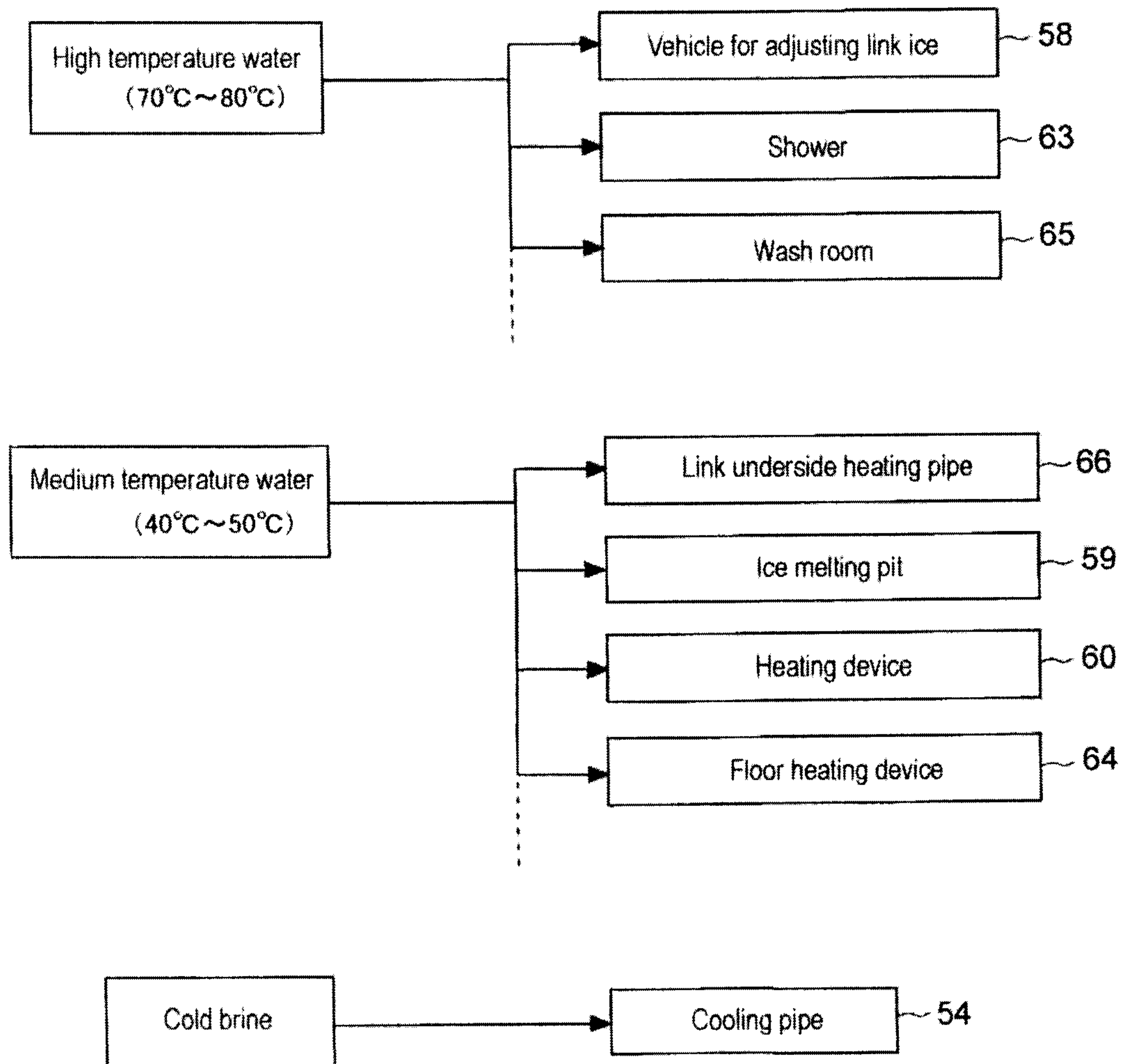


Fig.13

