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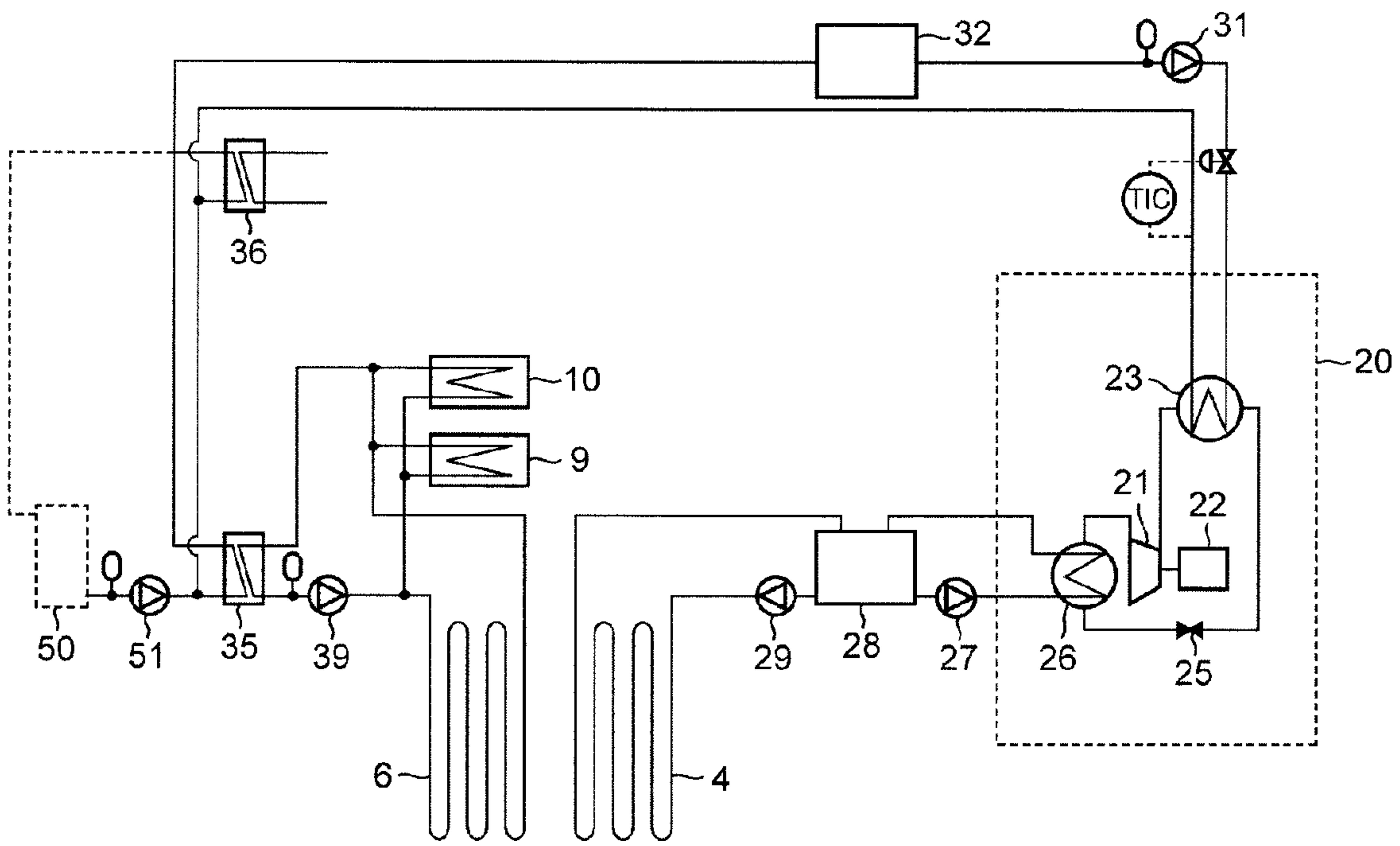
(54) Title: SYSTEM AND METHOD FOR CREATING RINK ICE AND UTILIZING HIGH-TEMPERATURE HEAT GENERATED WHEN CREATING RINK ICE



(57) Abrégé/Abstract:
A system for creating rink ice and utilizing high-temperature heat generated when creating rink ice, the rink ice being created by spraying water over a base material layer and flowing cold brine through cooling tubes embedded in the base material layer includes: a heat pump performing a refrigerating cycle using CO2 as a refrigerant for producing cold brine and hot water, and a means for introducing the brine which has worked to freeze the water sprayed over the base material layer and received heat from the water sprayed over the base material layer and the ice created to the heat pump, thereby the hot water is produced by the heat pump by using heat contained in the brine introduced to the heat pump as a heat source and the brine deprived of the heat in the heat pump is returned to the cooling tubes to be used as the cold brine, thus the cold brine for creating the rink ice and cooling the ice layer created and the hot water to be used in ancillary facilities of the ice-skating rink facility are produced.

ABSTRACT

A system for creating rink ice and utilizing high-temperature heat generated when creating rink ice, the rink ice being created by spraying water over a base material layer and flowing cold brine through cooling tubes embedded in the base material layer includes: a heat pump performing a refrigerating cycle using CO_2 as a refrigerant for producing cold brine and hot water, and a means for introducing the brine which has worked to freeze the water sprayed over the base material layer and received heat from the water sprayed over the base material layer and the ice created to the heat pump, thereby the hot water is produced by the heat pump by using heat contained in the brine introduced to the heat pump as a heat source and the brine deprived of the heat in the heat pump is returned to the cooling tubes to be used as the cold brine, thus the cold brine for creating the rink ice and cooling the ice layer created and the hot water to be used in ancillary facilities of the ice-skating rink facility are produced.

SYSTEM AND METHOD FOR CREATING RINK ICE AND UTILIZING HIGH-TEMPERATURE HEAT GENERATED WHEN CREATING RINK ICE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a system and method for creating skating rink ice and utilizing high-temperature heat when creating rink ice, more specifically for creating skating rink ice and maintaining the ice in a proper condition and for producing hot water required for ancillary facilities of the skating rink by utilizing high temperature heat generated when creating rink ice.

Description of the Related Art

In an ice-skating rink, it is required to create rink ice and maintain the ice created in a proper condition. Proper temperature of the ice to maintain it in a proper condition is different depending on intended use such as for competitive sport such as ice hockey and figure skating, for leisure sport, etc., usually the temperature of the ice must be maintained at a range of -1~-5℃. Generally, to maintain the temperature of ice layer at a range of -1~-5℃, brine of temperature of -8~-12℃ is flown in cooling tubes laid under the ice layer. (In the present invention, "brine" includes fluid cooling agent such as ethylene glycol solution, propylene glycol solution and the like.)

Such an art is disclosed for example in Japanese Laid-Open Patent Application No.07-241363(Patent literature 1).

On the other hand, in a skating rink facility are needed in addition to refrigerating equipment for creating ice and maintaining the ice created in a proper condition, equipment for producing hot water to perform resurfacing of the ice, melting the ice scraped for the resurfacing, and heating of the rink floor. Further, there are ancillary facilities in the skating rink facility which require space heating or supply of hot water, such as spectors' stands, shower room, etc.

Furthermore, many of skating rink facilities have accompanying facilities such as a heated swimming pool, library, public hall, etc. These accompanying facilities may also require space heating and supply of hot water.

Cooling and heating equipment used generally at the present day in an ice-skating rink will be explained with reference to FIGS.4-6.

FIG.4 is a schematic representation of an ice-skating rink facility commonly used.

A skating rink facility 1 has an accompanying facility 12 which may include a library, for example.

An ice layer 2 on the skating rink is created by spraying water on a concrete layer 3 and freezing the water by flowing cold brine in ice creation cooling tubes 4 laid in the concrete layer 3.

In a concrete layer 5 underneath the concrete layer 3 are laid heating tubes 6 in order to prevent freezing of moisture contained in the soil underneath the concrete layer 5 by flowing warm brine in the heating tubes.

As ruts are formed on the surface of the rink ice by skates, the rink ice is resurfaced by an ice resurfacing vehicle 8. The ice resurfacing vehicle 8 scraps a thin layer of ice and sprays water over the ice to allow fresh thin ice layer to be formed. As water for spraying is used hot water of about 70℃ in order to smooth the roughened surface of the rink ice by melting the surface layer thereof. The shavings scraped by the resurfacing vehicle 8 is transported to an ice shavings melting pot 9 to be melted there by warm water of 40~50℃.

Further, a space heating unit 10 with which warm air is obtained by allowing air to exchange heat with the warm water of 40~50℃ to be used for the heating of the skating rink space, and an underfloor heating system 14 consisting of heating tubes laid underneath spectors' stands 11 to perform underfloor heating by flowing the warm water, are provided.

A shower bath 13 and a rest room 15 are provided in the accompanying facility 12, where hot water is supplied.

Heating and cooling equipment as shown in FIG.4 is necessary to be provided in a common skating rink facility.

In FIG.5 are shown places or devices where high temperature water, medium temperature water, and cold brine are used in the common skating rink facility as shown in FIG.4.High temperature water of 70~80℃ is used for the resurfacing vehicle 8, shower bath 13, and rest room 15. Medium temperature water of 40~50℃ is used for the under rink heating tubes 6 in the concrete layer 5, ice shavings melting pit 9, space heating unit 10, and underfloor heating system 14. Cold brine is used for ice creation cooling tube 4 for creating rink ice.

FIG.6 is a schematic representation of an example of conventional system for producing high temperature water, medium temperature water, and cold brine. In FIG.6, a brine chiller 120 for producing cold brine for creating rink ice and maintaining the ice in a proper condition comprises a compressor 121, an electric motor 122 for driving the compressor, an evaporation type condenser 123, a liquid receiver 124, an expansion valve 125, and an evaporator 126, and a refrigerating cycle is performed by circulating a primary refrigerant. A secondary refrigerant (brine) supplied from a brine tank 128 to the evaporator 126 by means of a primary brine pump 127 is cooled in the evaporator 126 and returned to the brine tank 128. The cold brine in the brine tank 128 is sent to the ice creation cooling tubes 4 by means of a secondary brine pump 129, freezes the water sprayed over the concrete layer 3 passing through the cooling tubes and serves also to maintain the ice in a proper condition.

Heat transferred to the brine in the cooling tubes from water on the surface of the ice or the ice created is transferred to the primary refrigerant such as ammonia in the evaporator 126 to evaporate the primary refrigerant and received in the course of the circulation by a coolant supplied to the condenser 123 to be finally released to the atmosphere.

A system for producing hot water to be supplied to the ancillary facilities of the skating rink facility is comprised of a hot-water boiler 150, a first hot-water pump 151, a heat exchanger 155 for medium temperature water, a heat exchanger 156 for high temperature water, and a second hot-water pump 154. High temperature water of 90℃ or higher produced in the hot-water boiler 150 is introduced to both the heat exchanger 155 for medium temperature water and heat exchanger 156 for high temperature water.

In the heat exchanger 155 for medium temperature water, water is heated to medium temperature of 40~50℃ by heat exchange with the high temperature water of 90 °C or higher produced by the hot-water boiler 150, and the medium temperature water is supplied to the under-rink-floor heating tubes 6, ice shavings melting pit 9, space heating unit 10 etc., where medium temperature water is required by means of the second hot-water pump 154. Water decreased in temperature in these devices is returned to the heat exchanger 155 for medium temperature water to be again heated therein and again supplied those devices.

In the heat exchanger 156 for high temperature water, service water supplied to the heat exchanger 156 is heated to high temperature water by heat exchange with the high temperature water of about 70~80 °C produced by the hot-water boiler 150 to be supplied to the shower bath 13, rest room 15, and ice resurfacing vehicle 8, etc., where high temperature water is required.

However, in the prior art like this, the refrigerating apparatus 120 for producing cold brine and the hot-water boiler 150 for producing hot water are provided independently. Therefore, electric power is consumed by the electric motor 122 to drive the compressor 121, and heat the secondary refrigerant(brine) received from water on the surface of the ice or the ice created is not recovered, since the heat is received by the primary refrigerant in the evaporator 126 and released in the atmosphere. On the other hand, in the hot-water boiler 150 is produced hot water by using fossil fuel.

As mentioned above, waste heat generated in the cooling system is not recovered and hot water is produced using fossil fuel in the prior art, so energy efficiency is not high.

Measures against ozone layer destruction and global warming is strongly required at the present day, and development of systems not using alternative refrigerant HFC as refrigerant and improved in energy efficiency is urgently demanded in skating rink facilities, not only getting away from using HCFC, HFC.

As measures for preventing ozone layer destruction and global warming, adoption of heat pump using a natural refrigerant such as ammonia, hydrocarbon, air, CO_2, etc. and utilization of heat generated in the refrigerating system is conceivable.

However, ammonia is used as a refrigerant in many of refrigerating systems in skating rinks, and ammonia is increased more in temperature when compressed as compared with fluorocarbon group refrigerant because of its higher adiabatic index, so carbonization of lube oil used in the compressor tends to occur, occurrence of malfunction of the compressor due to the carbonization of the lube oil is feared. Further, from view point of heat utilization, the temperature of the hot water depends on the condensation temperature in the condenser, so almost all of the temperature of heat utilization is limited when using ammonia as the refrigerant. Because of these reasons, to use a refrigerating system using ammonia as a heat pump is not prevailed.

When considering using of a refrigerating system as a heat pump, it is conceivable to use alternate refrigerant HFC such as HFC404A. However, global warming potential of HFC is high although it does not destruct ozone. Therefore, to use such refrigerants is retrogression against prevention of global warming policy.

Further, when using natural refrigerants other than ammonia, hydrocarbon is high in flammability and there is a fear of explosion, and using of air deteriorates thermal efficiency, so to use these as refrigerant for heat pump system is not prevailed.

SUMMARY OF THE INVENTION

Therefore, the present invention aims in light of the problems mentioned above to provide a refrigerating and hot water producing system using a natural refrigerant for ice-skating rink facility which works to create ice rink and maintaining the ice created in a proper condition and at the same time is possible to produce hot water of temperature of 70℃ or higher required for ancillary facilities of the skating rink by utilizing high-temperature heat generated when creating rink ice.

To attain the object mentioned above, the invention proposes a system for creating rink ice and utilizing high-temperature heat generated when creating rink ice, the rink ice being created by spraying water over a base material layer and flowing cold brine through cooling tubes embedded in the base material layer including: a heat pump performing a refrigerating cycle using CO_2 as a refrigerant for producing cold brine and hot water, and a means for introducing the brine which has worked to freeze the water sprayed over the base material layer and received heat from the water sprayed over the base material layer and the ice created to the heat pump, by which the hot water is produced by the heat pump by using heat contained in the brine introduced to the heat pump as a heat source and the brine deprived of the heat in the heat pump is returned to the cooling tubes to be used as the cold brine, thus the cold brine for creating the rink ice and cooling the ice layer created and the hot water to be used in ancillary facilities of the ice-skating rink facility are produced.

The word "brine" in the explanation includes fluid cooling agent such as ethylene glycol solution, propylene glycol solution and the like.

CO_2 reaches its supercritical point at a moderate temperature of 31.3℃ and pressure of 7.3 MPa. Therefore, by using CO_2 as a refrigerant, the refrigerant can be easily brought to a supercritical state of high-temperature and high-pressure.

In the supercritical zone, CO_2 can not be discriminated between liquid phase and vapor phase and does not condense, so the temperature of the CO_2 in a supercritical state decreases continuously when cooled by the heat medium without condensing at a constant temperature. Therefore, temperature difference is maintained large during it is cooled and transfer of heat from the CO_2 in a supercritical state to the heat medium is performed effectively. Therefore, by adopting the heat pump using CO_2 as a refrigerant and compressing CO_2 to a supercritical state, hot water of high temperature higher than 70℃ that has not been attained by conventional heat pumps can be obtained. Thus, high temperature hot water higher than 70℃ demanded in the ice-skating rink for use for its ancillary facilities can be obtained by using heat released from CO_2 in the heat exchanger.

In this way, heat that the brine received when freezing water can be utilized to produce hot water without releasing to the atmosphere, and it is not needed to use fossil fuel to produce high temperature hot water higher than 70℃ by a hot-water boiler, so energy efficiency is increased and equipment cost is saved with the need of the hot-water boiler eliminated.

Further, as CO_2 is low in viscosity, heat transfer performance is increased resulting in decreased loss in heat exchange, thermal efficiency of the system can be increased by producing hot water by utilizing heat released from the CO_2.

On the other hand, as high-pressure high temperature CO_2 of supercritical state is used, equipment cost is increased to deal with the high-pressure high temperature CO_2, however, this is compensated for by the reduction of running cost and said reduction in equipment cost, and total cost of the system including running cost does not increase much.

Further, ozone destruction potential of CO_2 is zero, and global warming potential of CO_2 is as small as 1/1500~1/1700 of that of alternative refrigerant such as HFC, and moreover CO_2 is atoxic, nonflammable, and safe heat transfer medium, the system of the invention can comply with the demand against ozone destruction and global warming.

The heat pump includes a plurality of heat exchangers for heating water utilizing CO_2 compressed by a compressor to a supercritical state, the heat exchangers are arranged in series in a discharge side of the compressor, and hot water of different temperature ranges can be obtained separately from each of the heat exchangers.

As mentioned previously, high temperature water of 70~80℃ and medium temperature water of 40~50℃ are demanded generally in the ancillary facilities of the ice-skating rink. By arranging a plurality of heat exchangers in series, plural kinds of hot water different in temperature range can be obtained. Thus, hot water of different temperature ranges can be supplied from the plurality of heat exchangers.

The nearer the heat exchanger to the discharge side of the compressor, the larger the heat carried by the compressed CO_2, so the higher the temperature of hot water produced. It is preferable to provide a control valve to each of the heat exchangers to control the flow rate of water to be heated so that the hot water at the exit thereof from each of the heat exchangers is maintained at a constant temperature.

The invention is characterized in that a conduit is provided to introduce water heated in one of the heat exchangers to the other heat exchanger or exchangers provided nearer the compressor discharge side.

With this construction, hot water obtained one of the heat exchangers is further heated in the other heat exchanger or exchangers and hot water of higher temperature is obtained, so thermal efficiency is further increased.

The invention proposes a method of creating rink ice and producing hot water used in an ice-skating rink facility, the rink ice being created by spraying water over a base material layer and flowing cold brine through cooling tubes embedded in the base material layer, in which said cold brine is produced by a heat pump performing a refrigerating cycle using CO_2 as a refrigerant, and said brine which has worked to freeze the water sprayed over the base material layer and received heat from the water sprayed on the base material layer and the ice created to the heat pump is introduced to the heat pump, thereby the hot water is produced by the heat pump by introducing the brine containing heat received from the water sprayed over the base material layer and the ice created to the heat pump and utilizing the heat of the brine as a heat source, and the brine deprived of the heat in the heat pump is returned to the cooling tubes to be used as the cold brine, thus the cold brine for creating the rink ice and cooling the ice layer created and the hot water which is to be used in ancillary facilities of the ice-skating rink facility are produced.

In the heat pump, the CO_2 refrigerant is evaporated by the heat of the brine received heat from the water sprayed on the base material layer and the ice created, the evaporated CO_2 is compressed to a supercritical state, and the compressed CO_2 is introduced to a plurality of heat exchangers arranged in the discharge side of the compressor to heat water.

The method of the invention is characterized in that a part of water heated in one of the heat exchangers is introduced to the other heat exchanger or exchangers provided nearer the compressor discharge side so that the water is further heated.

As has been described in the foregoing, according to the invention, a system and method for creating rink ice and producing hot water used in an ice-skating rink can be provided in which CO_2 is used as a refrigerant of a heat pump which performs a refrigerating cycle.

The system of the invention can be installed subsidiarily to a chiller or a boiler used in an existing ice rink.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a schematic representation of system configuration of the first embodiment for producing high temperature water, medium temperature water and cold brine.

FIG.2 is a schematic representation of system configuration of the second embodiment for producing high temperature water, medium temperature water and cold brine.

FIG.3 is a mollier diagram to explain working of refrigeration and heat pump cycle.

FIG.4 is a schematic representation of an ice-skating rink facility commonly used.

FIG.5 is a diagram showing places or devices where high temperature water, medium temperature water, and cold brine are used in the common skating rink facility of FIG.4.

FIG.6 is a schematic representation of system configuration in the conventional skating rink facility of FIG.4 for producing high temperature water, medium temperature water and cold brine.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be detailed with reference to the accompanying drawings. It is intended, however, that unless particularly specified, dimensions, materials, relative positions and so forth of the constituent parts in the embodiments shall be interpreted as illustrative only not as limitative of the scope of the present invention.

[The first embodiment]

A first embodiment of the system for creating ice rink and producing hot water used in an ice-skating rink will be explained with reference to FIG.1 and FIGS.3-5. Over all construction of the skating rink and places or devices where high temperature water, medium temperature water, and cold brine of the embodiment are similar to those of the conventional ice-skating rink shown in FIG.4 and FIG.5, and explanation of the overall construction is omitted.

FIG.1 shows a system flowchart of the first embodiment for producing high temperature water, medium temperature water and cold brine.

Referring to FIG.1, a brine chiller 20 for producing cold brine for creating rink ice and maintaining the ice in a proper condition and producing hot water comprises a compressor 21, an electric motor 22 for driving the compressor, a heat exchanger 23, an expansion valve 25, and an evaporator 26, and a refrigerating cycle is performed by circulating CO_2, which is a natural refrigerant, as a refrigerant. A secondary refrigerant(brine) supplied from a brine tank 28 to the evaporator 26 by means of a primary brine pump 27 is cooled in the evaporator 26 and returned to the brine tank 28. The cold brine in the brine tank 28 is sent to ice creation cooling tubes 4 by means of a secondary brine pump 29, freezes the water sprayed over the concrete layer 3 passing through the cooling tubes 4 and serves also to maintain the ice in a proper condition.

Heat transferred to the brine in the cooling tubes 4 from water on the surface of the ice or the ice created is transferred to the primary refrigerant(CO_2) in the evaporator 26. The refrigerant CO_2 evaporates in the evaporator 26 by receiving heat from the brine which received heat from the water on the rink ice and rink ice created. This is shown by a line D→A in FIG.3.

The compressor 21 is driven by the electric motor 22 and compresses CO_2 evaporated in the evaporator 26 to a pressure above critical pressure. The amount of discharge from the compressor can be varied by controlling the rotation speed of the motor 22. The compressed CO_2 reaches a temperature of about 90℃ in the supercritical zone at its discharge side. This is shown by a line A→B in FIG.3. CO_2 reaches its supercritical point at a moderate temperature of 31.3℃ and pressure of 7.3 MPa. Therefore, by using CO_2 as a refrigerant, the refrigerant can be easily brought to a supercritical state of high-temperature and high-pressure.

In the heat exchanger 23, the CO_2 of supercritical state exchanges heat with a heat transfer medium such as low temperature water and raises the temperature of the heat transfer medium to about 80~90℃. In the supercritical zone,

CO_2 can not be discriminated between liquid phase and vapor phase does not condense, and the temperature of the CO_2 in a supercritical state decreases continuously when cooled by the heat medium without condensing at a constant temperature. Therefore, temperature difference is maintained large during it is cooled and transfer of heat from the CO_2 in a supercritical state to the heat medium is performed effectively. Accordingly, by using CO_2 in a supercritical state, the heat medium can be raised to high temperature of 80~90℃ easily. Thus, high temperature water of 70~80℃ required for the ancillary facilities in the ice-skating rink can be produced.

The CO_2 which has given its heat to the heat transfer medium is decreased in temperature as shown by a line B→C in FIG.3.

The CO_2 decreased in temperature in the heat exchanger 23 is expanded and reduced in pressure through the expansion valve 25 located between the heat exchanger 23 and the evaporator 26 to be reduced to wet vapor in a state of 2-phase, i.e. mixture of liquid and vapor and received in the evaporator 26. This is shown by a line C→D in FIG.3.

The heat transfer medium heated to temperature of 80~90℃ in the heat exchanger 23 is introduced to the high temperature heat exchanger 36, where heat exchange is performed between the heat transfer medium of temperature of 80~90℃ and service water supplied to the heat exchanger 36 to produce high temperature water of 70~80℃, which is supplied to the shower bath 13, rest room 15, ice resurfacing vehicle 8, etc., where high temperature water is required. Control of the temperature of high temperature water is performed by providing a temperature indicating and adjusting devices (TIC) at the exit of the service water from the high temperature heat exchanger 36 and providing a control valve at the inlet of the service water to the heat exchanger 36 or at the inlet of the heat medium to the heat exchanger 36 and controlling the flow rate of the service water or the heat medium to the heat exchanger 36.

Further, the heat transfer medium heated to temperature of 80~90℃ is introduced also to the medium temperature heat exchanger 35. In the medium temperature heat exchanger 35 is performed heat exchange between the heat transfer medium raised in temperature to 80~90℃ and water after utilized for the under-rink-floor heating tubes 6, ice shavings melting pit 9, space heating unit 10, etc., which is decreased in temperature to lower than 40℃, the water is raised in temperature to about 40~50℃ to obtain medium temperature water, and the medium temperature water is supplied by means of a medium temperature water pump 39 to the under-rink-floor heating tubes 6, ice shavings melting pit 9, space heating unit 10, etc., where medium temperature water required. The medium temperature water decreased in temperature in places or devices is returned to the medium temperature heat exchanger 35, thus the medium temperature water is again utilized by circulating it. Control of the temperature of medium temperature water is performed by providing a temperature indicating and adjusting devices (TIC) at the exit of the water from the medium temperature heat exchanger 35 and providing a control valve at the inlet of the water to the water heat exchanger 35 or at the inlet of the heat transfer medium to the heat exchanger 35 and controlling the flow rate of the water or the heat transfer medium to the heat exchanger 35. The heat transfer medium decreased in temperature by heat exchange in the high temperature heat exchanger 36 and medium temperature heat exchanger 35 is returned to a liquid tank 32 to be stored there, and introduced by means of a pump 31 to the heat exchanger 23 to be heated again.

It is possible to provide a hot-water boiler 50 as is in the prior art. In this case, when using water as the heat transfer medium heated in the heat exchanger 23, piping for the water can be used in common with water piping of the boiler 50, hot water produced by the hot-water boiler 50 can be used as complementary heat source by providing a first hot-water pump 51.

When a large amount of hot water supply is demanded, it is possible to heat service water directly by the heat exchanger

23 to 80~90℃ for hot water supplying without using the high temperature heat exchanger 36.

[The second embodiment]

A second embodiment of the system for creating ice rink and producing hot water used in an ice-skating rink will be explained with reference to FIGS.2-5. Over all construction of the skating rink and places or devices where high temperature water, medium temperature water, and cold water of the embodiment are similar to those of the conventional ice-skating rink shown in FIG.4 and FIG.5, and explanation of the over all construction is omitted.

FIG.2 shows a system flowchart of the second embodiment for producing high temperature water, medium temperature water and cold brine.

Referring to FIG.2, a brine chiller 20a for producing cold brine for creating rink ice and maintaining the ice in a proper condition and producing hot water comprises a compressor 21, an electric motor 22 for driving the compressor, two heat exchangers 23 and 24 arranged parallel to each other, an expansion valve 25, and an evaporator 26, and a refrigerating cycle is performed by circulating CO_2, which is a natural refrigerant, as a refrigerant.

A secondary refrigerant (brine) supplied from a brine tank 28 to the evaporator 26 by means of a primary brine pump 27 is cooled in the evaporator 26 and returned to the brine tank 28. The cold brine in the brine tank 28 is sent to ice creation cooling tubes 4 by means of a secondary brine pump 29, freezes the water sprayed over the concrete layer 3 passing through the cooling tubes 4 and serves also to maintain the ice in a proper condition.

Heat transferred to the brine in the cooling tubes 4 from water on the surface of the ice or the ice created is transferred to the primary refrigerant(CO_2) in the evaporator 26. The refrigerant CO_2 evaporates in the evaporator 26 by receiving heat from the brine which received heat from the water on the rink ice and rink ice created. This is shown by a line D→A in FIG.3.

The compressor 21 is driven by the electric motor 22 and compresses CO_2 evaporated in the evaporator 26 to a pressure above critical pressure. The amount of discharge from the compressor can be varied by controlling the rotation speed of the motor 22. The compressed CO_2 reaches a temperature of about 90℃ in the supercritical zone at its discharge side. This is shown by a line A→B in FIG.3. CO_2 reaches its supercritical point at a moderate temperature of 31.3℃ and pressure of 7.3 MPa. Therefore, by using CO_2 as a refrigerant, the refrigerant can be easily brought to a supercritical state of high-temperature and high-pressure.

In the heat exchanger 23, the CO_2 of supercritical state exchanges heat with a heat transfer medium heated in the heat exchanger 24 as mentioned later to about 40~50℃ to raise the temperature of the heat transfer medium to about 80~90℃. In the supercritical zone, CO_2 can not be discriminated between liquid phase and vapor phase and does not condense, and the temperature of the CO_2 in a supercritical state decreases continuously when cooled by the heat medium without condensing at a constant temperature. Therefore, temperature difference maintained large during it is cooled and transfer of heat from the CO_2 in a supercritical state to the heat medium is performed effectively. Accordingly, by using CO_2 in a supercritical state, the heat medium can be raised high temperature of 80~90℃ easily. Thus, high temperature water of 70~80℃ required for the ancillary facilities in the ice-skating rink can be produced. The CO_2 refrigerant brought to a supercritical state by the compressor 21 and decreased in temperature in the heat exchanger 23 by heat exchange with the heat transfer medium is introduced to the heat exchanger 24 where the heat transfer medium is heated to about 40~50℃ by heat exchange with the CO_2 refrigerant decreased in temperature introduced from the heat exchanger 23. Thus, by arranging two heat exchangers 23 and 24 in series, hot water of two temperature ranges required for the ancillary facilities can be obtained.

In order to control the temperature of the heat transfer medium exiting the heat exchanger 24 to 40~50℃, there are provided a temperature indicating and adjusting device(TIC) at the exit of the heat transfer medium from the heat exchanger 24 and a control valve at the inlet of the heat transfer medium to the heat exchanger 24, thereby the flow rate of the heat transfer medium introduced to the heat exchanger is controlled. The CO_2 which has given its heat to the heat transfer medium in the heat exchanger 23 and 24 is decreased in temperature as shown by a line B→C in FIG.3.

The CO_2 decreased in temperature in the heat exchanger 23 is expanded and reduced in pressure through the expansion valve 25 located between the heat exchanger 23 and the evaporator 26 to be reduced to wet vapor in a state of 2-phase, i.e. mixture of liquid and vapor and received in the evaporator 26. This is shown by a line C→D in FIG.3.

The heat transfer medium heated to temperature of 80~90℃ in the heat exchanger 23 is introduced to the high temperature heat exchanger 36, where heat exchange is performed between the heat transfer medium of temperature of 80~90℃ and service water supplied to the heat exchanger 36 to produce high temperature water of 70~80℃, which is supplied to the shower bath 13, rest room 15, ice resurfacing vehicle 8, etc., where high temperature water is required. Control of the temperature of high temperature water is performed by providing a temperature indicating and adjusting devices (TIC) at the exit of the service water from the high temperature heat exchanger 36 and providing a control valve at the inlet of the service water to the heat exchanger 36 or at the inlet of the heat medium to the heat exchanger 36 and controlling the flow rate of the service water or the heat medium to the heat exchanger 36.

A part of the heat transfer medium heated to 40~50℃ in the heat exchanger 24 is introduced to the heat exchanger 23, where it is heated to about 80~90℃. The rest of the heat transfer medium is sent to a medium temperature heat medium storage section 32a of a liquid tank 32 which is partitioned with partition wall 32c into two sections of 32a and 32b to be stored therein. The medium temperature heat transfer medium is supplied by means of a secondary pump 34 from the section 32a of the liquid tank 32 to the under-rink-floor heating tubes 6, ice shavings melting pit 9, space heating unit 10, etc., where medium temperature water is required.

The heat transfer medium decreased in temperature in the high temperature heat exchanger 36 and the heat transfer medium after used in the under-rink-floor heating tubes 6, ice shavings melting pit 9, space heating unit 10, etc., which is decreased in temperature, are recovered to the section 32b of the liquid tank 32 to be stored therein, then sent to the heat exchanger 24 by means of a pump 31 to be again heated.

It is possible to provide a hot-water boiler 50 as is in the prior art. In this case, when using water as the heat transfer medium heated in the heat exchanger 23, piping for the water can be used in common with water piping of the boiler 50, hot water produced by the hot-water boiler 50 can be used as complementary heat source by providing a first hot-water pump 51.

CLAIMS

1. A system for creating rink ice and utilizing high-temperature heat generated when creating rink ice, the rink ice being created by spraying water over a base material layer and flowing cold brine through cooling tubes embedded in the base material layer comprising:

a heat pump performing a refrigerating cycle using CO_2 as a refrigerant for producing cold brine and hot water, and

a means for introducing the brine which has worked to freeze the water sprayed over the base material layer and received heat from the water sprayed over the base material layer and the ice created to the heat pump,

whereby the hot water is produced by the heat pump by using heat contained in the brine introduced to the heat pump as a heat source and the brine deprived of the heat in the heat pump is returned to the cooling tubes to be used as the cold brine, thus the cold brine for creating the rink ice and cooling the ice layer created and the hot water to be used in ancillary facilities of the ice-skating rink facility are produced.

2. A system for creating rink ice and utilizing high-temperature heat generated when creating rink ice according to claim 1, wherein said heat pump includes a plurality of heat exchangers for heating water by utilizing CO_2 compressed by a compressor to a supercritical state, the heat exchangers are arranged in series in a discharge side of the compressor, and hot water of different temperature ranges can be obtained separately from each of the heat exchangers.

3. A system for creating rink ice and utilizing high-temperature heat generated when creating rink ice according to claim 2, wherein a conduit is provided to introduce water heated in one of the heat exchangers to the other heat exchanger or exchangers provided nearer the compressor discharge side.

4. A method of creating rink ice and utilizing high-temperature heat generated when creating rink ice, the rink ice being created by spraying water over a base material layer and flowing cold brine through cooling tubes embedded in the base material layer, comprising the steps of:

producing said cold brine by a heat pump performing a refrigerating cycle using CO_2 as a refrigerant, and

introducing said brine to the heat pump, the brine having worked to freeze the water sprayed over the base material layer and receiving heat from the water sprayed on the base material layer and the ice created,

whereby the hot water is produced by the heat pump by introducing the brine containing heat received from the water sprayed over the base material layer and the ice created to the heat pump and utilizing the heat of the brine as a heat source, and the brine deprived of the heat in the heat pump is returned to the cooling tubes to be used as the cold brine, thus the cold brine for creating the rink ice and cooling the ice layer created and the hot water which is to be used in ancillary facilities of the ice-skating rink facility are produced.

5. A method of creating rink ice and utilizing high-temperature heat generated when creating rink ice according to claim 4, wherein said CO_2 refrigerant is evaporated by allowing the refrigerant to receive heat from the brine which received heat from the water sprayed over the base material layer, the evaporated CO_2 is compressed to a supercritical state, and the compressed CO_2 is introduced to a plurality of heat exchangers arranged in series in the discharge side of the compressor to heat water so that hot water of different temperature ranges are obtained by the heat exchangers respectively.

6. A method of creating rink ice and utilizing high-temperature heat generated when creating rink ice according to claim 4, wherein a part of water heated in one of the heat exchangers is introduced to the other heat exchanger or exchangers provided nearer the compressor discharge side so that the water is further heated.

Fig. 1

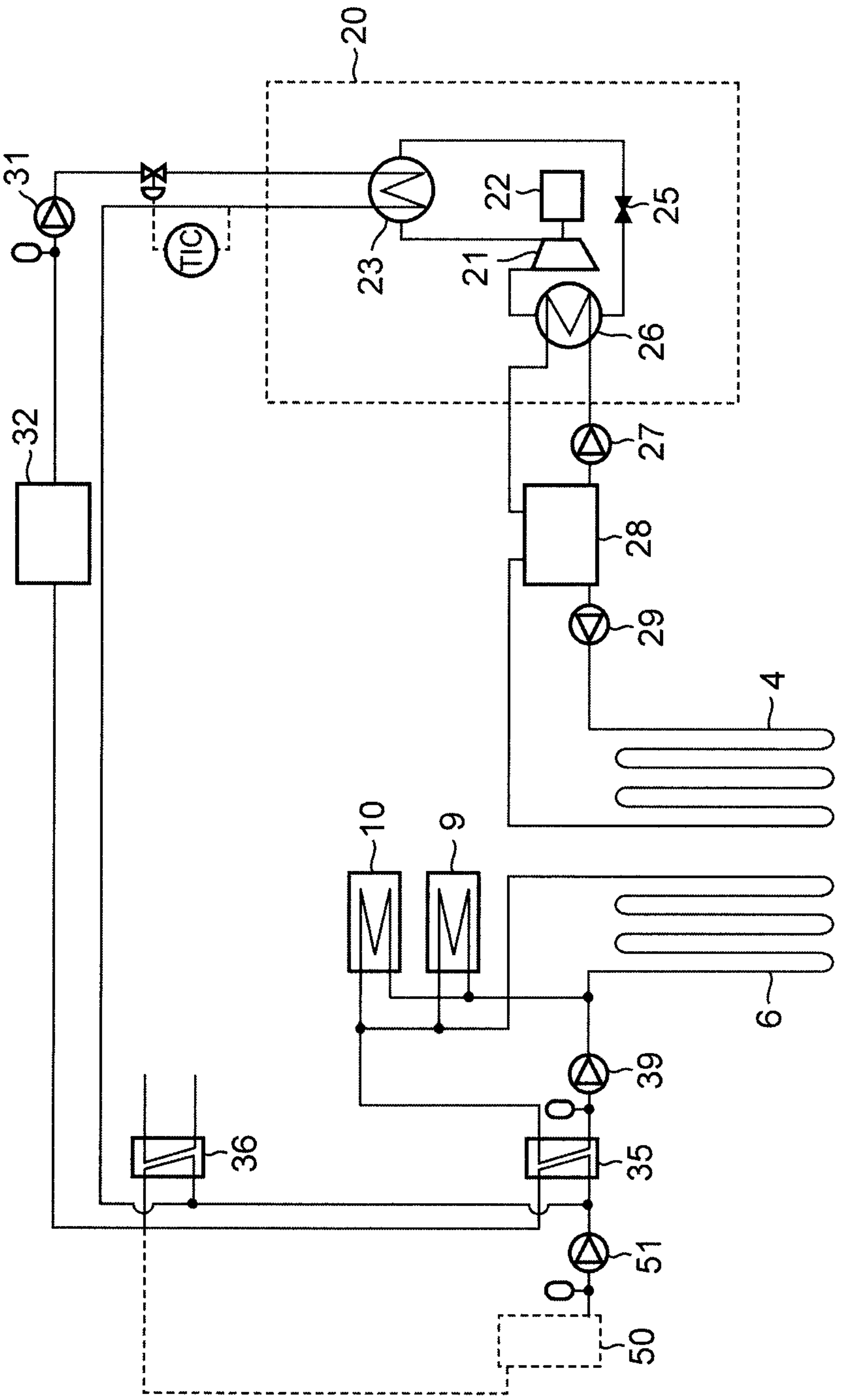


Fig. 2

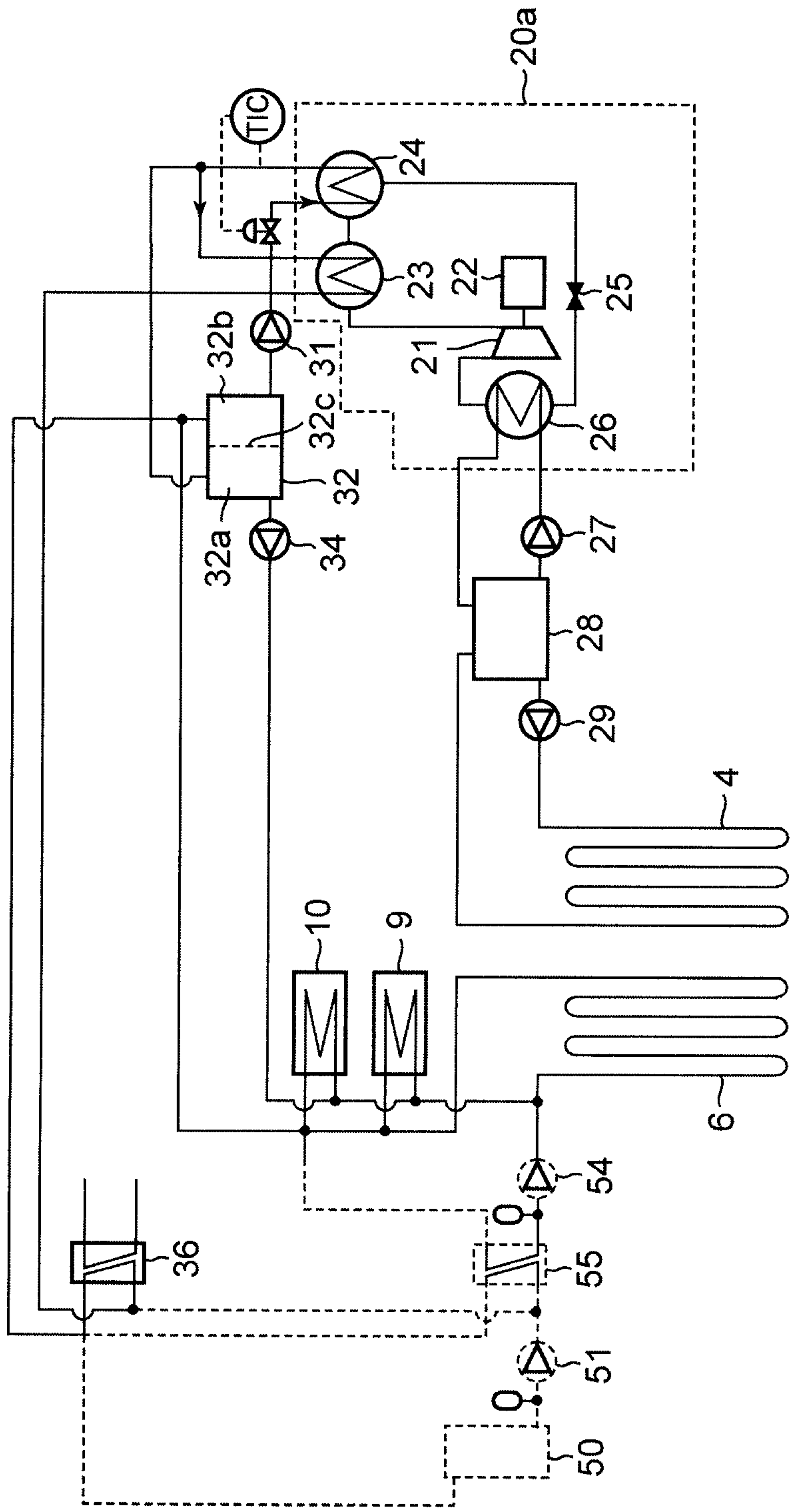

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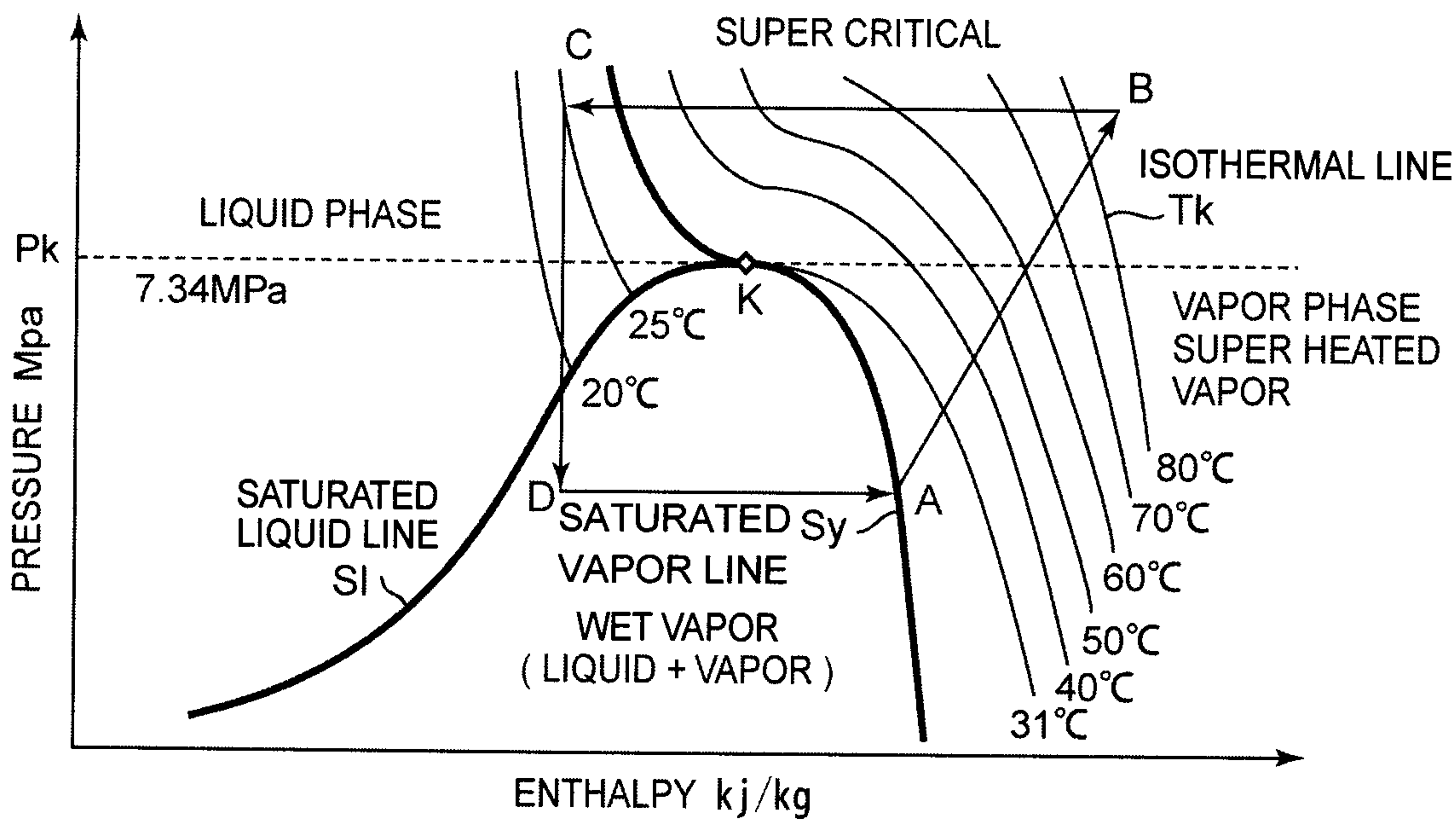
Fig. 3


SUPER CRITICAL
C
B
ISOTHERMAL LINE
Tk
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Pk
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K
25℃
20℃
VAPOR PHASE
SUPER HEATED
VAPOR
80℃
70℃
60℃
50℃
40℃
31℃
SATURATED
LIQUID LINE
Sl
D
SATURATED
VAPOR LINE
Sy
A
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(LIQUID + VAPOR)
PRESSURE Mpa
ENTHALPY kj/kg

Fig. 4

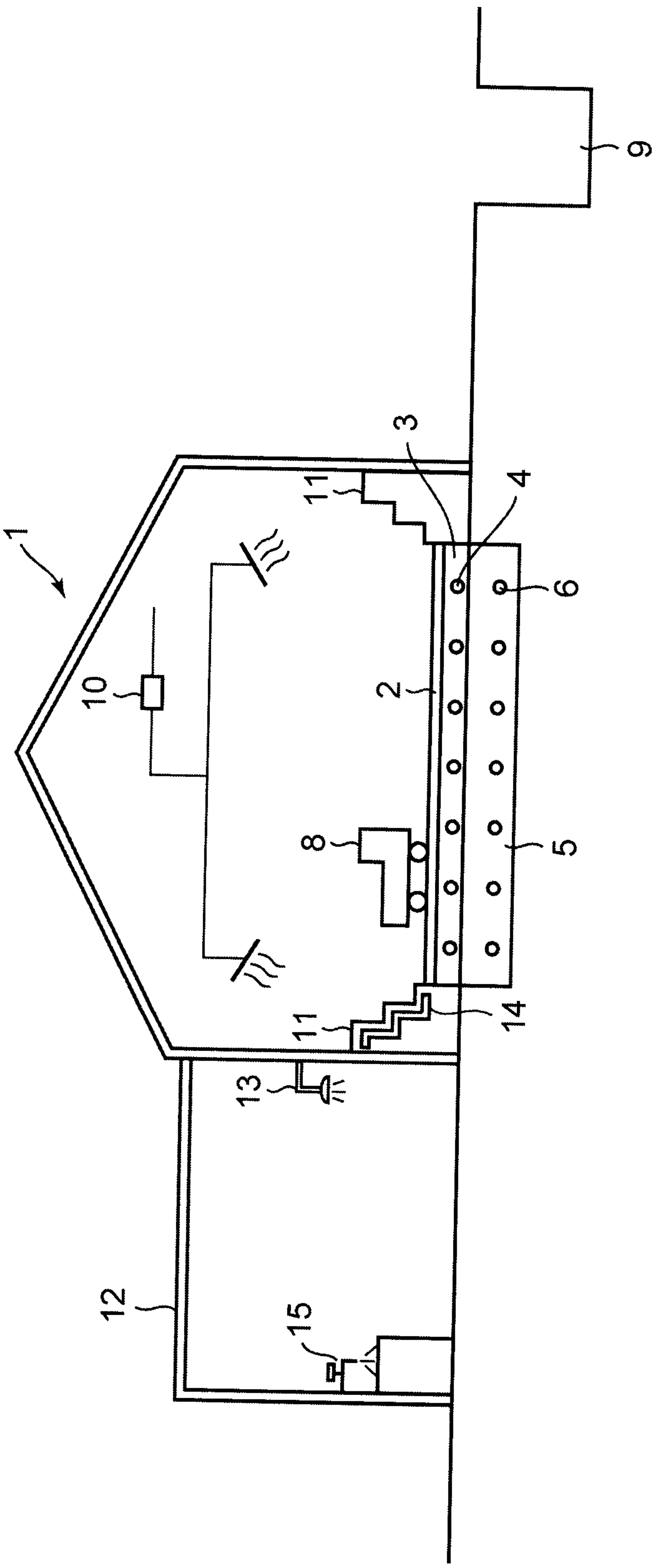


Fig. 5

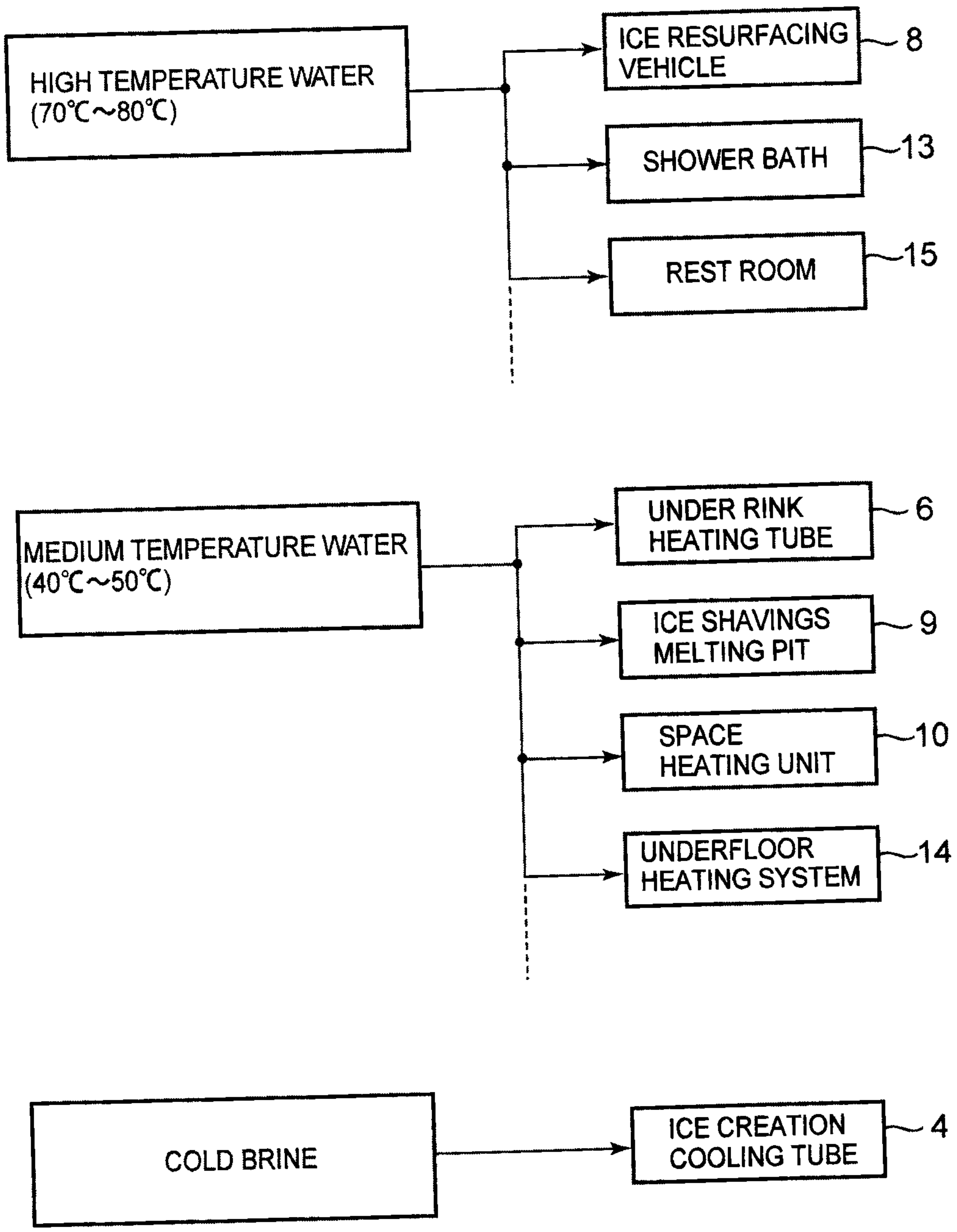
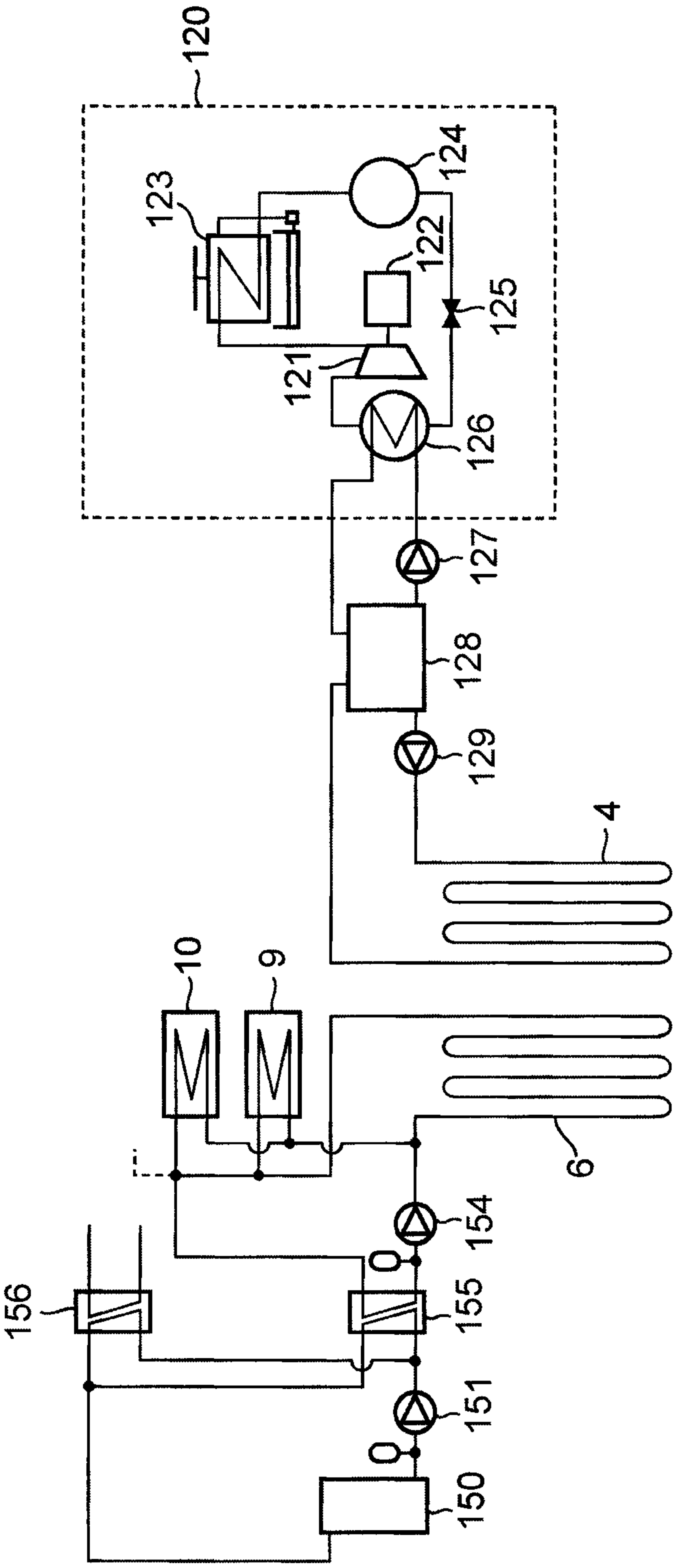

HIGH TEMPERATURE WATER (70℃~80℃)
ICE RESURFACING VEHICLE
8
SHOWER BATH
13
REST ROOM
15
MEDIUM TEMPERATURE WATER (40℃~50℃)
UNDER RINK HEATING TUBE
6
ICE SHAVINGS MELTING PIT
9
SPACE HEATING UNIT
10
UNDERFLOOR HEATING SYSTEM
14
COLD BRINE
ICE CREATION COOLING TUBE
4

Fig. 6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