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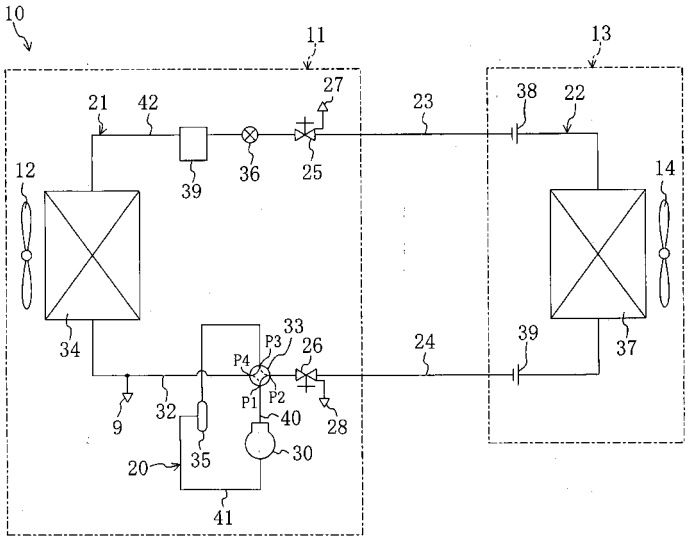
# (54) METHOD OF RECOVERING REFRIGERATOR OIL

(57) A first step and a second step are carried out sequentially. In the first step, via a gas side port **(28)** which is open to the gas side interconnecting line's **(24)** side of the shut-off position of a gas side shut-off valve **(26)** mounted at one end of the heat source side circuit **(21),** refrigeration oil is recovered together with refrigerant present in a portion of the refrigerant circuit **(20)**, which portion is in fluid communication with the gas side port **(28)**. In the second step, via a liquid side port **(27)** which is open to the liquid side interconnecting line's **(23)** side of the shut-off position of a liquid side shut-off valve **(25)** mounted at the other end of the heat source side circuit **(21)**, refrigeration oil is recovered together with a part or all of refrigerant present in a portion of the refrigerant circuit **(20),** which portion is in fluid communication with the liquid side port **(27)**, with the gas side shut-off valve **(26)** placed in the closed state.

FIG. 1

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a method, in a refrigeration system provided with a refrigerant circuit formed by connection of a heat source unit and a utilization unit by means of a gas side interconnecting line and a liquid side interconnecting line, for the recovery of refrigeration oil from these interconnecting lines.

### BACKGROUND ART

**[0002]** With regard to refrigeration systems including a refrigerant circuit which is formed by connection of a heat source unit and a utilization unit by means of interconnecting lines, methods that provide efficient removal of refrigeration oil from within the interconnecting lines have been known heretofore. For example, this type of refrigeration oil recovery method finds application where the heat source and utilization units are replaced with new units, but the existing interconnecting lines are left intact for use with the new units.

**[0003]** Specifically, JP-A-2003-194437 discloses, as a type of the aforesaid refrigeration oil recovery method, a method for the recovery of residual oil. In this residual oil recovery method, following pump-down that allows refrigerant in a refrigerant circuit to collect in a heat source circuit, a refrigerant accommodating operation and a refrigerant filling operation are carried out. In the refrigerant accommodating operation, either one of a liquid side shut-off valve and a gas side shut-off valve is closed whereas the other one of the shut-off valves is opened, and a recovery unit is connected to the port of the closed one of the shut-off valves whereby, together with the refrigerant in the refrigerant circuit, refrigeration oil is recovered. In the refrigerant filling operation, the shut-off valve, which was placed in the closed state in the refrigerant accommodating operation, is opened whereas the shut-off valve, which was placed in the opened state in the refrigerant accommodating operation, is closed. And, the recovery unit accommodating the refrigerant recovered by the refrigerant accommodating operation is connected through a refrigerant regenerator to the port of the shut-off valve being in the closed state. From the recovery unit, the refrigerant is discharged to the refrigerant regenerator for the removal of refrigeration oil. From the refrigerant regenerator, the refrigerant is filled into the refrigerant circuit. In this residual oil recovery method, the refrigerant accommodating operation and the refrigerant filling operation are repeatedly carried out according to need.

### DISCLOSURE OF THE INVENTION

### PROBLEMS THAT THE INVENTION INTENDS TO OVERCOME

**[0004]** Incidentally, the conventional refrigeration oil recovery method requires the carrying out of not only the refrigerant accommodating operation but also the refrigerant filling operation in order that as much as possible of refrigeration oil is recovered from the interconnecting lines. That is, it is necessary to carry out a refrigerant accommodating operation after a refrigerant filling operation and then to carry out another refrigerant accommodating operation, in other words, at least a series of three operations is required to be carried out. This makes the work operation for the recovery of refrigeration oil considerably time consuming.

**[0005]** In view of the above, the present invention was made. Accordingly, an object of the present invention is to achieve, in a refrigeration system provided with a refrigerant circuit formed by connection of a heat source unit and a utilization unit by means of interconnecting lines, the efficient recovery of refrigeration oil from the interconnecting lines while reducing the time required for the recovery of refrigeration oil.

### MEANS FOR OVERCOMING THE PROBLEMS

**[0006]** The present invention provides, as a first aspect, a method, in a refrigeration system **(10)** in which a refrigeration cycle is performed in a refrigerant circuit **(20)** which is formed by connection of a heat source side circuit **(21)** within a heat source unit **(11)** and a utilization side circuit **(22)** within a utilization unit **(13)** by means of a gas side interconnecting line **(24)** and a liquid side interconnecting line **(23),** for the recovery of refrigeration oil from the gas side interconnecting line **(24)** and the liquid side interconnecting line **(23)**. The method according to the first aspect sequentially comprises (i) a first step in which, via a gas side port **(28)** which is open to the gas side interconnecting line's **(24)** side of the shut-off position of a gas side shut-off valve **(26)** mounted at one end of the heat source side circuit **(21),** refrigeration oil is recovered together with a part of refrigerant present in a portion of the refrigerant circuit **(20)**, which portion is in fluid communication with the gas side port **(28)** and (ii) a second step in which, via a liquid side port **(27)** which is open to the liquid side interconnecting line's **(23)** side of the shut-off position of a liquid side shut-off valve **(25)** mounted at the other end of the heat source side circuit **(21),** refrigeration oil is recovered together with a part or all of refrigerant present in a portion of the refrigerant circuit **(20),** which portion is in fluid communication with the liquid side port **(27),** with the gas side shut-off valve **(26)** placed in the closed state.

**[0007]** The present invention provides, as a second aspect according to the aforesaid first aspect, a refrigeration oil recovery method in which the first step is carried out with the gas side shut-off valve **(26)** placed in the closed state.

**[0008]** The present invention provides, as a third aspect according to either the aforesaid first aspect or the aforesaid second aspect, a refrigeration oil recovery method in which the first step and the second step are carried out with the liquid side shut-off valve **(25)** placed in the opened state.

**[0009]** The present invention provides, as a fourth aspect according to any one of the aforesaid first to third aspects, a refrigeration oil recovery method in which, following the completion of the second step, there is performed a third step in which refrigerant in the heat source side circuit **(21)** is recovered.

**[0010]** The present invention provides, as a fifth aspect according to the aforesaid fourth aspect, a refrigeration oil recovery method in which, in the third step, refrigerant in the heat source side circuit **(21)** is recovered via the gas side port **(28)** with gradually opening the gas side shut-off valve **(26).**

**[0011]** The present invention provides, as a sixth aspect according to the aforesaid fourth aspect, a refrigeration oil recovery method in which, in the third step, a first work operation and a second work operation are performed in the former of which refrigerant in the heat source side circuit **(21)** is recovered via a heat source side port **(9)** which is open to the heat source side circuit **(21)** and in the latter of which refrigerant in the heat source side circuit **(21)** is recovered via the gas side port **(28)** with gradually opening the gas side shut-off valve **(26).**

## WORKING OPERATION

**[0012]** In the first aspect of the present invention, the first step and the second step are carried out sequentially. Incidentally, it is normal that, before the first step is carried out, more liquid refrigerant exists in the utilization side circuit **(22)** and the liquid side interconnecting line **(23)** than in the gas side interconnecting line **(24).** If, in this condition, the first step is carried out, then refrigerant is drawn out via the gas side port **(28)** which fluidly communicates with at least the gas side interconnecting line **(24),** the utilization side circuit **(22),** and the liquid side interconnecting line **(23),** thereby causing refrigerant from the utilization side circuit **(22)** and the liquid side interconnecting line **(23)** to flow into the gas side interconnecting line **(24)**. As a result, refrigeration oil adhering to the gas side interconnecting line **(24)** is removed therefrom by the flow of the refrigerant. Together with the refrigerant, the refrigeration oil thus removed is recovered via the gas side port **(28).**

**[0013]** The state at the point of time of the completion of the first step is that there is refrigerant remaining in the liquid side interconnecting line **(23),** the utilization side circuit **(22),** and the gas side interconnecting line **(24)** in the refrigerant circuit **(20).** If, in this condition, the second step is carried out, then refrigerant is drawn out via the liquid side port **(27)** which fluidly communicates with at least the liquid side interconnecting line **(23)**, the utilization side circuit **(22),** and the gas side interconnecting line **(24),** thereby causing refrigerant from the gas side interconnecting line's **(24)** side to flow into the liquid side interconnecting line **(23).** As a result, refrigeration oil adhering to the liquid side interconnecting line **(23)** is removed therefrom by the flow of the refrigerant. Together with the refrigerant, the refrigeration oil thus removed is recovered via the liquid side port **(27).** Since, in the second step, the gas side shut-off valve **(26)** is placed in the closed state, neither refrigerant nor refrigeration oil will flow into the gas side interconnecting line **(24)** from the heat source side circuit **(21).**

**[0014]** If, in each interconnecting line **(23, 24)** in the first and second steps, refrigerant is drawn out via a port **(27, 28)** positioned nearer thereto, this provides less energy loss thereby increasing the flow velocity of refrigerant. Therefore, refrigerant adhering to the gas side interconnecting line **(24)** is removed in larger quantity in the first step in which refrigerant is drawn out via the gas side port **(28)**. On the other hand, refrigerant adhering to the liquid side interconnecting line **(23)** is removed in larger quantity in the second step in which refrigerant is drawn out via the liquid side port **(27)**. In the first aspect of the present invention, the first and second steps use different ports (the ports **(27, 28))** for the drawing out of refrigerant, whereby relatively large amounts of refrigeration oil can be removed from each interconnecting line **(27, 28).**

**[0015]** In the first step of the second aspect of the present invention, refrigerant is drawn out via the gas side port **(28),** with the gas side shut-off valve **(26)** placed in the closed state. Therefore, the refrigerant in the heat source side circuit **(21)** is not drawn out via the gas side port **(28)** by way of the gas side shut-off valve **(26)**.

**[0016]** In the first step of the third aspect of the present invention, the gas side port **(28)** enters a state of fluid communication not only with the gas side interconnecting line **(24),** the utilization side circuit **(22)**, and the liquid side interconnecting line **(23)** but also with the heat source side circuit **(21)** through the liquid side shut-off valve **(25).** In this condition, refrigerant is drawn out via the gas side port **(28)** in the first step. Since, in the first step, refrigerant in the heat source side circuit **(21)** flows through the liquid side shut-off valve **(25)** into the utilization unit's **(13)** side, this increases the amount of refrigerant which flows back and forth on the utilization unit's **(13)** side between the gas side port **(28)** and the liquid side port **(27)** in the first and second steps, in comparison with the case where the first step is carried out, with the liquid side shut-off valve **(25)** placed in the closed state.

**[0017]** In the fourth aspect of the present invention, refrigerant in the heat source side circuit **(21)** is recovered in the third step following the second step. This reduces the amount of refrigerant which will remain in the heat source side circuit **(21)** after the carrying out of the refrigeration oil recovery method.

**[0018]** In the third step of the fifth aspect of the present invention, there is carried out a work operation by which to recover refrigerant in the heat source side circuit **(21)**

via the gas side port **(28)** with gradually opening the gas side shut-off valve **(26).** Here, there is a possibility that there may be a pressure difference across the gas side shut-off valve **(26)** before the third step is started, in other words, the pressure on the side of the gas side interconnecting line **(24)** after the recovery of refrigerant and refrigeration oil therefrom in the first and second steps may be lower than the pressure on the side of the heat source side circuit **(21).** And, if, in such a condition, the gas side shut-off valve **(26)** is rapidly opened, this causes refrigerant and refrigeration oil in the heat source side circuit **(21)** to flow into the gas side interconnecting line **(24).** In the fifth aspect of the present invention, however, the recovery of refrigerant is carried out with gradually opening the gas side shut-off valve **(26),** thereby suppressing refrigerant and refrigeration oil in the heat source side circuit **(21)** from flowing into the gas side interconnecting line **(24).**

**[0019]** In the sixth aspect of the present invention, refrigerant in the heat source side circuit **(21)** is recovered via the heat source side port **(9)** and the gas side port **(28).** As a result, the amount of refrigerant which will remain in the heat source side circuit **(21)** after the carrying out of the refrigeration oil recovery method is reduced to a further extent. In addition, like the fifth aspect of the present invention, there is performed a work operation by which to recover refrigerant in the heat source side circuit **(21)** via the gas side port **(28)** with gradually opening the gas side shut-off valve **(26)**, thereby suppressing refrigerant and refrigeration oil in the heat source side circuit **(21)** from flowing into the gas side interconnecting line **(24).**

## ADVANTAGEOUS EFFECTS OF THE INVENTION

**[0020]** In the first step of the present invention, refrigerant is drawn out via the gas side port **(28)** thereby mainly removing refrigeration oil adhering to the gas side interconnecting line **(24)** while, in the second step, refrigerant is drawn out via the liquid side port **(27)** thereby mainly removing refrigeration oil adhering to the liquid side interconnecting line **(23).** This is, if all refrigerant is drawn out via a port **(27, 28),** this impedes the recovery of refrigeration oil from an interconnecting line **(23, 24)** on the opposite side to the drawing-out port **(27, 28).** In the present invention, however, the first step in which refrigerant is drawn out via the gas side port **(28)** and the second step in which refrigerant is drawn out via the liquid side port **(27)** are carried out, thereby making it possible to recover refrigeration oil in relatively large amounts from the respective interconnecting lines **(23, 24).** In addition, a series of at least three or more work operations is required in a conventional method in which a refrigerant filling work operation is carried out in order to increase the recovery amount of refrigeration oil. In the method of the present invention, however, it is possible to achieve the efficient recovery of refrigeration oil from the gas side interconnecting line **(24)** and the liquid side interconnecting line **(23)** by performing only a series of two work operations, i.e., the first step and the second step. Besides, no refrigerant is filled and the recovery amount of refrigerant is reduced accordingly. This makes it possible to shorten the time taken for the recovery of refrigerant. Therefore, the present invention makes it possible to not only reduce the time taken for the recovery of refrigeration oil but also at the same time achieve the efficient recovery of refrigeration oil.

**[0021]** In addition, in the first step of the second aspect of the present invention, the gas side shut-off valve **(26)** is placed in the closed state thereby ensuring that refrigerant in the heat source side circuit **(21)** is prevented from being drawn out via the gas side port **(28)** by way of the gas side shut-off valve **(26)**. Therefore, the flow velocity of refrigerant in the gas side interconnecting line **(24)** is increased relative to the case where the first step is carried out with the gas side shut-off valve **(26)** placed in the opened state, and as a result, more refrigeration oil will be removed and recovered from the gas side interconnecting line **(24).**

**[0022]** In addition, in the third aspect of the present invention, the first step is carried out with the liquid side shut-off valve **(25)** placed in the opened state whereby the amount of refrigerant which flows back and forth on the utilization unit's **(13)** side between the gas side port **(28)** and the liquid side port **(27)** increases in the first and second steps. That is, the total of the amount of refrigerant circulating through the gas side interconnecting line **(24)** and the amount of refrigerant circulating through the liquid side interconnecting line **(23)** will increase. Therefore, refrigeration oil can be removed in still larger quantity and recovered from the gas side interconnecting line **(24)** and the liquid side interconnecting line **(23).**

**[0023]** In addition, in the fourth aspect of the present invention, by the carrying out of the third step for the recovery of refrigerant from the heat source side circuit **(21),** the amount of refrigerant remaining in the heat source side circuit **(21)** after the refrigeration oil recovery method is performed is reduced. Therefore, when removing and replacing the heat source unit **(11)** with a new unit, the time taken for the recovery of refrigerant from the removed heat source unit **(11)** can be saved or reduced. In addition, when replacing refrigerant in the refrigerant circuit **(20)** with new refrigerant, it becomes possible to enhance the reliability of the refrigeration system **(10).**

**[0024]** Additionally, it is arranged in the fifth aspect of the present embodiment such that, in the third step, the work operation for the recovery of refrigerant from the heat source side circuit **(21)** via the gas side port **(28)** is carried out with gradually opening the gas side shut-off valve **(26),** thereby preventing refrigerant and refrigeration oil in the heat source side circuit **(21)** from flowing into the gas side interconnecting line **(24)** from which refrigerant and refrigeration oil have been recovered. Therefore, it becomes possible to avoid the occurrence of a situation where the recovery of refrigerant and re-

frigeration oil from the gas side interconnecting line **(24)** is required after the third step is carried out.

**[0025]** In addition, in accordance with the sixth aspect of the present invention, refrigerant in the heat source side circuit **(21)** is recovered via the heat source side port **(9)** and the gas side port **(28)** whereby the amount of refrigerant remaining in the heat source side circuit **(21)** after the refrigeration oil recovery method is carried out is further reduced. Therefore, when removing and replacing the heat source unit **(11)** with a new unit, the time taken for the recovery of refrigerant from the removed heat source unit **(11)** can be saved or further reduced. In addition, when replacing refrigerant in the refrigerant circuit **(20)** with new refrigerant, it becomes possible to further enhance the reliability of the refrigeration system **(10).** Besides, like the fifth aspect of the present invention, the work operation for the recovery of refrigerant from the heat source side circuit **(21)** via the gas side port **(28)** is carried out with gradually opening the gas side shut-off valve **(26)** whereby it becomes possible to avoid the occurrence of a situation where the recovery of refrigerant and refrigeration oil from the gas side interconnecting line **(24)** is required after the third step is carried out.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0026]**

Figure **1** is a schematic block diagram of a refrigeration system according to an embodiment of the present invention.

Figure **2** is a schematic block diagram of the refrigeration system of the embodiment that illustrates a first step.

Figure **3** is a schematic block diagram of the refrigeration system of the embodiment that illustrates a second step.

## REFERENCE NUMERALS IN THE DRAWINGS

**[0027]**

9 heat source side port

10 refrigeration system

11 outdoor unit (heat source unit)

13 indoor unit (indoor unit)

20 refrigerant circuit

21 outdoor circuit (heat source side circuit)

22 indoor circuit (utilization side circuit)

23 liquid side interconnecting line

24 gas side interconnecting line

25 liquid side shut-off valve

26 gas side shut-off valve

27 liquid side service port (liquid side port)

28 gas side service port (gas side port)

## BEST MODE FOR CARRYING OUT THE INVENTION

**[0028]** The following is a description of an embodiment of the present invention. And, in the following, an air conditioning system, as a refrigeration system to which a refrigeration oil recovery method according to the present invention is applied, is first described, which is then followed by a description of the refrigeration oil recovery method of the present invention.

## CONFIGURATION OF THE REFRIGERATION SYSTEM

**[0029]** Figure 1 is a schematic block diagram of a refrigeration system **(10)** according to the present embodiment. This refrigeration system **(10)** is an air conditioning system including an outdoor unit **(11)** serving as a heat source unit and an indoor unit **(13)** serving as a utilization unit. The refrigeration system **(10)** is selectively operable either in a cooling mode or in a heating mode. It should be understood that a plurality of indoor units **(13)** can be provided.

**[0030]** An outdoor circuit **(21)** serving as a heat source side circuit is arranged within the outdoor unit **(11).** Arranged within the indoor unit **(13)** is an indoor circuit **(22)** serving as a utilization side circuit. In the refrigeration system **(10),** the outdoor circuit **(21)** and the indoor circuit **(22)** are connected together by means of a liquid side interconnecting line **(23)** and a gas side interconnecting line **(24)** to form a refrigerant circuit **(20)** in which a vapor compression refrigerating cycle is carried out.

## OUTDOOR UNIT

**[0031]** The outdoor circuit **(21)** of the outdoor unit **(11)** includes a compressor **(30)**, a four-way selector valve **(33),** an outdoor heat exchanger **(34)**, an expansion valve **(36)**, a receiver **(39)**, and an accumulator **(35).** Mounted at one end of the outdoor circuit **(21)** is a liquid side shut-off valve **(25)** to which the liquid side interconnecting line **(23)** is connected. Mounted at the other end of the outdoor circuit **(21)** is a gas side shut-off valve **(26)** to which the gas side interconnecting line **(24)** is connected.

**[0032]** The liquid side shut-off valve **(25)** is provided with a liquid side service port **(27).** The liquid side service port **(27)** is open to the liquid side interconnecting line's

**(23)** side of the shut-off position of the liquid side shut-off valve **(25)**. On the other hand, the gas side shut-off valve **(26)** is provided with a gas side service port **(28).** The gas side service port **(28)** is open to the gas side interconnecting line's **(24)** side of the shut-off position of the gas side shut-off valve **(26).** These ports **(27, 28)** are used when recovering refrigerant and refrigeration oil from within the refrigerant circuit **(20)** and when filling the refrigerant circuit **(20)** with refrigerant, and are placed in the closed state in the cooling mode and the heating mode.

**[0033]** The compressor **(30)** is configured as a hermetic, high-pressure dome compressor. The outlet side of the compressor **(30)** is connected through an outlet pipe **(40)** to a first port (P1) of the four-way selector valve **(33)**. The inlet side of the compressor **(30)** is connected through an inlet pipe **(41)** to a third port (P3) of the four-way selector valve **(33)**.

**[0034]** The outdoor heat exchanger **(34)** is configured as a fin and tube heat exchanger of the cross fin type. An outdoor fan **(12)** is arranged in the vicinity of the outdoor heat exchanger **(34).** In the outdoor heat exchanger **(34)**, heat exchange takes place between the outdoor air supplied by the outdoor fan **(12)** and the circulating refrigerant. One end of the outdoor heat exchanger **(34)** is connected through a connection line **(32)** to a fourth port (P4) of the four-way selector valve **(33).** The other end of the outdoor heat exchanger **(34)** is connected through a liquid line **(42)** to the liquid side shut-off valve **(25)**. In addition, connected to a second port (P2) of the four-way selector valve **(33)** is the gas side shut-off valve **(26).**

**[0035]** The connection line **(32)** is provided with a heat source side port **(9)** which is open to the connection line **(32)**. The heat source side port **(9)** is used when refrigerant in the heat source side circuit **(21)** is recovered in a third step (described later). The heat source side port **(9)** is placed in the closed state in the cooling mode and the heating mode.

**[0036]** In the liquid line **(42),** the receiver **(39)** and the expansion valve **(36)** are arranged sequentially in that order from the outdoor heat exchanger's **(34)** side. The receiver **(39)** is shaped like a hermetic container and is configured such that it can temporarily store high pressure refrigerant condensed in the outdoor heat exchanger **(34)**. The expansion valve **(36)** is configured as an opening-degree variable electronic expansion valve.

**[0037]** The accumulator **(35)** is disposed in the inlet pipe **(41).** The accumulator **(35)** is shaped like a hermetic container, and is configured such that it separates liquid refrigerant from refrigerant flowing towards the compressor **(30)** and stores therein the separated liquid refrigerant so that no liquid refrigerant will be drawn into the compressor **(30).**

**[0038]** The four-way selector valve **(33)** is selectively switchable either in a first state (indicated by solid line in Figure **1**) or in a second state (indicated by broken line in Figure **1**). When the four-way selector valve **(33)** is placed in the first state, the first port (P1) and the second port (P2) are in fluid communication with each other and the third port (P3) and the fourth port (P4) are in fluid communication with each other. On the other hand, when the four-way selector valve **(33)** is placed in the second state, the first port (P1) and the fourth port (P4) are in fluid communication with each other and the second port (P2) and the third port (P3) are in fluid communication with each other.

## INDOOR UNIT

**[0039]** The indoor circuit **(22)** of the indoor unit **(13)** is provided with an indoor heat exchanger **(37).** A liquid side flare joint **(38)** to which is connected the liquid side interconnecting line **(23)** is mounted at one end of the indoor circuit **(22).** A gas side flare joint **(39)** to which is connected the gas side interconnecting line **(24)** is mounted at the other end of the indoor circuit **(22).**

**[0040]** The indoor heat exchanger **(37)** is configured as a fin and tube heat exchanger of the cross fin type. An indoor fan **(14)** is disposed in the vicinity of the indoor heat exchanger **(37).** In the indoor heat exchanger **(37),** heat exchange takes place between the indoor air supplied by the indoor fan **(14)** and the circulating refrigerant.

## RUNNING OPERATION OF THE REFRIGERATION SYSTEM

**[0041]** Next, the refrigeration system **(10)** will be described in terms of its running operation. The refrigeration system **(10)** is allowed to be selectively operable either in a cooling mode or in a heating mode by changing the state of the four-way selector valve **(33).**

## COOLING MODE

**[0042]** In the cooling mode, the four-way selector valve **(33)** is placed in the second state. And, in this condition, the compressor **(30)** is set in operation. In the refrigerant circuit **(20),** a vapor compression refrigerating cycle, in which the outdoor heat exchanger **(34)** becomes a condenser and the indoor heat exchanger **(37)** becomes an evaporator, is performed. In addition, the degree of opening of the expansion valve **(36)** is adjusted suitably in the cooling mode.

**[0043]** More specifically, refrigerant discharged from the compressor **(30)** exchanges heat with the outdoor air in the outdoor heat exchanger **(34)** and condenses. The refrigerant condensed in the outdoor heat exchanger **(34)** is pressure reduced during its passage through the expansion valve **(36)**, exchanges heat with the indoor air in the indoor heat exchanger **(37),** and evaporates. The refrigerant evaporated in the indoor heat exchanger **(37)** is drawn into the compressor **(30)** to be compressed.

## HEATING MODE

**[0044]** In the heating mode, the four-way selector valve **(33)** is placed in the first state. And, in this condition, the compressor **(30)** is set in operation. In the refrigerant circuit **(20),** a vapor compression refrigerating cycle, in which the outdoor heat exchanger **(34)** becomes an evaporator and the indoor heat exchanger **(37)** becomes a condenser, is performed. Also in the heating mode, the degree of opening of the expansion valve **(36)** is adjusted suitably.

**[0045]** More specifically, refrigerant discharged from the compressor **(30)** exchanges heat with the indoor air in the indoor heat exchanger **(37)** and condenses. The refrigerant condensed in the indoor heat exchanger **(37)** is pressure reduced during its passage through the expansion valve **(36)**, exchanges heat with the outdoor air in the outdoor heat exchanger **(34)**, and evaporates. The refrigerant evaporated in the outdoor heat exchanger **(34)** is drawn into the compressor **(30)** to be compressed.

## METHOD FOR THE RECOVERY OF REFRIGERATION OIL

**[0046]** Next, the following is a description of a method of the present invention for the recovery of refrigeration oil from the gas side interconnecting line **(24)** and the liquid side interconnecting line **(23)** in the refrigeration system **(10).** This refrigeration oil recovery method finds application where the outdoor unit **(11)** and the indoor unit **(13)** are replaced with new units, but the gas side interconnecting line **(24)** and the liquid side interconnecting line **(23)** are left intact for use with the new units, or where the refrigerant in the refrigerant circuit **(20)** is replaced with new refrigerant. This refrigeration oil recovery method includes a first step, a second step, and a third step which are carried out sequentially in that order. Each step will be described below.

## FIRST STEP

**[0047]** In the first step, the gas side shut-off valve **(26)** is placed in the closed state and the liquid side shut-off valve **(25)** is placed in the opened state. The four-way selector valve **(33)** and the expansion valve **(36)** in the outdoor circuit **(21)** remain unchanged in state from that when the operation of the refrigeration system **(10)** was last terminated, because these valves are not subjected to special adjustment. In this condition, the gas side service port **(28)** is in fluid communication with the gas side interconnecting line **(24**), the indoor circuit **(22),** and the liquid side interconnecting line **(23),** and is also in fluid combination through the liquid side shut-off valve **(25)** with the outdoor circuit **(21).**

**[0048]** And, referring to Figure **2,** there is shown a refrigerant recovery unit **(45)** which is connected to the gas side service port **(28).** The refrigerant recovery unit **(45)** is a unit provided with a vacuum pump and a recovery container. The refrigerant recovery unit **(45)** is configured such that it can hold refrigerant drawn, by the vacuum pump, into the recovery container. With the refrigerant recovery unit **(45)** connected to the gas side service port **(28)**, the vacuum pump of the refrigerant recovery unit **(45)** is set in operation.

**[0049]** It is normal that, before the vacuum pump is started, more liquid refrigerant exists in the indoor circuit **(22)** and the liquid side interconnecting line **(23)** than in the gas side interconnecting line **(24).** Upon setting, in this condition, the vacuum pump in operation, refrigerant in the portion of the refrigerant circuit **(20)** that is being in fluid communication with the gas side service port **(28)** travels in the direction of the gas side service port **(28)**. With the operation of the vacuum pump, refrigerant in the indoor circuit **(22)** and the liquid side interconnecting line **(23)** flows, without change in state or in the gas/liquid two-phase state, into the gas side interconnecting line **(24)**. And, refrigeration oil adhering to the gas side interconnecting line **(24)** is absorbed into the liquid refrigerant (or the refrigerant in the gas/liquid two-phase state) or washed away by the flow of the refrigerant. As a result, the refrigeration oil adhering to the gas side interconnecting line **(24)** is removed therefrom. The removed refrigeration oil is recovered via the gas side service port **(28)** together with the refrigerant. In the first step, the vacuum pump is operated for a predetermined length of time (for example, for one (1) minute). The length of time for which the vacuum pump is to be operated is determined such that not all the refrigerant in the portion of the refrigerant circuit **(20)** in fluid communication with the gas side service port **(28)** will have been recovered therefrom. At the point in time when the first step is completed, the state is that in which refrigerant remains in the liquid side interconnecting line **(23),** the indoor circuit **(22),** and the gas side interconnecting line **(24)** in the refrigerant circuit **(20)**.

## SECOND STEP

**[0050]** In the second step, the gas side shut-off valve **(26)** is placed in the closed state and the liquid side shut-off valve **(25)** is placed in the opened state, as in the first step. In this condition, the liquid side service port **(27)** is in fluid communication with both sides of the shut-off position of the liquid side shut-off valve **(25).** That is, the liquid side service port **(27)** is in fluid communication with the liquid side interconnecting line **(23),** the indoor circuit **(22)**, and the gas side interconnecting line **(24),** and is also in fluid communication with the outdoor circuit **(21).** And, as shown in Figure 3, the refrigerant recovery unit **(45)** detached from the gas side service port **(28)** is connected to the liquid side service port **(27)**, and the vacuum pump of the refrigerant recovery unit **(45)** is set in operation.

**[0051]** Upon setting the vacuum pump in operation, refrigerant in the portion of the refrigerant circuit **(20)** that is being in fluid communication with the liquid side service

port **(27)** travels in the direction of the liquid side service port **(27).** With the operation of the vacuum pump, liquid refrigerant (refrigerant in the gas/liquid two-phase state) in the indoor circuit **(22)** and the gas side interconnecting line **(24)** flows into the liquid side interconnecting line **(23)**. And, refrigeration oil adhering to the liquid side interconnecting line **(23)** is absorbed into the liquid refrigerant (the refrigerant in the gas/liquid two-phase state) or washed away by the flow of the refrigerant. As a result, the refrigeration oil adhering to the liquid side interconnecting line **(23)** is removed therefrom. The removed refrigeration oil is recovered, together with the refrigerant, via the liquid side service port **(27).** In the second step, the vacuum pump is operated until the pressure, which is measured at the liquid side service port **(27),** falls below a first predetermined pressure value, in order that most of the refrigerant on the side of the indoor unit **(13)** with reference to the gas side shut-off valve **(26)** and the liquid side shut-off valve **(25)** may be recovered.

**THIRD STEP**

**[0052]** In the third step, a first work operation and a second work operation are carried out. In the first work operation, the gas side shut-off valve **(26)** is placed in the closed state and the liquid side shut-off valve **(25)** is placed in the opened state, as in the first and second steps. And, the refrigerant recovery unit **(45)** detached from the liquid side service port **(27)** is now connected to the heat source side port **(9)**, and the vacuum pump of the refrigerant recovery unit **(45)** is set in operation. Upon setting the vacuum pump in operation, refrigerant in the outdoor circuit **(21)** is recovered. In the first work operation, the vacuum pump is operated until the pressure, which is measured at the heat source side port **(9),** falls below a second predetermined value which is smaller than the first pressure value.

**[0053]** Here, there is a possibility that refrigerant on the side of the gas side shut-off valve **(26)** in the outdoor circuit **(21)** with reference to the compressor **(30)** (that is, refrigerant present between the outlet of the compressor **(30)** and the gas side shut-off valve **(26)** when the four-way selector valve **(33)** is placed in the first state or refrigerant present between the inlet of the compressor **(30)** and the gas side shut-off valve **(26)** when the four-way selector valve **(33)** is placed in the second state) may not be recovered completely by the first work operation alone. To cope with this, the second work operation is carried out. In the second work operation, the refrigerant recovery unit **(45)** detached from the heat source side port **(9)** is now connected to the gas side service port **(28).** And, the gas side shut-off valve **(26)** is closed and the liquid side shut-off valve **(25)** is opened. In this condition, the vacuum pump is set in operation with gradually opening the gas side shut-off valve **(26).** When the vacuum pump starts operating, refrigerant lingering in the outdoor circuit **(21)** after the carrying out of the first work operation is recovered. In the second work operation, the vacuum pump is operated until the pressure, which is measured at the gas side service port **(28),** falls below a third predetermined pressure value which is smaller than the second pressure value. Therefore, most of the refrigerant in the outdoor circuit **(21)** is recovered.

**[0054]** The reason for carrying out the second work operation with gradually opening the gas side shut-off valve **(26)** is to prevent refrigerant and refrigeration oil in the outdoor circuit **(21)** from flowing into the gas side interconnecting line **(24).** That is, after the first work operation is carried out, there is a possibility that there may be a pressure difference across the gas side shut-off valve **(26)**, in other words, the pressure on the side of the gas side interconnecting line **(24)** may be lower than the pressure on the side of the outdoor circuit **(21)**. And, in this case, if the gas side shut-off valve **(26)** is opened rapidly, this causes refrigerant and refrigeration oil in the outdoor circuit **(21)** to flow into the gas side interconnecting line **(24)** from which refrigerant and refrigeration oil have already been recovered. Therefore, the second work operation is carried out with gradually opening the gas side shut-off valve **(26).**

**[0055]** In the present embodiment, if, in each interconnecting line **(23, 24)** in the first and second steps, refrigerant is drawn out via a port **(27, 28)** positioned nearer thereto, this provides less energy loss thereby increasing the flow velocity of refrigerant. Therefore, refrigerant adhering to the gas side interconnecting line **(24)** is removed in larger quantity in the first step in which refrigerant is drawn out via the gas side service port **(28).** On the other hand, refrigerant adhering to the liquid side interconnecting line **(23)** is removed in larger quantity in the second step in which refrigerant is drawn out via the liquid side service port **(27).** In the present embodiment, refrigerant is drawn out via different ports in the first and second steps, in other words, refrigerant is drawn out via the port **(28)** in the first step whereas in the second step refrigerant is drawn out via the port **(27)**, whereby relatively large amounts of refrigeration oil can be removed from each interconnecting line **(27,28).**

**[0056]** In addition, in the present embodiment, the gas side shut-off valve **(26)** is placed in the closed state in the first step, which prevents refrigerant in the outdoor circuit **(21)** from being drawn out via the gas side service port **(28)** by way of the gas side shut-off valve **(26)**. Besides, since the liquid side shut-off valve **(25)** is placed in the opened state in the first step, refrigerant in the outdoor circuit **(21)** flows through the liquid side shut-off valve **(25)** into the indoor unit's **(13)** side. Therefore, in comparison with the case where the first step is carried out with the liquid side shut-off valve **(25)** placed in the closed state, the amount of refrigerant which flows back and forth on the indoor unit's **(13)** side between the gas side service port **(28)** and the liquid side service port **(27)** in the first and second steps is increased.

## ADVANTAGEOUS EFFECTS OF THE EMBODIMENT

**[0057]** In the first step of the present embodiment, refrigerant is drawn out via the gas side service port **(28)** thereby removing refrigeration oil adhering to the gas side interconnecting line **(24)** while in the second step, refrigerant is drawn out via the liquid side service port **(27)** thereby mainly removing refrigeration oil adhering to the liquid side interconnecting line **(23)**. To sum up, if all of the refrigerant is drawn out via a port **(27, 28),** this impedes the recovery of refrigeration oil in an interconnecting line **(23, 24)** on the opposite side to the drawing-out port **(27, 28).** In the present embodiment, however, the first step in which refrigerant is drawn out via the gas side service port **(28)** and the second step in which refrigerant is drawn out via the liquid side service port **(27)** are carried out thereby making it possible to recover refrigeration oil in relatively large amounts from the respective interconnecting lines **(23, 24)**. In addition, a series of at least three or more work operations are required in a conventional method in which a refrigerant filling work operation is carried out in order to increase the recovery amount of refrigeration oil. In the method of the present invention, however, it is possible to achieve the efficient recovery of refrigeration oil from the gas side interconnecting line **(24)** and the liquid side interconnecting line **(23)** by performing only a series of two work operations, i.e., the first step and the second step. Besides, no refrigerant is filled and the recovery amount of refrigerant is reduced accordingly. This makes it possible to shorten the time taken for the recovery of refrigerant. Therefore, it becomes possible to not only reduce the time taken for the recovery of refrigeration oil but also at the same time achieve the efficient recovery of refrigeration oil.

**[0058]** In addition, in the present embodiment, there is no need for the carrying out of pump-down to collect refrigerant in the refrigerant circuit **(20)** into the outdoor circuit **(21)**. Additionally, since no pump down is carried out, this makes it possible to carry out a work operation of the recovery of refrigeration oil even when the compressor **(30)** breaks down.

**[0059]** Furthermore, in the first step of the present embodiment, the gas side shut-off valve **(26)** is placed in the closed state thereby ensuring that refrigerant in the outdoor circuit **(21)** is prevented from being drawn out via the gas side service port **(28)** by way of the gas side shut-off valve **(26).** Therefore, the flow velocity of refrigerant in the gas side interconnecting line **(24)** is increased relative to the case where the first step is carried out with the gas side shut-off valve **(26)** placed in the opened state, and as a result, more refrigeration oil will be removed and recovered from the gas side interconnecting line **(24).**

**[0060]** In addition, in the present embodiment, there is a possibility that the carrying out of the first step with the liquid side shut-off valve **(25)** placed in the opened state may cause refrigerant collected in the receiver **(39)** to flow into the liquid side interconnecting line **(23)** if the expansion valve **(36)** is opened. This increases the amount of refrigerant which flows back and forth on the indoor unit's **(13)** side between the gas side service port **(28)** and the liquid side service port **(27)** in the first and second steps. That is, the total of the amount of refrigerant circulating through the gas side interconnecting line **(24)** and the amount of refrigerant circulating through the liquid side interconnecting line **(23)** will increase. Therefore, still larger amounts of refrigeration oil can be removed and recovered from the gas side interconnecting line **(24)** and the liquid side interconnecting line **(23).**

**[0061]** In addition, in the present embodiment, by the carrying out of the third step for the recovery of refrigerant from the outdoor circuit **(21)**, the amount of refrigerant remaining in the outdoor circuit **(21)** after the refrigeration oil recovery method is performed is reduced. In particular, in the present embodiment, it is ensured that refrigerant is recovered from the outdoor circuit **(21)** by carrying out, in the third step, the first work operation in which refrigerant is recovered from the outdoor circuit **(21)** via the heat source side port **(9)** and the second work in which refrigerant is recovered from the outdoor circuit **(21)** via the gas side service port **(28).** Therefore, when removing and replacing the outdoor unit **(11)** with a new one, the time taken for the recovery of refrigerant from the removed outdoor unit **(11)** can be saved. In addition, when replacing the refrigerant in the refrigerant circuit **(20)** with new refrigerant, it becomes possible to enhance the reliability of the refrigeration system **(10).**

**[0062]** Additionally, in the present embodiment, the work operation in the third step for the recovery of refrigerant from the outdoor circuit **(21)** via the gas side service port **(28)** is carried out with gradually opening the gas side shut-off valve **(26),** thereby preventing refrigerant and refrigeration oil in the outdoor circuit **(21)** from flowing into the gas side interconnecting line **(24)** from which refrigerant and refrigeration oil have been recovered. Therefore, it becomes possible to avoid the occurrence of a situation where the recovery of refrigerant and refrigeration oil from the gas side interconnecting line **(24)** is required after the third step is carried out.

## MODIFICATION OF THE EMBODIMENT

**[0063]** A modification of the embodiment will be described. This modification is a refrigeration oil recovery method when the refrigeration system **(10)** is not provided with the heat source side port **(9)**. Like the aforesaid embodiment, the first step and the second step are carried out, but only the second work operation is carried out in the third step. In the second work operation, the refrigerant recovery unit **(45)** detached from the liquid side service port **(27)** is connected to the gas side service port **(28)**. And, the gas side shut-off valve **(26)** is closed and the liquid side shut-off valve **(25)** is opened. In this condition, the vacuum pump is set in operation with gradually opening the gas side shut-off valve **(26)**.

## ANOTHER EMBODIMENT

**[0064]** The aforesaid embodiment may be configured as follows.

**[0065]** In the aforesaid embodiment, the vacuum pump is operated for a predetermined length of time in the first step. Alternatively, the vacuum pump may be operated until the pressure, which is measured at the gas side service port **(28)**, falls below a predetermined pressure value.

**[0066]** In addition, with respect to the aforesaid embodiment, the first step may be carried out with the liquid side shut-off valve **(25)** placed in the closed state. Furthermore, the second step may be carried out with the liquid side shut-off valve **(25)** placed in the closed state.

**[0067]** In addition, with respect to the aforesaid embodiment, the first step may be carried out with the gas side shut-off valve **(26)** placed in the opened state.

**[0068]** Additionally, with respect to the aforesaid embodiment, the first work operation and the second work operation may be carried out at the same time in the third step. More specifically, refrigerant recovery units **(45)** are connected, respectively, to the heat source side port **(9)** and to the gas side service port **(28)**. And, the gas side shut-off valve **(26)** is closed and the liquid side shut-off valve **(25)** is opened. In this condition, the vacuum pumps of the refrigerant recovery units **(45)** are set in operation with gradually opening the gas side shut-off valve **(26)**. In addition, the first work operation may be carried out after the second work operation is carried out.

**[0069]** In addition, with respect to the aforesaid embodiment, the first step may be carried out after the expansion valve **(18)** is forcedly placed in the opened state. In this case, in comparison with the case where the first step is carried out with the expansion valve **(18)** placed in the closed state, the amount of refrigerant which flows back and forth on the indoor unit's **(13)** side between the gas side service port **(28)** and the liquid side service port **(27)** in the first and second steps is increased.

**[0070]** It should be noted that the above-described embodiments are merely preferable exemplifications in nature and are no way intended to limit the scope of the present invention, its application, or its application range.

## INDUSTRIAL APPLICABILITY

**[0071]** As has been described above, the present invention finds useful application in a refrigeration oil recovery method, in a refrigeration system including a refrigerant circuit formed by connection of a heat source unit and a utilization unit by mean of a gas side interconnecting line and a liquid side interconnecting pipeline, for recovering refrigeration oil from the gas side interconnecting line and the liquid side interconnecting line.

## Claims

**1.** A method, in a refrigeration system **(10)** in which a refrigeration cycle is performed in a refrigerant circuit **(20)** which is formed by connection of a heat source side circuit **(21)** within a heat source unit **(11)** and a utilization side circuit **(22)** within a utilization unit **(13)** by means of a gas side interconnecting line **(24)** and a liquid side interconnecting line **(23)**, for the recovery of refrigeration oil from the gas side interconnecting line **(24)** and the liquid side interconnecting line **(23),** the method sequentially comprising:

a first step in which, via a gas side port **(28)** which is open to the gas side interconnecting line's **(24)** side of the shut-off position of a gas side shut-off valve **(26)** mounted at one end of the heat source side circuit **(21),** refrigeration oil is recovered together with a part of refrigerant present in a portion of the refrigerant circuit **(20)**, which portion is in fluid communication with the gas side port **(28);** and

a second step in which, via a liquid side port **(27)** which is open to the liquid side interconnecting line's **(23)** side of the shut-off position of a liquid side shut-off valve **(25)** mounted at the other end of the heat source side circuit (21), refrigeration oil is recovered together with a part or all of refrigerant present in a portion of the refrigerant circuit **(20),** which portion is in fluid communication with the liquid side port **(27),** with the gas side shut-off valve **(26)** placed in the closed state.

**2.** The method of claim 1, wherein the first step is carried out with the gas side shut-off valve **(26)** placed in the closed state.

**3.** The method of either claim 1 or claim 2, wherein the first step and the second step are carried out with the liquid side shut-off valve **(25)** placed in the opened state.

**4.** The method of claim 1, wherein, following the completion of the second step, there is performed a third step in which refrigerant in the heat source side circuit **(21)** is recovered.

**5.** The method of claim 4, wherein, in the third step, refrigerant in the heat source side circuit **(21)** is recovered via the gas side port **(28)** with gradually opening the gas side shut-off valve **(26).**

**6.** The method of claim 4, wherein, in the third step, a first work operation and a second work operation are performed in the former of which refrigerant in the heat source side circuit **(21)** is recovered via a heat source side port **(9)** which is open to the heat source

side circuit **(21)** and in the latter of which refrigerant in the heat source side circuit **(21)** is recovered via the gas side port **(28)** with gradually opening the gas side shut-off valve **(26).**

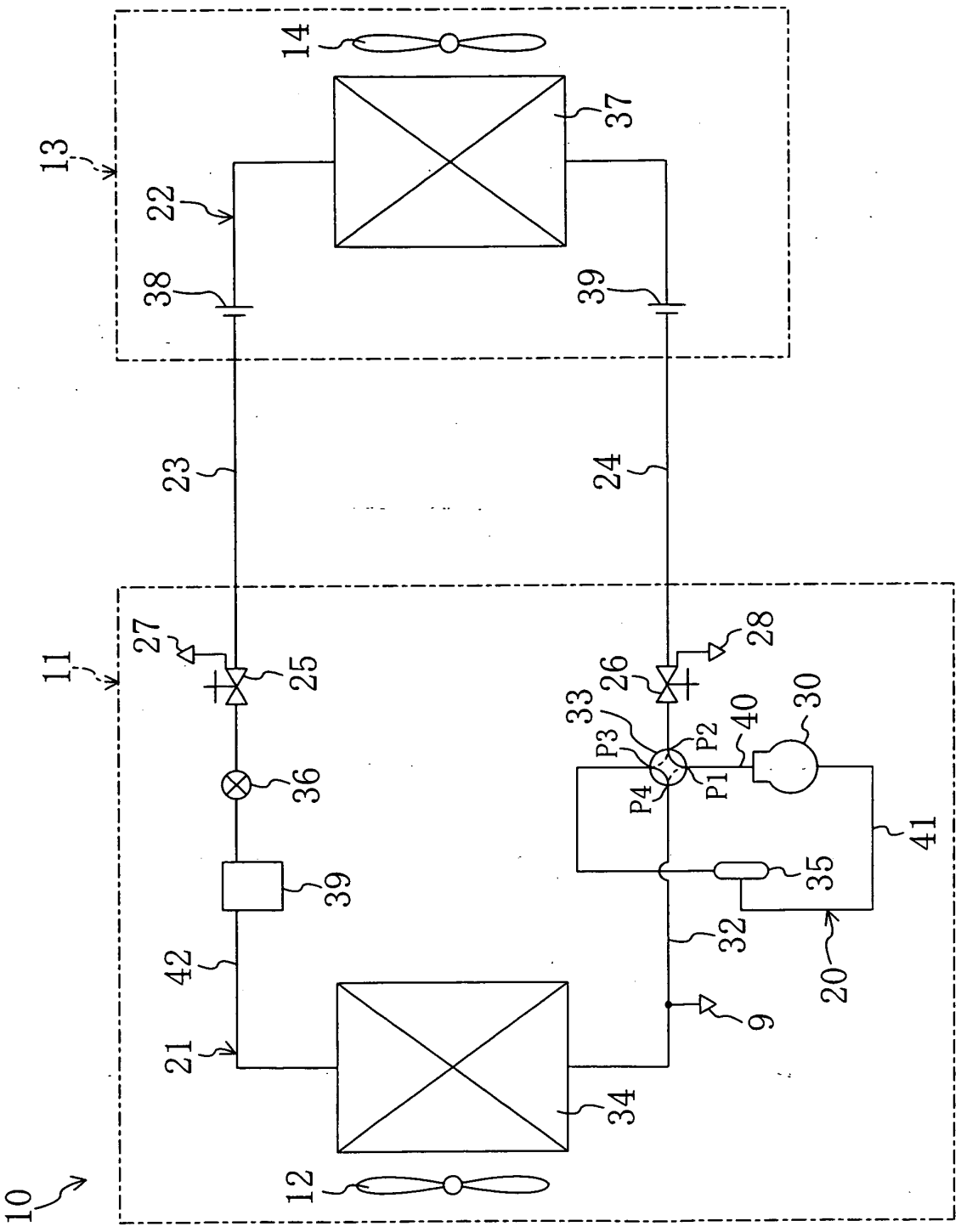
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FIG. 1

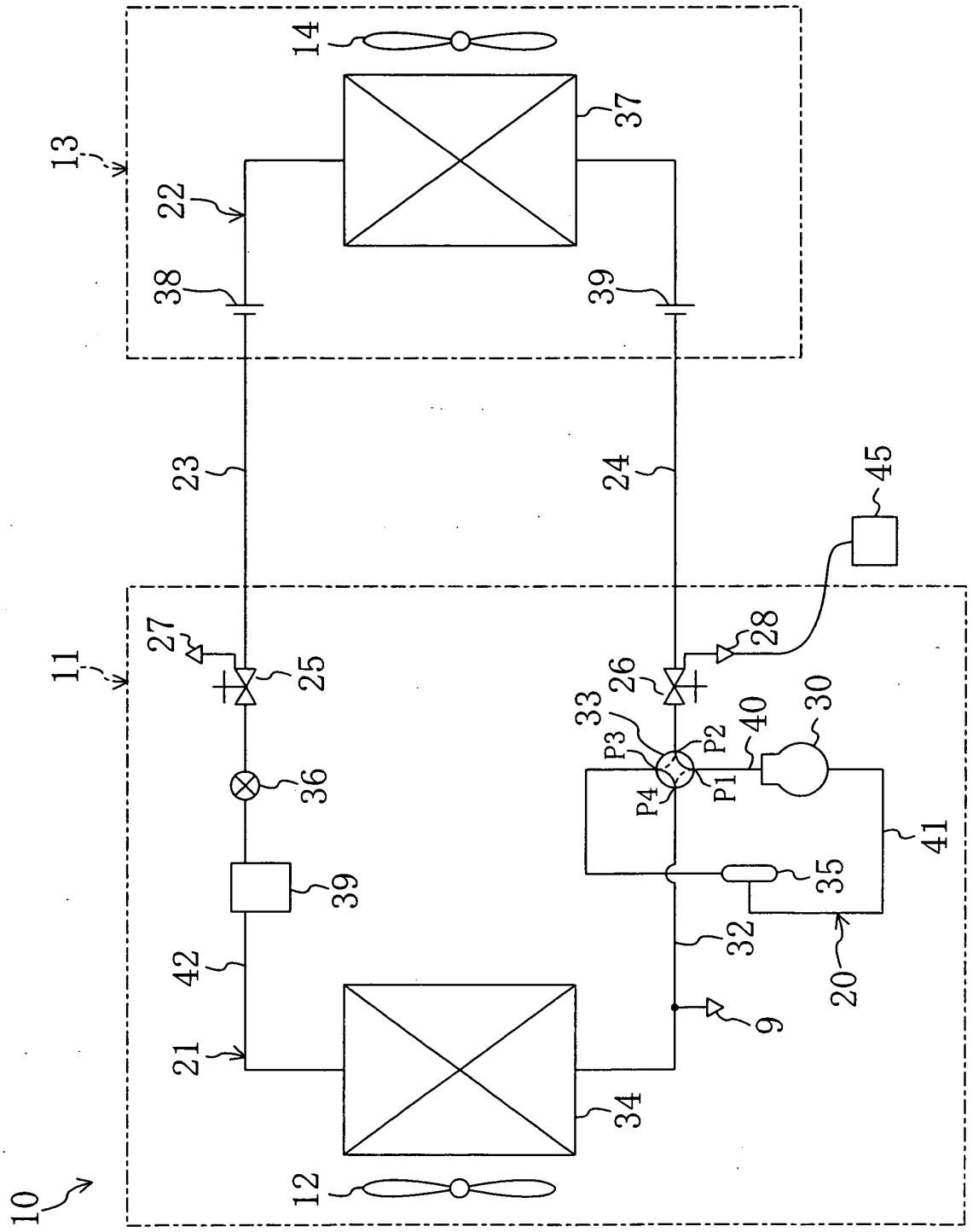
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FIG. 2

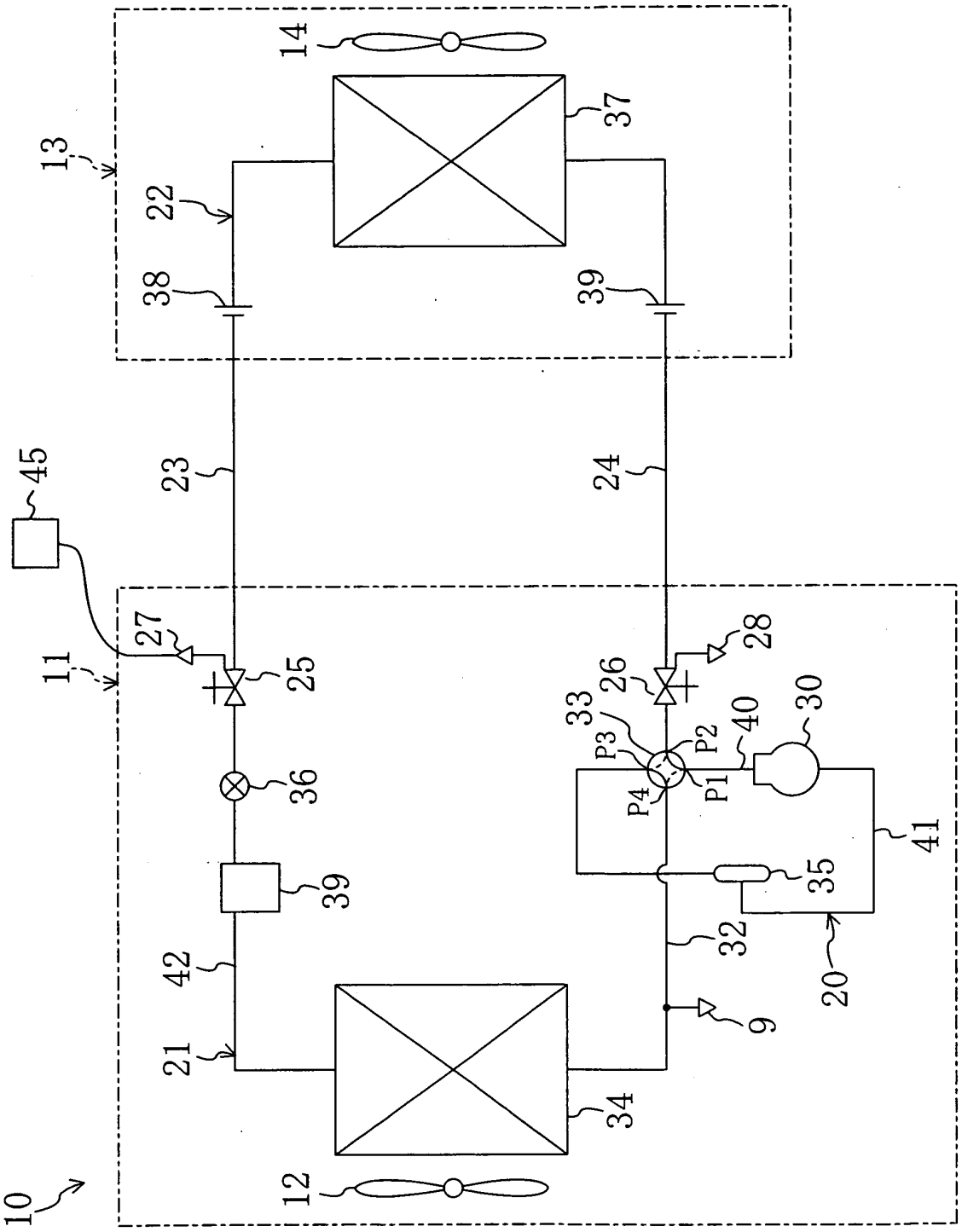
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FIG. 3

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2007/053061

A. CLASSIFICATION OF SUBJECT MATTER
*F25B45/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B45/00, F25B47/00, F25B43/02, F25B1/00, F28G9/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2007
Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP 2003-194437 A (Daikin Industries, Ltd.), 09 July, 2003 (09.07.03), Claims 2, 3; Par. Nos. [0009] to [0015]; Fig. 2 (Family: none) | 1-6 |
| A | JP 10-197107 A (Hitoyoshi AIZAWA), 31 July, 1998 (31.07.98), Claims 1 to 3; Par. Nos. [0030] to [0034]; Figs. 1 to 5 (Family: none) | 1-6 |
| A | JP 2004-293986 A (Mitsubishi Electric Corp.), 21 October, 2004 (21.10.04), Claim 1; Par. Nos. [0014] to [0016]; Figs. 1, 2 (Family: none) | 1-6 |

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 11 April, 2007 (11.04.07) | 24 April, 2007 (24.04.07) |
| Name and mailing address of the ISA/ Japanese Patent Office<br>Facsimile No. | Authorized officer<br>Telephone No. |

Form PCT/ISA/210 (second sheet) (April 2005)

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2007/053061

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP 2005-037020 A (Hitachi, Ltd.),<br>10 February, 2005 (10.02.05),<br>Par. Nos. [0003] to [0008], [0012] to [0016];<br>Figs. 1 to 4<br>(Family: none) | 1-6 |
| A | JP 2000-249433 A (Daikin Industries, Ltd.),<br>14 September, 2000 (14.09.00),<br>Par. Nos. [0014] to [0018]; Fig. 1<br>(Family: none) | 1-6 |

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

## REFERENCES CITED IN THE DESCRIPTION

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