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(54) **Air Conditioner having refrigerant leakage alarming function based on the senses of human**

Klimaanlage mit Kühlmittelleckanzeige anhand menschlicher Sinneswahrnehmung

Dispositif de climatisation avec détection de fuite de réfrigérant par perception humaine

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**EP 0 872 693 B1**

## Description

### 1. Field of the Invention

**[0001]** The present invention relates to an air conditioner in which leakage of refrigerant can be easily recognized by stimulating at least one of the senses of human such as the sense of smell, the sense of sight, the sense of hearing or the like.

### 2. Description of the Related Art

**[0002]** Recently, HCFC-based refrigerant such as R22 having a small ozone-layer destruction coefficient or the like has been used as refrigerant for a refrigerating machine, however, alternative refrigerant containing no chlorine as constituent elements has been required to be used from the viewpoint of complete prevention of the destruction of the ozone-layer. HFC-based mixed refrigerant such as R407C, R410A or the like is popular as the alternative refrigerant, however, even use of these materials cannot suppress the global warming of the earth. Therefore, Research and development of HC-based refrigerant group containing R290, etc. which have a global warming coefficient of zero, air conditioners using these refrigerant group, etc. have been increasingly promoted.

**[0003]** It is known that HC-based refrigerant group containing R290 which is propane gas are generally flammable, and these materials has a problem in prevention of disasters when the refrigerant leaks. Further, when a lot of refrigerant leaks into an enclosed room, the oxygen concentration in the room is quickly reduced, and there is a risk that inhabitants may be kept in an oxygen-deficient atmosphere. Therefore, in an air conditioner as disclosed in Japanese Post-examined Utility Mode Registration Application No. sho-60-38858, leakage of refrigerant is judged by a refrigerant leakage sensor to produce an alarm sound from an alarm unit. However, in this type of air conditioner, the recognition of the leakage of refrigerant is enabled only by stimulating the acoustic sense of human, and thus when an inhabitant has an acoustic disorder or when the refrigerant leakage sensor or the alarm is out of order, the above trouble cannot be avoided, and finally a critical disaster may occur.

**[0004]** EP-A-0 768 198 discloses an air conditioning system having a compressor, a condenser, pressure reducing means and an evaporator which are successively connected to one another in this order to construct a refrigerating cycle, a flammable refrigerant being filled in said refrigeration cycle, the air conditioner including: Leakage detecting means for detecting leakage of the refrigerant from said refrigeration cycle; and means for stopping the operation of said compressor when the leakage is detected by said leakage detector means.

**[0005]** JP-A-58 080373 discloses a refrigerant for a compression refrigerator in which refrigerant incorporat-

ed is a colored lubricating oil and an oil soluble dye blended therewith.

## SUMMARY OF THE INVENTION

**[0006]** Therefore, an object of the present invention is to provide an air conditioner which can easily check leakage of refrigerant and enhance the safety when the refrigerant leaks.

**[0007]** This object is solved by the features of claim 1.

**[0008]** Advantageous embodiments are mentioned in the subclaims.

**[0009]** The air conditioner of the present invention includes a partition plate (5) for partitioning into an indoor space and an outdoor space a single case in which the constituent elements of the refrigeration cycle are accommodated, an air flow port (65) which is provided to the partition plate (5) and allows air to flow therethrough between the indoor space and the outdoor space, a damper (67) for closing and opening the air flow port (65), and means for opening the damper to validate the air flow port (65) when the refrigerant leakage is detected by the leakage detection mean.

**[0010]** According to the above air conditioner, when the refrigerant leakage is judged on the basis of the output signal of the leakage detection means such as the refrigerant leakage sensor or the like, the controller drives the damper on the basis of the output signal so that the damper is open, and allows the indoor space and the outdoor space to intercommunicate with each other, whereby the refrigerant leaking from the indoor to the outdoor is discharged and air is newly introduced from the outdoor into the indoor.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0011]

Fig. 1 is a diagram showing a refrigerant circuit and a control system of an air conditioner according to the present invention;

Fig. 2 is a perspective view showing the internal construction of the air conditioner according to the present invention; and

Fig. 3 is a longitudinally-sectional view showing the internal construction of the air conditioner according to the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0012]** Preferred embodiments according to the present invention will be described hereunder with reference to the accompanying drawings.

**[0013]** Fig. 1 is a diagram showing a refrigerant circuit and a control system of an air conditioner according to the present invention. In Fig. 1, a solid line represents a refrigerant circuit (refrigeration cycle), and a one-dot-

ted chain line represents flow of a control signal. Figs. 2 and 3 are perspective and longitudinally-sectional view showing the internal construction of the air conditioner. The air conditioner of this embodiment is a so-called integral-type air conditioner including an indoor unit and an outdoor unit which are fabricated into a single body, and HC-based flammable refrigerant (R290) is used as refrigerant circulating in the refrigerant circuit.

**[0014]** The air conditioner 1 is disposed in a building in such a manner that it penetrates through the wall 3 of the building, and the inside of the air conditioner 1 is partitioned into an indoor portion (space) 7 and an outdoor portion (space) 9. In the indoor portion 7 are disposed an indoor heat exchanger 11, an indoor fan 13, a capillary tube 15 serving as an expansion device, etc. Further, in the outdoor portion 9 are disposed a compressor 21, an outdoor heat exchanger 23, an outdoor fan 25, an accumulator 27, a strainer 29, etc. In Fig. 1, reference numeral 31 represents a center impeller type fan motor which is disposed in the outdoor portion 9, and it serves to drive an indoor fan 13 and the outdoor fan 25 coaxially. The respective elements constituting the refrigerant circuit are connected to one another through refrigerant pipes 33 to 40 which are used for flow of gas refrigerant or liquid refrigerant.

**[0015]** In the indoor portion 7 is also disposed an electronic control unit (hereinafter referred to as "ECU") which comprises a CPU, input/output interfaces, ROM, RAM, etc. The input interface of the ECU 51 is connected to a room temperature sensor 53 for detecting the room temperature, an outside air temperature sensor 55 for detecting the outside air temperature, a refrigerant leakage sensor 57 (leakage detection means) for detecting (judging) the leakage of refrigerant on the basis of variation in concentration of oxygen of the indoor portion 7, etc., and the output interface is connected to the compressor 21, the fan motor 31, etc.

**[0016]** In this embodiment, electromagnetic cutoff valves 61 and 63 which are used to cut off the refrigerant circuit and actuated on the basis of a control signal from the ECU 51 are provided at the upstream side of the capillary tube 15 and the downstream side of the indoor heat exchanger 11, respectively. The partition plate 5 is provided with an intercommunication port 65 which makes an intercommunication between the indoor portion 7 and the outdoor portion 9 and allows air to flow from the indoor portion 7 to the outdoor portion 9, and also provided with a damper 67 for opening/closing the intercommunication port 65 and an electromagnetic actuator 69 for driving the damper. Further, an alarm buzzer 71 is disposed in the indoor portion 7 and makes an alarm sound when refrigerant leakage occurs. The electromagnetic actuator 69 and the alarm buzzer 71 are connected to the output interface of the ECU 51, and they are actuated on the basis of the control signal from the ECU 51 as in the case of the electromagnetic cutoff valves 61 and 63.

**[0017]** HC-based refrigerant and refrigeration ma-

chine oil are hermetically filled into the refrigeration cycle, and circulated in the compressor 21 and the heat exchangers 11 and 23 while mixed with each other. The HC-based refrigerant which is used for the refrigeration cycle is inherently colorless and transparent and non-odorous. However, in this embodiment, a prescribed smell element and dye are added. Further, the refrigeration machine oil which is used together with the HC-based refrigerant is light color and transparent, however, prescribed dye is added to the refrigeration machine oil in this embodiment. The smell element provides irritant smell to the refrigerant, and when the refrigerant is discharged to the air, it stimulates the sense of smell of the human even when the amount thereof is slight. Further, the dye provides bright color such as bright red color, bright yellow color or the like, and when the refrigerant or the refrigeration machine oil is discharged to the air, the portion surrounding the leakage portion is brightly dyed. It is needless to say that the smell element and the dye used in this embodiment are harmless to the human body and inactive to the refrigerant and does not corrode the constituent parts of the refrigeration cycle, and mercaptan and pigment may be used, for example. In the present invention, it is sufficient that the leakage position is specified when the refrigerant leaks, and thus the dye may be added to only one of the refrigerant and the refrigeration machine oil.

**[0018]** Next, the flow of the refrigerant under cooling operation will be described.

**[0019]** Gas refrigerant which is sucked from the accumulator 27 through the refrigerant pipe 40 into the compressor 21 is adiabatically compressed and discharged as high-temperature and high-pressure gas refrigerant from the compressor 21. The high-pressure gas refrigerant thus discharged flows through the refrigerant pipe 33 into the outdoor heat exchanger 23. The high-temperature and high-pressure gas refrigerant is cooled by the outside air and condensed into liquid refrigerant while passing through the outdoor heat exchanger 23, and thereafter flows through the refrigerant pipe 34, the strainer 29, the refrigerant pipe 35, the electromagnetic cutoff valve 61 and the refrigerant pipe 36 into the capillary tube 15.

**[0020]** The liquid refrigerant is reduced in pressure by the capillary tube 15, and then flows through the refrigerant pipe 37 into the indoor heat exchanger 11. The liquid refrigerant is vaporized into gas refrigerant while passing the indoor heat exchanger 11, and the indoor air which is sucked into the room by the indoor fan 13 is cooled through the heat exchange between the indoor air and the liquid refrigerant with the vaporization latent heat of the liquid refrigerant. The gas refrigerant which is vaporized in the indoor heat exchanger 11 flows through the refrigerant pipe 38, the electromagnetic cutoff valve 63 and the refrigerant pipe 39 into the accumulator 27, and then sucked from the refrigerant pipe 40 into the compressor 21 again.

**[0021]** According to this embodiment, when refriger-

ant leakage occurs in the indoor portion 7 due to some cause, the refrigerant leakage is judged on the basis of the reduction of the oxygen concentration by the refrigerant leak sensor 57, and the ECU 51 performs the processing such as the leakage control, etc. That is, when a detection signal representing the refrigerant leakage is input from the refrigerant leakage sensor 57, the ECU 51 stops the compressor 17 and the fan motor 31, and at the same time it controls the electromagnetic cutoff valves 61 and 63 to cut off the refrigerant circuit. Further, the ECU 51 controls the electromagnetic actuator 69 to drive the damper 67 so that the damper 67 is opened.

**[0022]** Upon the stop of the compressor 17, the refrigerant flow in the refrigerant circuit is stopped and the refrigerant pressure is lowered, so that the leakage rate of the refrigerant is rapidly lowered. In addition, since the refrigerant circuit is cut off, the refrigerant in the compressor 17 or the outdoor heat exchanger 23 can be prevented from leaking even when refrigerant leakage occurs in the indoor heat exchanger 11, the capillary tube 15 or the pipe connection portion thereof. That is, the refrigerant leakage portion in the refrigeration cycle can be separated from the other portions in the refrigeration cycle to prevent the refrigerant leakage from expanding to the other portions. Further, the leaking refrigerant is discharged through the intercommunication port 65 to the outside by opening the damper 67, and at the same time fresh air is introduced from the outside air. In addition, since the fan motor 31, etc. are stopped, any spark which causes firing does not occur to thereby prevent burning of the refrigerant.

**[0023]** In parallel to the execution of the above processing, the ECU 51 controls the alarm buzzer 71 to make an alarm sound, thereby acoustically making the inhabitants recognize the refrigerant leakage. At the same time, the inhabitants can also easily recognize the refrigerant leakage with the sense of smell and/or the sense of vision. That is, even when the amount of the smell element is small, the irritant smell of the smell element added to the refrigerant floats in the room, and the portion surrounding the leakage portion is dyed with red or yellow color by the dye added to the refrigerant even when the leakage amount of the refrigerant is small. Accordingly, even when an inhabitant has troubles of any two of the sense of hearing, the sense of smell and the sense of vision, he/she can recognize the refrigerant leakage, and open the door or window or escape from the room.

**[0024]** As described above, according to the air conditioner of this embodiment, when the refrigerant leakage occurs, the leakage amount can be suppressed to an extremely small value, ventilation can be promoted and the firing can be prevented. Further, the inhabitants can be made to recognize the refrigerant leakage with the sense of hearing, the sense of smell and the sense of vision. Therefore, high safety can be kept although flammable refrigerant is used.

**[0025]** The present invention is not limited to the above embodiment, and various modifications may be made. For example, in the above embodiment, the present invention is applied to an in-wall type air conditioner. However, the present invention may be applied to a separation type air conditioner in which an indoor unit and an outdoor unit are separated from each other, or a heat pump type air conditioner. Further, the fan motor may be designed in an explosion-proof type. In this case, when the damper of the intercommunication port is opened at the refrigerant leakage time, the indoor fan and the outdoor fan are driven to positively discharge the refrigerant to the outside and take in the outside air. Further, the materials of the smell element and the dye to be added to the refrigerant may be suitably selected in consideration of compatibility with the refrigerant, easiness of removal when attached to furniture, the cost, etc.

**[0026]** According to the present invention, a prescribed smell element is added to the refrigerant used in the air conditioner. Therefore, the prescribed smell element floats in the room when the refrigerant leaks from the indoor heat exchanger, the pipe connection portion or the like, whereby an inhabitant can easily recognize the refrigerant leakage.

**[0027]** Further, according to the present invention, a prescribed dye is added to at least one of the refrigerant and the refrigeration machine oil used in the air conditioner. Therefore, when the refrigerant leaks from the indoor heat exchanger, the pipe connection portion or the like, the colored gas or the colored refrigeration machine oil is ejected from the leakage portion. Accordingly, an inhabitant can easily recognize the refrigerant leakage, and also can easily grasp the leakage position.

**[0028]** According to the present invention, the smell element or the dye added to the refrigerant or the like is inactive to the refrigerant, and does not corrode the constituent elements of the refrigeration cycle. Therefore, the physical properties of the refrigerant are not changed by the addition of the smell element or the dye, and there occurs no corrosion in the heat exchangers and the pipe group and no expansion in the rubber group.

**[0029]** According to the present invention, in the air conditioner having the flammable refrigerant filled in the refrigeration cycle, when the refrigerant leaks from the refrigeration cycle, the driving of the compressor is stopped. Specifically, when the refrigerant leakage is judged on the basis of the output signal from the refrigeration leakage sensor or the like, the controller stops the compressor on the basis of the output signal, whereby the pressure in the refrigeration cycle is lowered and the refrigerant leakage is suppressed to thereby ensure high safety.

**[0030]** Further, according to the present invention, plural cutoff valves are provided in the refrigeration cycle, and when the refrigerant leaks from the refrigeration cycle, these cutoff valves are closed to separate the

leakage position from the refrigeration cycle. Accordingly, when the refrigerant leakage is judged on the basis of the output signal of the refrigerant leakage sensor or the like, the controller drives the cutoff valves disposed at the inlet and outlet sides of the outdoor heat exchanger to be closed on the basis of the output signal, thereby preventing the refrigerant at the other portions of the refrigeration cycle from leaking into the room, and keeping high safety.

**[0031]** Still further, according to the present invention, the constituent elements of the refrigeration cycle is accommodated in a single case, the intercommunication port is formed in the partition plate through which the inside of the single case is partitioned into the indoor side and the outdoor side, the damper for opening/closing the intercommunication port is provided, and the damper is opened when the refrigerant in the refrigeration cycle leaks. Accordingly, when the refrigerant leakage is judged on the basis of the output signal of the refrigerant leakage sensor or the like, the controller drives the damper on the basis of the output signal so that the damper is opened. Therefore, the indoor and the outdoor intercommunicate with each other, so that the refrigerant is discharged from the indoor to the outdoor and the air is introduced from the outdoor into the indoor, thereby ensuring the high safety.

## Claims

1. An air conditioner (1) having a compressor (21), a condenser (23, 11), pressure-reducing means (15) and an evaporator (11, 23) which are successively connected to one another in this order to construct a refrigeration cycle, wherein a prescribed dye is added to both HC-based refrigerant and machine oil which are filled in said refrigeration cycle, and further comprising:

leakage detection means (57) for detecting leakage of the refrigerant from said refrigeration cycle; and

means (51) for stopping the operation of said compressor (21) when the leakage of the refrigerant is detected by said leakage detection means (57),

### characterized in that

it further comprises a partition plate (5) for partitioning into an indoor space (7) and an outdoor space (9) a single case in which the constituent elements of said refrigeration cycle are accommodated;

an air flow port (65) which is provided to said partition plate (5) and allows air to flow therethrough between the indoor space (7) and the outdoor space (9);

a damper (67) for closing and opening said air

flow port; and

means (51) for opening said damper (67) to validate said air flow port (65) when the refrigerant leakage is detected by said leakage detection means (57).

2. The air-conditioner as claimed in claim 1, wherein said dye provides both of the refrigerant and the machine oil with bright color.
3. The air-conditioner as claimed in claim 1, wherein said dye is inactive to the refrigerant, and does not corrode the constituent elements of said refrigeration cycle.
4. The air-conditioner as claimed in claim 1, further including plural cut-off valves (61, 63) in said refrigeration cycle, wherein said cut-off valves (61, 63) are closed to separate the leakage position of the refrigerant from said refrigeration cycle when the leakage of the refrigerant is detected by the leakage detection means (57).

## Patentansprüche

1. Klimaanlage (1) mit einem Kompressor (21), einem Kondensor (23, 11), Druckreduziermitteln (15) und einem Verdampfer (11, 23), die aufeinander folgend in dieser Reihenfolge verbunden sind, um einen Kältemittelzyklus aufzubauen, wobei sowohl dem auf HCbasierenden Kühlmittel als auch dem Maschinenöl, die in den Kältemittelzyklus eingefüllt sind, ein vorgeschriebener Farbstoff zugefügt ist, und weiterhin mit:

einer Leckagedetektionseinrichtung (57) zum Detektieren einer Leckage von Kühlmittel aus dem Kältemittelzyklus; und  
Mitteln (51) zum Stoppen des Betriebes des Kompressors (21), wenn die Leckage des Kühlmittels durch die Leckagedetektoreinrichtung (57) detektiert worden ist,

**dadurch gekennzeichnet, dass** sie weiterhin aufweist

eine Trennplatte (5) zum Unterteilen eines einzelnen Gehäuses in einen Innenraum (7) und einem Außenraum (9), in welchem die den Kältemittelzyklus bildenden Elemente aufgenommen sind;

eine Luftströmöffnung (65), die in der Trennplatte (5) vorgesehen ist und zulässt, dass Luft durch diese zwischen dem Innenraum (7) und dem Außenraum (9) strömt;

einen Dämpfer (67) zum Schließen und Öffnen dieser Luftströmungsöffnung; und

eine Einrichtung (51) zum Öffnen des Dämpfers (67), um die Luftströmungsöffnung (65) zu va-

lidieren, wenn durch die Leckagedetektoreinrichtung (57) eine Kühlmittleckage detektiert worden ist.

2. Klimaanlage nach Anspruch 1, wobei der Farbstoff sowohl dem Kühlmittel als auch dem Maschinenöl eine helle Farbe verleiht. 5
3. Klimaanlage nach Anspruch 1, wobei der Farbstoff gegenüber dem Kühlmittel inaktiv ist und die Bauelemente des Kältemittelzyklus nicht korrodiert. 10
4. Klimaanlage nach Anspruch 1, weiterhin mit einer Anzahl von Absperrventilen (61, 63) in dem Kältemittelzyklus, wobei die Absperrventile (61, 63) geschlossen werden, um die Leckageposition des Kühlmittels vom Kältemittelzyklus zu separieren, wenn die Leckage des Kühlmittels durch die Leckagedetektoreinrichtung (57) detektiert worden ist. 15

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dit colorant communique une couleur brillante à la fois au réfrigérant et à l'huile de machine.

3. Climatiseur selon la revendication 1, dans lequel le dit colorant est inactif par rapport au réfrigérant et il ne corrode pas les éléments constitutifs du dit circuit de réfrigération.
4. Climatiseur selon la revendication 1, comprenant en outre plusieurs vannes d'isolement (61, 63) dans le dit circuit de réfrigération, dans lequel les dites vannes d'isolement (61, 63) sont fermées pour séparer la position de fuite du réfrigérant du reste du dit circuit de réfrigération lorsque la fuite du réfrigérant est détectée par le moyen de détection de fuite (57).

## Revendications

1. Climatiseur (1) comprenant un compresseur (21), un condenseur (23, 11), un moyen de réduction de pression (15) et un évaporateur (11, 23) qui sont successivement connectés les uns aux autres dans cet ordre pour construire un circuit de réfrigération, dans lequel un colorant prescrit est ajouté à la fois au réfrigérant à base de HC et à l'huile de machine qui sont chargés dans le dit circuit de réfrigération, et comprenant en outre : 25

un moyen de détection de fuite (57) pour détecter une fuite du réfrigérant à partir du dit circuit de réfrigération ; et 35

un moyen (51) pour arrêter le fonctionnement du dit compresseur (21) lorsque la fuite du réfrigérant est détectée par le dit moyen de détection de fuite (57) ; 40

**caractérisé en ce qu'il comprend en outre**

une cloison (5) pour subdiviser en un espace intérieur (7) et un espace extérieur (9) un caisson unique dans lequel sont logés les éléments constitutifs du dit circuit de réfrigération ; 45

un orifice d'écoulement d'air (65) qu'est ménagé dans la dite cloison (5) et permet à l'air de s'écouler à travers cet orifice entre l'espace intérieur (7) et l'espace extérieur (9) ; 50

un volet (67) pour fermer et ouvrir le dit orifice d'écoulement d'air ; et

un moyen (51) d'ouverture du dit volet (67) pour ouvrir le dit orifice d'écoulement d'air (65) lorsque la fuite de réfrigérant est détectée par le dit moyen de détection de fuite (57). 55

2. Climatiseur selon la revendication 1, dans lequel le

FIG. 1

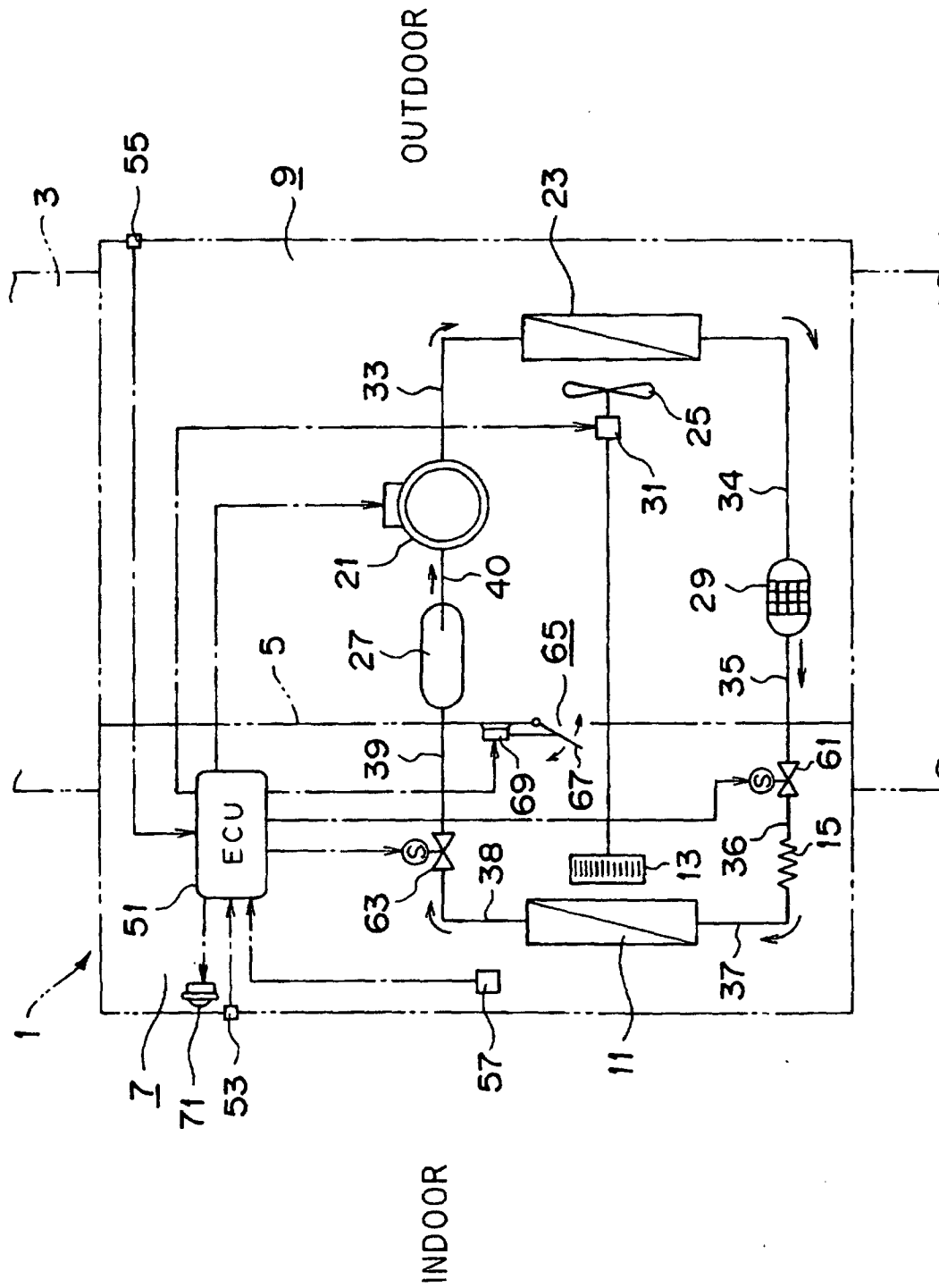


FIG. 2

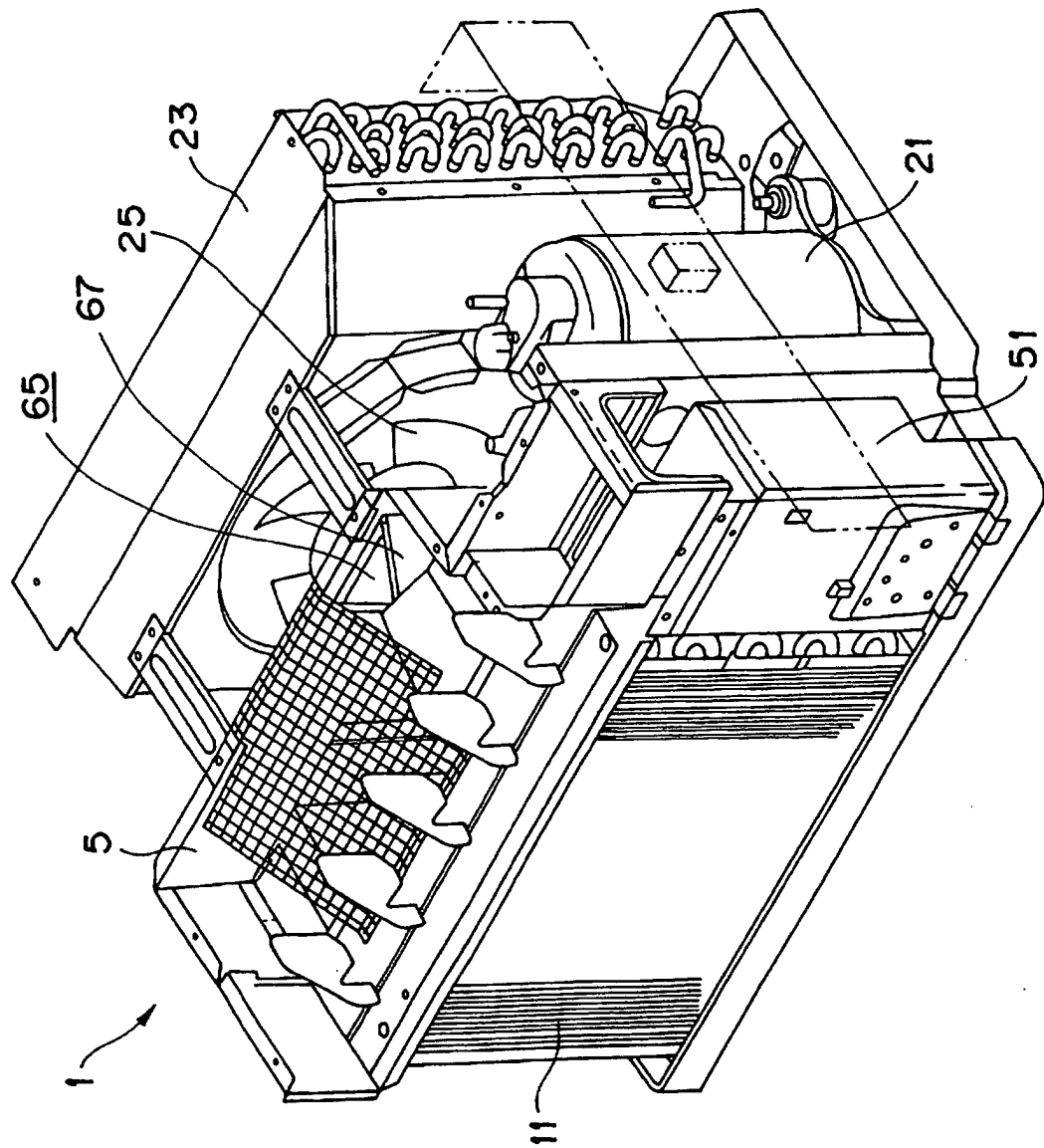




FIG. 3

