DESCRIPTION

TITLE OF THE INVENTION: AIR CONDITIONING SYSTEM

Technical Field

[0001] The present invention relates to an air conditioning system, more specifically, it relates to an air conditioning system which includes a convective indoor machine and a radiant indoor machine to prevent damage to a compressor and lowering in reliability of the compressor.

Background Art

[0002] An air conditioner is generally used which has a compressor, an outdoor heat exchanger, an expansion valve, a convective indoor machine and a refrigerant piping connecting them. The air conditioner supplies cooled or heated air to an indoor space, at an air conditioning target space, by a fan and circulates or convects indoor air to perform air conditioning.

Additionally, air conditioning is performed by making refrigerant pass through a radiant indoor machine and cooling or heating air of the indoor space at an air conditioning target space.

[0003] The convective air conditioning using the convective indoor machine is quick in startup time, however, is low in the degree of comfort due to bodily sensation of supplied air, so-called draft sensation.

On the other hand, the radiant air conditioning using the radiant indoor machine has a disadvantage that startup time is long, however, has advantages that the degree of comfort on the human body is high, heating effect is excellent even if the temperature of indoor air is low, and heat loss is small.

Accordingly, if the convective air conditioning and the radiant air conditioning are used together, the advantage of one overcomes the disadvantage of the other, and comfortable and ideal air conditioning can be realized.

[0004] An air conditioning system, in which a radiant indoor machine is added to an air conditioner including a convective indoor machine, has already been proposed by the inventors in Patent Document 1.

Prior Art

Patent Document

[0005] Patent Document 1: Patent No. 5285179

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

[0006] The inventors repeated experiments for utilizing an air conditioning system in which a radiant indoor machine is added to an air conditioner including a convective indoor machine, and then found that an oil accumulation is caused at a lower part of the refrigerant pipe by meanderingly forming a refrigerant pipe of the radiant indoor machine (hereinafter, referred to as "meandering pipe"), the pipe including a plurality of vertically juxtaposed straight pipes and connection pipes connecting between upper ends of the adjacent straight pipes and between lower ends thereof.

[0007] Refrigerant of the air conditioner is partially a two-phase refrigerant of gas and liquid and circulates in a refrigerant piping, the refrigerant contains lubricating oil of a compressor, and the oil accumulation is considered to be caused by separation of the lubricating oil in the refrigerant. When the lubricating oil is separated and lost from the refrigerant, the compressor runs short of lubricating oil and receives excess load, and thus, is a cause for a failure.

[0008] The cause of separation of lubricating oil in refrigerant is not clear, however, it is thought as follows. That is, when the radiant indoor machine is added to the air conditioner including the convective indoor machine, it is considered to be the same as when the refrigerant piping is lengthened. In the given design no consideration is made for the radiant indoor machine which results in lack of capacity of the compressor, reducing the flow speed of the refrigerant, and thus, the oil accumulation is considered to be caused at the lower part of the refrigerant pipe of the radiant indoor machine.

[0009] Although it is considered that this problem can be solved by enhancing the capacity of the compressor, it is difficult, in terms of cost, to exchange the existing compressor for a compressor having higher capacity in the case of adding a radiant indoor machine to the existing air conditioner. Additionally, in the case of newly manufacturing an air conditioner, enhancing the capacity of a compressor in consideration of preparation of a radiant indoor machine which is not always used, results in increasing cost.

[0010] The inventors, in order to solve the problem, repeated their investigation on a radiant indoor machine, found that not reducing the flow speed of refrigerant flowing through the radiant indoor machine prevents oil accumulation from being caused, and accomplished the present invention.

[0011] (Object of the Invention)

The present invention has been made in order to solve the above problem, and it is a first object of the invention to provide an air conditioning system which includes a convective indoor machine and a radiant indoor machine to prevent separation of lubricating oil in refrigerant and consequently prevent damage to a compressor, and can prevent a lowering in reliability of the compressor.

In addition to the first object, it is a second object of the invention to provide an air conditioning system which prevents the flow speed of the refrigerant from decreasing even if the radiant indoor machine is upsized.

Means for Solving the Problem

[0012] The means taken by the present invention to solve the above problem are as follows.

An air conditioning system of the present invention includes: an air conditioner having at least: an outdoor machine having a compressor, an outdoor heat exchanger and an expansion valve; a convective indoor machine; and a refrigerant piping connecting them; and a radiant indoor machine which is arranged between the convective indoor machine and the outdoor machine and has a refrigerant pipe connecting between the convective indoor machine and the outdoor machine and having an inner diameter smaller than that of the refrigerant piping.

[0013] The inner diameter and the length of the refrigerant pipe of the radiant indoor machine can be optionally set in a design range where the air conditioning system functions as described in the following descriptions and embodiments. When the inner diameter of the refrigerant pipe is too small, the flow speed of refrigerant increases, however, pressure loss increases by resistance, the load of the compressor increases and efficiency is considered to deteriorate.

[0014] The relationship between the inner diameter of the refrigerant piping of the air conditioner and that of the refrigerant pipe of the radiant indoor machine is specifically as follows.

(1) For example, refrigerant flowing in a refrigerant piping [inner diameter: 7.92φ (49.2mm²)] of the air conditioner is branched into two systems by a meandering two-system refrigerant pipe [inner diameter: 4.75φ (17.7mm²)] of a radiant indoor machine. Straight pipe parts of the meandering pipe are vertically arranged.

The total cross-sectional area (35.4mm²) of the refrigerant pipe having an inner diameter of 4.75φ (17.7mm²) is about 72% of that of the refrigerant piping having an inner diameter of 7.92φ (49.2mm²), the inner diameter of the refrigerant pipe is smaller than that of the refrigerant piping, and therefore the flow speed of the refrigerant flowing in the refrigerant pipe increases.

[0015] A heat generating part of the radiant indoor machine including the refrigerant pipe has 12 heat radiation plates for one unit (two-system meandering pipe having 6 plates per one system) as a reference unit of one radiant indoor machine. Note that the above experiments were performed by using the reference unit.

[0016] (2) For example, refrigerant flowing in a refrigerant piping [inner diameter: 11.1φ (96.7mm²)] of the air conditioner is branched into two systems by a meandering two-system refrigerant pipe [inner diameter: 7.92φ (49.2mm²)] of a radiant indoor machine. Straight pipe parts of the meandering pipe are vertically arranged.

The total cross-sectional area (98.4mm²) of the refrigerant pipe having an inner diameter of 7.92φ (49.2mm²) is about 101.7% of that of the refrigerant piping having an inner diameter of 11.1φ (96.7mm²), and the flow speeds of the refrigerants flowing in the pipe and the piping become approximately the same.

[0017] (3) For example, refrigerant flowing in a refrigerant piping [inner diameter: 13.88φ (151.2mm²)] of the air conditioner is branched into two systems by a meandering two-system refrigerant pipe [inner diameter: 6.4φ (32.2mm²)] of a radiant indoor machine. Straight pipe parts of the meandering pipe are vertically arranged. If two two-system meandering pipes are juxtaposed into four systems (two radiant indoor machines), the total cross-sectional area (128.8mm²) of the refrigerant pipe having an inner diameter of 6.4φ (32.2mm²) is about 85.1% of that of the refrigerant piping having an inner diameter of 13.88φ (151.2mm²) and the flow speed increases.

[0018] The larger the radiant indoor machine becomes, the longer the refrigerant pipe becomes. Since refrigerant moves to an outlet while slowly radiating heat from the vicinity of an inlet of the refrigerant pipe, a temperature difference between the vicinities of the inlet and the outlet is caused and there is a possibility that the capacity of a heating element of the radiant indoor machine is not sufficiently shown. That is, temperature unevenness of the heating element causes heat radiation capacity of the heating element to be insufficiently shown. Additionally, the flow speed of the refrigerant decreases, and oil accumulation is caused.

[0019] Accordingly, in order to branch the refrigerant in a design range where the air conditioning system sufficiently functions, the radiant indoor machine, preferably, includes a branch part for branching a flow of refrigerant into a plurality of flows and a collecting part for collecting the refrigerant formed by the branching part.

Additionally, when the inner diameter of the refrigerant pipe is made small in a design range where the air conditioning system functions, and when a plurality of radiant indoor machines are provided, heat efficiency of the radiant indoor machines as a whole can be raised.

[0020] In terms of smoothness of a flow of refrigerant, it is preferable that the refrigerant pipe of the radiant indoor machine includes a plurality of straight pipes vertically juxtaposed and connection pipes connecting between upper ends of the adjacent straight pipes and between lower ends thereof, and is meanderingly formed.

[0021] The plurality of straight pipes each are covered with an oval heat radiating part having outer surfaces of opposite walls expanded outward, and the heat radiating parts may be arranged in the shape of a polygonal line so that ends of the adjacent heat radiating parts do not align.

According to the experiments, when expansion parts of the heat radiating parts are arranged opposite to each other, a vertical temperature difference of the radiant indoor machine increases. The reason for this is considered that air is made to be heated or cooled by arranging the expansion parts of the heat radiating parts opposite to each other.

Additionally, when the expansion parts of the heat radiating parts are horizontally aligned, the radiant indoor machine is excellent in radiating performance of radiant heat. Accordingly, by arranging the heat radiating parts in the shape of a polygonal line, vertical convection of indoor air can be kept while keeping a necessary radiant heat radiating surface.

[0022] Since frost or ice is deposited on the outdoor heat exchanger in winter and decreases in operation capacity, the exchanger is periodically subjected to defrosting operation. Compared with providing no radiant indoor machine, the number of times of defrosting operation is considered to be reduced by providing a radiant indoor machine. The reason for the reduction is not clear, however, it is considered that, by providing the radiant indoor machine, efficiency of condensation and vaporization of the refrigerant is improved, the load to the compressor is reduced and frost is hardly deposited on the outdoor heat exchanger.

By reducing the number of times of defrosting operation, energy is saved. Additionally, lowering of the temperature on the indoor side in the defrosting operation can be prevented.

[0023] When the compressor is high in capacity, the plurality of radiant indoor machines can be connected to a refrigerant circuit in series.

As another method, other than constituting a refrigerant circuit which makes all of the refrigerant pass through a radiant indoor machine, if a channel is secured through which part of refrigerant flows to the outdoor machine and the convective indoor machine without flowing through the radiant indoor machine, the radiant indoor machine is prevented from causing pressure loss of the refrigerant, and the compressor can be operated with no load.

[0024] (Actions) Since the inner diameter of the refrigerant pipe of the radiant indoor machine is made smaller than that of the refrigerant piping of the air conditioner in the air conditioning system including the convective indoor machine and the radiant indoor machine, decrease of the flow speed of refrigerant flowing through the refrigerant pipe is prevented and oil accumulation can be prevented from being caused in the refrigerant pipe of the radiant indoor machine.

Effect of the Invention

[0025] According to the present invention, an air conditioning system can be provided which includes a convective indoor machine and a radiant indoor machine to prevent separation of lubricating oil in refrigerant and consequently prevent damage to a compressor and can prevent lowering reliability of the compressor, since the inner diameter of a refrigerant pipe of the radiant indoor machine is made smaller than that of a refrigerant piping of an air conditioner.

Additionally, in the case where the radiant indoor machine includes a branching part for branching a flow of refrigerant flowing through the refrigerant pipe into a plurality of flows and a collecting part for collecting the refrigerant formed by the branching part, decrease of the flow speed of the refrigerant in the refrigerant pipe can be prevented by branching the refrigerant pipe into a plurality of pipes even if the radiant indoor machine is upsized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Fig. 1 is a schematic explanatory view of an air conditioning system according to an embodiment.

Fig. 2 is a refrigerant circuit diagram of the air conditioning system shown in Fig. 1.

Fig. 3 is a schematic explanatory view of a radiant indoor machine of which a screen decorative plate of an upper part is partially omitted.

Fig. 4 is a schematic explanatory view in the case where the machine is viewed in the A-A direction shown in Fig. 3.

Fig. 5 is a plan schematic explanatory view showing the structure of a refrigerant pipe of the radiant indoor machine, and showing the flow of refrigerant during heating by an arrow.

Fig. 6 is a front schematic explanatory view showing the structure of the refrigerant pipe of the radiant indoor machine shown in Fig. 5, and showing the flow of refrigerant during heating by an arrow.

Fig. 7 is a schematic explanatory view in the case where the machine is viewed in the A-A direction shown in Fig. 3.

Fig. 8 is a schematic cross-sectional explanatory view showing a relationship between a straight pipe and a heat radiation area enlarging member.

Fig. 9 is a plan schematic explanatory view showing the structure of the refrigerant pipe of the radiant indoor machine, and showing the flow of refrigerant during cooling by an arrow.

Fig. 10 is a front schematic explanatory view showing the structure of the refrigerant pipe of the radiant indoor machine shown in Fig. 9, and showing the flow of refrigerant during cooling by an arrow.

Fig. 11 is a front schematic explanatory view showing the structure of a refrigerant pipe of a modified radiant indoor machine of the present invention.

Mode for Carrying Out the Invention

[0027] The present invention will be described in detail based on embodiments shown in the drawings. Note that the symbols of the drawings are attached in order to avoid complexity and make for easier understanding.

[0028] As shown in Fig. 1, an air conditioning system 100 is constituted by one outdoor machine 1 and two indoor machines connected to the outdoor machine 1 in parallel. One of the two indoor machines is a general convective indoor machine 2, and the other is a radiant indoor machine 10.

The convective indoor machine 2 and the radiant indoor machine 10 are installed in a room or the like having an air conditioning target space and have a function of cooling or heating the air conditioning target space.

[0029] The convective indoor machine 2 and the radiant indoor machine 10 are communicatively connected by a refrigerant piping 7. Accordingly, the convective indoor machine 2 and the radiant indoor machine 10 of the air conditioning system 100 forms part of a refrigerant circuit, and cooling operation or heating operation can be performed by circulating refrigerant in the refrigerant circuit.

[0030] Note that, although one outdoor machine, one convective indoor machine 2 and one radiant indoor machine 10 are shown in Figs. 1 and 2, the number of each of the machines is not limited to the number shown in the figures.

[0031] As shown in Fig. 2, the outdoor machine 1 includes a compressor 3, an outdoor heat exchanger 4 and an expansion valve 5, and the structure thereof is well known. Additionally, the convective indoor machine 2 includes an indoor heat exchanger 6 and a blowing fan (not shown), and the structure thereof is well known.

[0032] The indoor heat exchanger 6 serves as a vaporizer during cooling operation and as a condenser (radiator) during heating operation, performs thermal exchange between air supplied from a blower such as a fan (not shown) and refrigerant, and generates heating air or cooling air to be supplied to the air conditioning target space.

The above devices are connected via the refrigerant piping 7, and constitute part of a refrigerating cycle (refrigerant circuit) of the air conditioning system 100.

[0033] [Radiant indoor machine]

The radiant indoor machine 10 is provided in the refrigerating cycle of the air conditioning system 100.

The radiant indoor machine 10 includes a heating element 11 and a frame 12 for fixing and supporting the heating element 11. The frame 12 includes, at its both left-right sides, vertical frames 12a and 12b vertically erected in parallel. As material of the frame 12, for example, wood, synthetic resin or metal such as aluminum can be employed.

Although the frame 12 includes a reflector for reflecting radiant heat or a back plate as a heat insulator in the embodiment, it does not need to include the back plate.

[0034] The heating element 11 is arranged between the vertical frames 12a and 12b.

The heating element 11 is vertically arranged in its longitudinal direction, and has a refrigerant pipe 110 which has a plurality of horizontally juxtaposed straight pipes 112 and connection pipes 114 connecting between upper ends of the adjacent straight pipes and between lower ends thereof and is meanderingly formed as a whole. As shown in Fig. 3, the heating element 11 is constituted in such a way that the straight pipe 112 of the refrigerant pipe 110 is surrounded by a heat radiation area enlarging member 111.

The refrigerant pipe 110 can be made of metal such as aluminum or copper, or, if necessary, another material.

[0035] In the embodiment, the heating element 11 has, at its upper side, a branching part 113 for branching a flow of refrigerant flowing through the refrigerant piping 7 into two flows and a collecting part 115 for collecting the refrigerant formed by the branching part 113. A connection port of the branching part 113 and a connection port of the collecting part 115 are respectively connected to the refrigerant piping 7, and the radiant indoor machine 10 is incorporated in the refrigerant circuit.

[0036] Note that, although the branching part 113 and the collecting part 115 are arranged at the upper side of the heating element 11 in the embodiment shown in Figs. 3, 4 and 6, not limited to this, for example, as shown in Fig. 11 (modified radiant indoor machine), the branching part 113 and the collecting part 115 may be arranged at a lower side of the heating element 11.

[0037] The branching part 113 includes branch pipes 113a and 113b. A flow of refrigerant is branched into two flows by the branch pipes 113a and 113b. For example, the arrow in Fig. 6 indicates the flow of refrigerant, one flow formed by the branch pipe 113a passes through the 6 straight pipes 112 shown in the right side of Fig. 6 (second heat generating part 11b), and the other flow formed by the branch pipe 113b passes through the 6 straight pipes 112 shown at the left side of Fig. 6 (first heat generating part 11a). The refrigerants converge at the collecting part 115, and the refrigerant flows from the collecting part 115 to the refrigerant circuit 7.

[0038] Note that the arrows in Figs. 5 and 6 indicate the flow of refrigerant during heating.

On the other hand, as shown in Figs. 9 and 10, the flow of refrigerant during cooling is opposite to that during heating (reverse direction of the arrow).

The reason for this setting is that, particularly during heating, when refrigerant flowing in the heating element 11 flows from the center side to the outer side (that is, the refrigerant flows from the branching part 113 side to the collecting part 115 side), heat is radiated more efficiently.

[0039] The reason for this is as follows. That is, although, during heating, refrigerant in the vicinity of an inlet is highest in temperature and the temperature slowly lowers by heat radiation as an outlet approaches, when the inlet of refrigerant is positioned outside the heating element 11 (the refrigerant flows in from the collecting part 115 side), heat is shielded by the vertical frames 12a and 12b (in other words, outermost parts of the heating element are positioned in shades of the vertical frames) due to the structure of the radiant indoor machine 10 of the embodiment and it is difficult to say that heat is radiated most efficiently.

On the other hand, when the inlet of refrigerant is positioned at the center side of the heating element 11, there exists no obstruction for obstructing heat radiation such as the vertical frame 12a or 12b, and thus, heat is radiated most efficiently.

[0040] In the embodiment, in terms of safety or protection of the system (in particular, the heating element), the vertical frames 12a and 12b are provided. However, in the case where neither of the vertical frames 12a and 12b is provided or heat radiation is not prevented by, for example, providing slits on the vertical frames 12a and 12b, refrigerant flowing in the heating element 11 may, during heating, flow from the outer side to the center side (that is, refrigerant flows from the collecting part 115 side to the branching part 113 side, during cooling, the refrigerant flows reversely).

[0041] In the embodiment, the lengths of the first heat generating part 11a and second heat generating part 11b are the same, about 6m. Additionally, the inner diameter, 4.75φ (17.7mm²), of the straight pipe 112 is smaller than that, 7.92φ (49.2mm²), of the refrigerant piping 7.

The refrigerant piping having an inner diameter of 7.92φ (49.2mm²) is branched into two systems by a two-system refrigerant pipe having an inner diameter of 4.75φ (17.7mm²). Thus, the flow speed of refrigerant in the heating element 11 between the branching part 113 and the collecting part 115 is higher than that of refrigerant flowing in the refrigerant piping 7, and separation of lubricating oil in two-phase refrigerant can be prevented.

[0042] As shown in Fig. 8, each straight pipe 112 is surrounded by the oval heat radiation area enlarging member 111 having outer surfaces of opposite walls expanded outward. The heat radiation area enlarging member 111 is made of, for example, aluminum, and thus, the area of a heat radiation of the straight pipe 112 for performing thermal exchange in an indoor space is enlarged.

[0043] The heat radiation area enlarging member 111 is constituted by two parts 111a and 111b between which the straight pipe 112 is sandwiched from both sides and which are connected by engagement of contact parts.

Additionally, the strength of pressure contact between the straight pipe 112 and the heat radiation area enlarging member 111 is set to the extent that the heat radiation area enlarging member 111 can rotate around the straight pipe 112. Thus, a direction of a heat radiating surface of the heat radiation area enlarging member 111 can be changed. Note that the member 111 does not need to rotate.

[0044] As shown in Figs. 3 and 4, at the lower side of the heating element 11, a drain pan 116, which is a water collecting member formed in the shape of a gutter having an opened upper part, is arranged with both ends of the pan fixed between the vertical frames 12a and 12b. A drain pipe is connected to one end side of the bottom of the drain pan 116. Dew condensation water condensing on a surface of the heating element 11 drops on the drain pan 116, and is appropriately collected and discarded through the drain pipe. The reference numeral 117 denotes a screen decorative plate.

[0045] (Actions)

The flow of refrigerant during each operation of the air conditioning system 100 will be described with reference to Figs. 1 and 2.

[0046] [Cooling operation Fig. 2(a)]

When the air conditioning system 100 performs cooling operation, a four-way valve 8 is switched so that refrigerant discharged from the compressor 3 flows into the outdoor heat exchanger 4, and the compressor 3 is driven.

[0047] Refrigerant sucked into the compressor 3 is formed into high-pressure and high-temperature gas in the compressor 3 and discharged therefrom, and flows into the outdoor heat exchanger 4 via the four-way valve 8. The refrigerant flowing in the outdoor heat exchanger 4 is cooled while radiating heat to air supplied from the blower (not shown), becomes low-pressure and high-temperature liquid refrigerant, and flows out from the outdoor heat exchanger 4.

[0048] The liquid refrigerant, which has flowed out from the outdoor heat exchanger 4, flows into the convective indoor machine 2 through the expansion valve 5. The refrigerant flowing in the convective indoor machine 2 becomes two-phase refrigerant. The low-pressure two-phase refrigerant flows into the indoor heat exchanger 6, and vaporizes by absorbing heat from air supplied from the blower (not shown) to become gas. At this time, cooling air is supplied to the air conditioning target space such as an indoor space to realize cooling operation of the air conditioning target space.

[0049] The two-phase refrigerant, which has flowed out from the indoor heat exchanger 6, flows out from the convective indoor machine 2, flows into the radiant indoor machine 10 and passes through the refrigerant pipe 110. At this time, heat absorption action to the atmosphere and cooling of the atmosphere, that is air, of the air conditioning target space such as an indoor space is performed to realize cooling of the air conditioning target space.

[0050] The refrigerant, which has flowed out from the radiant indoor machine 10, flows into the outdoor machine 1, passes through the four-way switch valve 8 of the outdoor machine 1 and is sucked into the compressor 3 again.

The cooling operation is performed by repeating the above refrigerant cycle.

[0051] [Heating operation Fig. 2(b)]

When the air conditioning system 100 performs heating operation, the four-way valve 3 is switched so that refrigerant discharged from the compressor 3 flows into the indoor heat exchanger 6, and the compressor 3 is driven. Refrigerant sucked into the compressor 3 is formed into high-pressure and high-temperature gas in the compressor 3 and discharged therefrom, and flows into the radiant indoor machine 10 via the four-way valve 8.

[0052] The refrigerant flowing in the radiant indoor machine 10 radiates radiant heat from the refrigerant pipe 110 of the heat generating part 11 to heat the atmosphere of the air conditioning target space such as an indoor space. The refrigerant, which has flowed out from the radiant indoor machine 10, flows into the indoor heat exchanger 6 of the convective indoor machine 2. The refrigerant flowing in the indoor heat exchanger 6 is cooled while radiating heat to air supplied from the blower (not shown) and becomes liquid refrigerant. At this time, heating air is supplied to the air conditioning target space such as an indoor space to realize heating operation of the air conditioning target space.

[0053] The liquid refrigerant, which has flowed out from the indoor heat exchanger 6, is decompressed by the expansion valve 5 and becomes low-pressure two-phase refrigerant. The low-pressure two-phase refrigerant flows into the outdoor heat exchanger 4 of the outdoor machine 1. The low-pressure two-phase refrigerant flowed into the outdoor heat exchanger 4 vaporizes by absorbing heat from air supplied from the blower (not shown) to become gas. The low-pressure gas refrigerant flows out from the outdoor heat exchanger 4, passes through the four-way valve 8 and is sucked into the compressor 3 again.

Heating operation is performed by repeating the above refrigerant cycle.

[0054] Note that, the terms and expressions used in the present specification are merely descriptive, are not restrictive by any means, and not intended to exclude terms and expressions equivalent to the features and portions thereof described in the present specification. Also, various modifications are possible within the scope of the technical ideas of the present invention.

Additionally, the terms, first, second and the like, mean neither grade nor priority, and are used for distinguishing one element from the other elements.

Description of the Symbols

[0055] 1: outdoor machine, 2: convective indoor machine, 3: compressor, 4: outdoor heat exchanger, 5: expansion valve, 6: indoor heat exchanger, 7: refrigerant piping, 8: four-way valve, 10: radiant indoor machine, 11: heating element, 12: frame, 100: air conditioning system, 110: refrigerant pipe, 111: heat radiation area enlarging member, 112: straight pipe, 113: branching part, 115: collecting part

DESCRIPTION

TITLE OF THE INVENTION: AIR CONDITIONING SYSTEM

Technical Field

[0001] The present invention relates to an air conditioning system, more specifically, it relates to an air conditioning system which includes a convective indoor machine and a radiant indoor machine to prevent damage to a compressor and lowering in reliability of the compressor.

Background Art

[0002] An air conditioner is generally used which has a compressor, an outdoor heat exchanger, an expansion valve, a convective indoor machine and a refrigerant piping connecting them. The air conditioner supplies cooled or heated air to an indoor space, at an air conditioning target space, by a fan and circulates or convects indoor air to perform air conditioning.

Additionally, air conditioning is performed by making refrigerant pass through a radiant indoor machine and cooling or heating air of the indoor space at an air conditioning target space.

[0003] The convective air conditioning using the convective indoor machine is quick in startup time, however, is low in the degree of comfort due to bodily sensation of supplied air, so-called draft sensation.

On the other hand, the radiant air conditioning using the radiant indoor machine has a disadvantage that startup time is long, however, has advantages that the degree of comfort on the human body is high, heating effect is excellent even if the temperature of indoor air is low, and heat loss is small.

Accordingly, if the convective air conditioning and the radiant air conditioning are used together, the advantage of one overcomes the disadvantage of the other, and comfortable and ideal air conditioning can be realized.

[0004] An air conditioning system, in which a radiant indoor machine is added to an air conditioner including a convective indoor machine, has already been proposed by the inventors in Patent Document 1.

Prior Art

Patent Document

[0005] Patent Document 1: Patent No. 5285179

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

[0006] The inventors repeated experiments for utilizing an air conditioning system in which a radiant indoor machine is added to an air conditioner including a convective indoor machine, and then found that an oil accumulation is caused at a lower part of the refrigerant pipe by meanderingly forming a refrigerant pipe of the radiant indoor machine (hereinafter, referred to as "meandering pipe"), the pipe including a plurality of vertically juxtaposed straight pipes and connection pipes connecting between upper ends of the adjacent straight pipes and between lower ends thereof.

[0007] Refrigerant of the air conditioner is partially a two-phase refrigerant of gas and liquid and circulates in a refrigerant piping, the refrigerant contains lubricating oil of a compressor, and the oil accumulation is considered to be caused by separation of the lubricating oil in the refrigerant. When the lubricating oil is separated and lost from the refrigerant, the compressor runs short of lubricating oil and receives excess load, and thus, is a cause for a failure.

[0008] The cause of separation of lubricating oil in refrigerant is not clear, however, it is thought as follows. That is, when the radiant indoor machine is added to the air conditioner including the convective indoor machine, it is considered to be the same as when the refrigerant piping is lengthened. In the given design no consideration is made for the radiant indoor machine which results in lack of capacity of the compressor, reducing the flow speed of the refrigerant, and thus, the oil accumulation is considered to be caused at the lower part of the refrigerant pipe of the radiant indoor machine.

[0009] Although it is considered that this problem can be solved by enhancing the capacity of the compressor, it is difficult, in terms of cost, to exchange the existing compressor for a compressor having higher capacity in the case of adding a radiant indoor machine to the existing air conditioner. Additionally, in the case of newly manufacturing an air conditioner, enhancing the capacity of a compressor in consideration of preparation of a radiant indoor machine which is not always used, results in increasing cost.

[0010] The inventors, in order to solve the problem, repeated their investigation on a radiant indoor machine, found that not reducing the flow speed of refrigerant flowing through the radiant indoor machine prevents oil accumulation from being caused, and accomplished the present invention.

[0011] (Object of the Invention)

The present invention has been made in order to solve the above problem, and it is a first object of the invention to provide an air conditioning system which includes a convective indoor machine and a radiant indoor machine to prevent separation of lubricating oil in refrigerant and consequently prevent damage to a compressor, and can prevent a lowering in reliability of the compressor.

In addition to the first object, it is a second object of the invention to provide an air conditioning system which prevents the flow speed of the refrigerant from decreasing even if the radiant indoor machine is upsized.

Means for Solving the Problem

[0012] The means taken by the present invention to solve the above problem are as follows.

An air conditioning system of the present invention includes: an air conditioner having at least: an outdoor machine having a compressor, an outdoor heat exchanger and an expansion valve; a convective indoor machine; and a refrigerant piping connecting them; and a radiant indoor machine which is arranged between the convective indoor machine and the outdoor machine and has a refrigerant pipe connecting between the convective indoor machine and the outdoor machine and having an inner diameter smaller than that of the refrigerant piping.

[0013] The inner diameter and the length of the refrigerant pipe of the radiant indoor machine can be optionally set in a design range where the air conditioning system functions as described in the following descriptions and embodiments. When the inner diameter of the refrigerant pipe is too small, the flow speed of refrigerant increases, however, pressure loss increases by resistance, the load of the compressor increases and efficiency is considered to deteriorate.

[0014] The relationship between the inner diameter of the refrigerant piping of the air conditioner and that of the refrigerant pipe of the radiant indoor machine is specifically as follows.

(1) For example, refrigerant flowing in a refrigerant piping [inner diameter: 7.92φ (49.2mm²)] of the air conditioner is branched into two systems by a meandering two-system refrigerant pipe [inner diameter: 4.75φ (17.7mm²)] of a radiant indoor machine. Straight pipe parts of the meandering pipe are vertically arranged.

The total cross-sectional area (35.4mm²) of the refrigerant pipe having an inner diameter of 4.75φ (17.7mm²) is about 72% of that of the refrigerant piping having an inner diameter of 7.92φ (49.2mm²), the inner diameter of the refrigerant pipe is smaller than that of the refrigerant piping, and therefore the flow speed of the refrigerant flowing in the refrigerant pipe increases.

[0015] A heating element of the radiant indoor machine including the refrigerant pipe has 12 heat radiation plates for one unit (two-system meandering pipe having 6 plates per one system) as a reference unit of one radiant indoor machine. Note that the above experiments were performed by using the reference unit.

[0016] (2) For example, refrigerant flowing in a refrigerant piping [inner diameter: 11.1φ (96.7mm²)] of the air conditioner is branched into two systems by a meandering two-system refrigerant pipe [inner diameter: 7.92φ (49.2mm²)] of a radiant indoor machine. Straight pipe parts of the meandering pipe are vertically arranged.

The total cross-sectional area (98.4mm²) of the refrigerant pipe having an inner diameter of 7.92φ (49.2mm²) is about 101.7% of that of the refrigerant piping having an inner diameter of 11.1φ (96.7mm²), and the flow speeds of the refrigerants flowing in the pipe and the piping become approximately the same.

[0017] (3) For example, refrigerant flowing in a refrigerant piping [inner diameter: 13.88φ (151.2mm²)] of the air conditioner is branched into two systems by a meandering two-system refrigerant pipe [inner diameter: 6.4φ (32.2mm²)] of a radiant indoor machine. Straight pipe parts of the meandering pipe are vertically arranged. If two two-system meandering pipes are juxtaposed into four systems (two radiant indoor machines), the total cross-sectional area (128.8mm²) of the refrigerant pipe having an inner diameter of 6.4φ (32.2mm²) is about 85.1% of that of the refrigerant piping having an inner diameter of 13.88φ (151.2mm²) and the flow speed increases.

[0018] The larger the radiant indoor machine becomes, the longer the refrigerant pipe becomes. Since refrigerant moves to an outlet while slowly radiating heat from the vicinity of an inlet of the refrigerant pipe, a temperature difference between the vicinities of the inlet and the outlet is caused and there is a possibility that the capacity of a heating element of the radiant indoor machine is not sufficiently shown. That is, temperature unevenness of the heating element causes heat radiation capacity of the heating element to be insufficiently shown. Additionally, the flow speed of the refrigerant decreases, and oil accumulation is caused.

[0019] Accordingly, in order to branch the refrigerant in a design range where the air conditioning system sufficiently functions, the radiant indoor machine, preferably, includes a branch part for branching a flow of refrigerant into a plurality of flows and a collecting part for collecting the refrigerant formed by the branching part.

Additionally, when the inner diameter of the refrigerant pipe is made small in a design range where the air conditioning system functions, and when a plurality of radiant indoor machines are provided, heat efficiency of the radiant indoor machines as a whole can be raised.

[0020] In terms of smoothness of a flow of refrigerant, it is preferable that the refrigerant pipe of the radiant indoor machine includes a plurality of straight pipes vertically juxtaposed and connection pipes connecting between upper ends of the adjacent straight pipes and between lower ends thereof, and is meanderingly formed.

[0021] The plurality of straight pipes each are covered with an oval heat radiating part having outer surfaces of opposite walls expanded outward, and the heat radiating parts may be arranged in the shape of a polygonal line so that ends of the adjacent heat radiating parts do not align.

According to the experiments, when expansion parts of the heat radiating parts are arranged opposite to each other, a vertical temperature difference of the radiant indoor machine increases. The reason for this is considered that air is made to be heated or cooled by arranging the expansion parts of the heat radiating parts opposite to each other.

Additionally, when the expansion parts of the heat radiating parts are horizontally aligned, the radiant indoor machine is excellent in radiating performance of radiant heat. Accordingly, by arranging the heat radiating parts in the shape of a polygonal line, vertical convection of indoor air can be kept while keeping a necessary radiant heat radiating surface.

[0022] Since frost or ice is deposited on the outdoor heat exchanger in winter and decreases in operation capacity, the exchanger is periodically subjected to defrosting operation. Compared with providing no radiant indoor machine, the number of times of defrosting operation is considered to be reduced by providing a radiant indoor machine. The reason for the reduction is not clear, however, it is considered that, by providing the radiant indoor machine, efficiency of condensation and vaporization of the refrigerant is improved, the load to the compressor is reduced and frost is hardly deposited on the outdoor heat exchanger.

By reducing the number of times of defrosting operation, energy is saved. Additionally, lowering of the temperature on the indoor side in the defrosting operation can be prevented.

[0023] When the compressor is high in capacity, the plurality of radiant indoor machines can be connected to a refrigerant circuit in series.

As another method, other than constituting a refrigerant circuit which makes all of the refrigerant pass through a radiant indoor machine, if a channel is secured through which part of refrigerant flows to the outdoor machine and the convective indoor machine without flowing through the radiant indoor machine, the radiant indoor machine is prevented from causing pressure loss of the refrigerant, and the compressor can be operated with no load.

[0024] (Actions) Since the inner diameter of the refrigerant pipe of the radiant indoor machine is made smaller than that of the refrigerant piping of the air conditioner in the air conditioning system including the convective indoor machine and the radiant indoor machine, decrease of the flow speed of refrigerant flowing through the refrigerant pipe is prevented and oil accumulation can be prevented from being caused in the refrigerant pipe of the radiant indoor machine.

Effect of the Invention

[0025] According to the present invention, an air conditioning system can be provided which includes a convective indoor machine and a radiant indoor machine to prevent separation of lubricating oil in refrigerant and consequently prevent damage to a compressor and can prevent lowering reliability of the compressor, since the inner diameter of a refrigerant pipe of the radiant indoor machine is made smaller than that of a refrigerant piping of an air conditioner.

Additionally, in the case where the radiant indoor machine includes a branching part for branching a flow of refrigerant flowing through the refrigerant pipe into a plurality of flows and a collecting part for collecting the refrigerant formed by the branching part, decrease of the flow speed of the refrigerant in the refrigerant pipe can be prevented by branching the refrigerant pipe into a plurality of pipes even if the radiant indoor machine is upsized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Fig. 1 is a schematic explanatory view of an air conditioning system according to an embodiment.

Fig. 2 is a refrigerant circuit diagram of the air conditioning system shown in Fig. 1.

Fig. 3 is a schematic explanatory view of a radiant indoor machine of which a screen decorative plate of an upper part is partially omitted.

Fig. 4 is a schematic explanatory view in the case where the machine is viewed in the A-A direction shown in Fig. 3.

Fig. 5 is a plan schematic explanatory view showing the structure of a refrigerant pipe of the radiant indoor machine, and showing the flow of refrigerant during heating by an arrow.

Fig. 6 is a front schematic explanatory view showing the structure of the refrigerant pipe of the radiant indoor machine shown in Fig. 5, and showing the flow of refrigerant during heating by an arrow.

Fig. 7 is a schematic explanatory view in the case where the machine shown in Fig. 3 is viewed from above.

Fig. 8 is a schematic cross-sectional explanatory view showing a relationship between a straight pipe and a heat radiation area enlarging member.

Fig. 9 is a plan schematic explanatory view showing the structure of the refrigerant pipe of the radiant indoor machine, and showing the flow of refrigerant during cooling by an arrow.

Fig. 10 is a front schematic explanatory view showing the structure of the refrigerant pipe of the radiant indoor machine shown in Fig. 9, and showing the flow of refrigerant during cooling by an arrow.

Fig. 11 is a front schematic explanatory view showing the structure of a refrigerant pipe of a modified radiant indoor machine of the present invention.

Mode for Carrying Out the Invention

[0027] The present invention will be described in detail based on embodiments shown in the drawings. Note that the symbols of the drawings are attached in order to avoid complexity and make for easier understanding.

[0028] As shown in Fig. 1, an air conditioning system 100 is constituted by one outdoor machine 1 and two indoor machines connected to the outdoor machine 1 in serial. One of the two indoor machines is a general convective indoor machine 2, and the other is a radiant indoor machine 10.

The convective indoor machine 2 and the radiant indoor machine 10 are installed in a room or the like having an air conditioning target space and have a function of cooling or heating the air conditioning target space.

[0029] The convective indoor machine 2 and the radiant indoor machine 10 are communicatively connected by a refrigerant piping 7. Accordingly, the convective indoor machine 2 and the radiant indoor machine 10 of the air conditioning system 100 forms part of a refrigerant circuit, and cooling operation or heating operation can be performed by circulating refrigerant in the refrigerant circuit.

[0030] Note that, although one outdoor machine, one convective indoor machine 2 and one radiant indoor machine 10 are shown in Figs. 1 and 2, the number of each of the machines is not limited to the number shown in the figures.

[0031] As shown in Fig. 2, the outdoor machine 1 includes a compressor 3, an outdoor heat exchanger 4 and an expansion valve 5, and the structure thereof is well known. Additionally, the convective indoor machine 2 includes an indoor heat exchanger 6 and a blowing fan (not shown), and the structure thereof is well known.

[0032] The indoor heat exchanger 6 serves as a vaporizer during cooling operation and as a condenser (radiator) during heating operation, performs thermal exchange between air supplied from a blower such as a fan (not shown) and refrigerant, and generates heating air or cooling air to be supplied to the air conditioning target space.

The above devices are connected via the refrigerant piping 7, and constitute part of a refrigerating cycle (refrigerant circuit) of the air conditioning system 100.

[0033] [Radiant indoor machine]

The radiant indoor machine 10 is provided in the refrigerating cycle of the air conditioning system 100.

The radiant indoor machine 10 includes a heating element 11 and a frame 12 for fixing and supporting the heating element 11. The frame 12 includes, at its both left-right sides, vertical frames 12a and 12b vertically erected in parallel. As material of the frame 12, for example, wood, synthetic resin or metal such as aluminum can be employed.

Although the frame 12 includes a reflector for reflecting radiant heat or a back plate as a heat insulator in the embodiment, it does not need to include the back plate.

[0034] The heating element 11 is arranged between the vertical frames 12a and 12b.

The heating element 11 is vertically arranged in its longitudinal direction, and has a refrigerant pipe 110 which has a plurality of horizontally juxtaposed straight pipes 112 and connection pipes 114 connecting between upper ends of the adjacent straight pipes and between lower ends thereof and is meanderingly formed as a whole. As shown in Fig. 3, the heating element 11 is constituted in such a way that the straight pipe 112 of the refrigerant pipe 110 is surrounded by a heat radiation area enlarging member 111.

The refrigerant pipe 110 can be made of metal such as aluminum or copper, or, if necessary, another material.

[0035] In the embodiment, the heating element 11 has, at its upper side, a branching part 113 for branching a flow of refrigerant flowing through the refrigerant piping 7 into two flows and a collecting part 115 for collecting the refrigerant formed by the branching part 113. A connection port of the branching part 113 and a connection port of the collecting part 115 are respectively connected to the refrigerant piping 7, and the radiant indoor machine 10 is incorporated in the refrigerant circuit.

[0036] Note that, although the branching part 113 and the collecting part 115 are arranged at the upper side of the heating element 11 in the embodiment shown in Figs. 3, 4 and 6, not limited to this, for example, as shown in Fig. 11 (modified radiant indoor machine), the branching part 113 and the collecting part 115 may be arranged at a lower side of the heating element 11.

[0037] The branching part 113 includes branch pipes 113a and 113b. A flow of refrigerant is branched into two flows by the branch pipes 113a and 113b. For example, the arrow in Fig. 6 indicates the flow of refrigerant, one flow formed by the branch pipe 113a passes through the 6 straight pipes 112 shown in the right side of Fig. 6 (second heating element 11b), and the other flow formed by the branch pipe 113b passes through the 6 straight pipes 112 shown at the left side of Fig. 6 (first heating element 11a). The refrigerants converge at the collecting part 115, and the refrigerant flows from the collecting part 115 to the refrigerant circuit 7.

[0038] Note that the arrows in Figs. 5 and 6 indicate the flow of refrigerant during heating.

On the other hand, as shown in Figs. 9 and 10, the flow of refrigerant during cooling is opposite to that during heating (reverse direction of the arrow).

The reason for this setting is that, particularly during heating, when refrigerant flowing in the heating element 11 flows from the center side to the outer side (that is, the refrigerant flows from the branching part 113 side to the collecting part 115 side), heat is radiated more efficiently.

[0039] The reason for this is as follows. That is, although, during heating, refrigerant in the vicinity of an inlet is highest in temperature and the temperature slowly lowers by heat radiation as an outlet approaches, when the inlet of refrigerant is positioned outside the heating element 11 (the refrigerant flows in from the collecting part 115 side), heat is shielded by the vertical frames 12a and 12b (in other words, outermost parts of the heating element are positioned in shades of the vertical frames) due to the structure of the radiant indoor machine 10 of the embodiment and it is difficult to say that heat is radiated most efficiently.

On the other hand, when the inlet of refrigerant is positioned at the center side of the heating element 11, there exists no obstruction for obstructing heat radiation such as the vertical frame 12a or 12b, and thus, heat is radiated most efficiently.

[0040] In the embodiment, in terms of safety or protection of the system (in particular, the heating element), the vertical frames 12a and 12b are provided. However, in the case where neither of the vertical frames 12a and 12b is provided or heat radiation is not prevented by, for example, providing slits on the vertical frames 12a and 12b, refrigerant flowing in the heating element 11 may, during heating, flow from the outer side to the center side (that is, refrigerant flows from the collecting part 115 side to the branching part 113 side, during cooling, the refrigerant flows reversely).

[0041] In the embodiment, the lengths of the first heating element 11a and the second heating element 11b are the same, about 6m. Additionally, the inner diameter, 4.75φ (17.7mm²), of the straight pipe 112 is smaller than that, 7.92φ (49.2mm²), of the refrigerant piping 7.

The refrigerant piping having an inner diameter of 7.92φ (49.2mm²) is branched into two systems by a two-system refrigerant pipe having an inner diameter of 4.75φ (17.7mm²). Thus, the flow speed of refrigerant in the heating element 11 between the branching part 113 and the collecting part 115 is higher than that of refrigerant flowing in the refrigerant piping 7, and separation of lubricating oil in two-phase refrigerant can be prevented.

[0042] As shown in Fig. 8, each straight pipe 112 is surrounded by the oval heat radiation area enlarging member 111 having outer surfaces of opposite walls expanded outward. The heat radiation area enlarging member 111 is made of, for example, aluminum, and thus, the area of a heat radiation of the straight pipe 112 for performing thermal exchange in an indoor space is enlarged.

[0043] The heat radiation area enlarging member 111 is constituted by two parts 111a and 111b between which the straight pipe 112 is sandwiched from both sides and which are connected by engagement of contact parts.

Additionally, the strength of pressure contact between the straight pipe 112 and the heat radiation area enlarging member 111 is set to the extent that the heat radiation area enlarging member 111 can rotate around the straight pipe 112. Thus, a direction of a heat radiating surface of the heat radiation area enlarging member 111 can be changed. Note that the member 111 does not need to rotate.

[0044] As shown in Figs. 3 and 4, at the lower side of the heating element 11, a drain pan 116, which is a water collecting member formed in the shape of a gutter having an opened upper part, is arranged with both ends of the pan fixed between the vertical frames 12a and 12b. A drain pipe is connected to one end side of the bottom of the drain pan 116. Dew condensation water condensing on a surface of the heating element 11 drops on the drain pan 116, and is appropriately collected and discarded through the drain pipe. The reference numeral 117 denotes a screen decorative plate.

[0045] (Actions)

The flow of refrigerant during each operation of the air conditioning system 100 will be described with reference to Figs. 1 and 2.

[0046] [Cooling operation Fig. 2(a)]

When the air conditioning system 100 performs cooling operation, a four-way valve 8 is switched so that refrigerant discharged from the compressor 3 flows into the outdoor heat exchanger 4, and the compressor 3 is driven.

[0047] Refrigerant sucked into the compressor 3 is formed into high-pressure and high-temperature gas in the compressor 3 and discharged therefrom, and flows into the outdoor heat exchanger 4 via the four-way valve 8. The refrigerant flowing in the outdoor heat exchanger 4 is cooled while radiating heat to air supplied from the blower (not shown), becomes low-pressure and high-temperature liquid refrigerant, and flows out from the outdoor heat exchanger 4.

[0048] The liquid refrigerant, which has flowed out from the outdoor heat exchanger 4, flows into the convective indoor machine 2 through the expansion valve 5. The refrigerant flowing in the convective indoor machine 2 becomes two-phase refrigerant. The low-pressure two-phase refrigerant flows into the indoor heat exchanger 6, and vaporizes by absorbing heat from air supplied from the blower (not shown) to become gas. At this time, cooling air is supplied to the air conditioning target space such as an indoor space to realize cooling operation of the air conditioning target space.

[0049] The two-phase refrigerant, which has flowed out from the indoor heat exchanger 6, flows out from the convective indoor machine 2, flows into the radiant indoor machine 10 and passes through the refrigerant pipe 110. At this time, heat absorption action to the atmosphere and cooling of the atmosphere, that is air, of the air conditioning target space such as an indoor space is performed to realize cooling of the air conditioning target space.

[0050] The refrigerant, which has flowed out from the radiant indoor machine 10, flows into the outdoor machine 1, passes through the four-way valve 8 of the outdoor machine 1 and is sucked into the compressor 3 again.

The cooling operation is performed by repeating the above refrigerant cycle.

[0051] [Heating operation Fig. 2(b)]

When the air conditioning system 100 performs heating operation, the four-way valve 8 is switched so that refrigerant discharged from the compressor 3 flows into the indoor heat exchanger 6, and the compressor 3 is driven. Refrigerant sucked into the compressor 3 is formed into high-pressure and high-temperature gas in the compressor 3 and discharged therefrom, and flows into the radiant indoor machine 10 via the four-way valve 8.

[0052] The refrigerant flowing in the radiant indoor machine 10 radiates radiant heat from the refrigerant pipe 110 of the heating element 11 to heat the atmosphere of the air conditioning target space such as an indoor space. The refrigerant, which has flowed out from the radiant indoor machine 10, flows into the indoor heat exchanger 6 of the convective indoor machine 2. The refrigerant flowing in the indoor heat exchanger 6 is cooled while radiating heat to air supplied from the blower (not shown) and becomes liquid refrigerant. At this time, heating air is supplied to the air conditioning target space such as an indoor space to realize heating operation of the air conditioning target space.

[0053] The liquid refrigerant, which has flowed out from the indoor heat exchanger 6, is decompressed by the expansion valve 5 and becomes low-pressure two-phase refrigerant. The low-pressure two-phase refrigerant flows into the outdoor heat exchanger 4 of the outdoor machine 1. The low-pressure two-phase refrigerant flowed into the outdoor heat exchanger 4 vaporizes by absorbing heat from air supplied from the blower (not shown) to become gas. The low-pressure gas refrigerant flows out from the outdoor heat exchanger 4, passes through the four-way valve 8 and is sucked into the compressor 3 again.

Heating operation is performed by repeating the above refrigerant cycle.

[0054] Note that, the terms and expressions used in the present specification are merely descriptive, are not restrictive by any means, and not intended to exclude terms and expressions equivalent to the features and portions thereof described in the present specification. Also, various modifications are possible within the scope of the technical ideas of the present invention.

Additionally, the terms, first, second and the like, mean neither grade nor priority, and are used for distinguishing one element from the other elements.

Description of the Symbols

[0055] 1: outdoor machine, 2: convective indoor machine, 3: compressor, 4: outdoor heat exchanger, 5: expansion valve, 6: indoor heat exchanger, 7: refrigerant piping, 8: four-way valve, 10: radiant indoor machine, 11: heating element, 12: frame, 100: air conditioning system, 110: refrigerant pipe, 111: heat radiation area enlarging member, 112: straight pipe, 113: branching part, 115: collecting part