

RADIANT AIR CONDITIONING DEVICE, RADIANT UNIT, AND RADIANT AIR CONDITIONING SYSTEM

Technical Field

[0001] The present invention relates to a radiant air conditioning device, a radiant unit, and a radiant air conditioning system.

Background Art

[0002] In recent years, a cooling and heating ceiling panel has been proposed which cools or heats an indoor space by radiant air conditioning (see, e.g., Patent Literature 1).

[0003] The heating and cooling ceiling panel described in Patent Literature 1 includes a plate-shaped metal radiant panel (also referred to as a metal panel), a resin heat exchange pipe through which a heat medium flows, and plural metal holding members that partially fix the heat exchange pipe to the back surface of the radiant panel. To use the ceiling heating and cooling panels, plural radiant panels are laid so that heat exchange pipes fixed thereto are located on the ceiling side. In this heating and cooling ceiling panel, a heated or cooled heat medium is passed through the heat exchange pipe to heat or cool the metal panel, and the surface of the metal panel on the floor side acts as a radiant surface that radiates or absorbs infrared rays, thereby performing radiant air conditioning for the indoor space.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Patent No. 5224171

Patent Literature 2: Japanese Patent No. 5887577

Summary of Invention

[0005] However, the known heating and cooling ceiling panels use metal panels as radiant

members with floor-side surfaces acting as radiant surfaces, metal holding members to fix heat exchange pipes, and a frame member (generally formed of metal) in a grid pattern provided to lay the plural metal panels across the entire ceiling (see, e.g., Patent Literature 2). Therefore, the heating and cooling ceiling panel as a whole is heavy, which places a burden on workers during transport and installation.

[0006] Therefore, it is an object of the invention to provide a radiant air conditioning device, a radiant unit and a radiant air conditioning system that allow for reduction in work burden during transport and installation, etc.

[0007] To solve the above-mentioned problem, the invention provides a radiant air conditioning device, comprising:

- a tubular member that is arranged in a region smaller than a ceiling surface of an indoor space, with a first space provided between the tubular member and the ceiling surface, and that comprises a plurality of flow path portions through which a heat medium flows substantially parallel to the ceiling surface; and

- a fabric radiant member that is arranged in a region smaller than the ceiling surface, with a second space provided between the radiant member and the tubular member, so as to expose a radiant surface thereof on a side of the tubular member opposite to the ceiling surface and that directly exchanges heat with the tubular member.

To solve the above-mentioned problem, the invention also provides a radiant unit, comprising:

- a frame body formed in a rectangular shape so as to surround an inner region in plan view;

- a tubular member that comprises a plurality of flow path portions with a heat medium flowing therethrough and is attached to the frame body so as to be located in the inner region of

the frame body; and

a fabric radiant member that is attached to the frame body in the inner region of the frame body, with a space provided between the radiant member and the tubular member, so as to expose a radiant surface thereof on one side of the tubular member and that directly exchanges heat with the tubular member.

To solve the above-mentioned problem, the invention also provides a radiant air conditioning system, comprising:

a plurality of the above-described radiant air conditioning devices; and

a heat source machine that causes the heat medium with controlled temperature and flow rate to circulate through the tubular members of the plurality of the radiant air conditioning devices.

Advantageous Effects of Invention

[0008] According to the invention, it is possible to provide a radiant air conditioning device, a radiant unit and a radiant air conditioning system that allow for reduction in work burden during transport and installation, etc.

Brief Description of Drawings

[0009] (FIG. 1A) FIG. 1A is a front view showing an example of an installed state of a radiant air conditioning device constituting a radiant air conditioning system in the first embodiment of the present invention.

(FIG. 1B) FIG. 1B is a cross-sectional view taken along line A-A of FIG. 1A.

(FIG. 2) FIG. 2 is a plan view showing the radiant air conditioning device shown in FIG. 1.

(FIG. 3) FIG. 3 is a diagram illustrating an example configuration of a heat exchange mat.

(FIG. 4) FIG. 4 is a main part perspective view showing an example of a first attachment portion

to attach a first heat exchange mat and a second heat exchange mat.

(FIG. 5) FIG. 5 is a main part perspective view showing an example of a second attachment portion to attach a curtain member.

(FIG. 6) FIG. 6 is a block diagram illustrating an example configuration of a control device.

(FIG. 7) FIG. 7 is a schematic plan view showing an example of a heat medium path between a heat source machine and the heat exchange mats.

(FIG. 8) FIG. 8 is a front view showing an example of the installed state of the radiant air conditioning device constituting the radiant air conditioning system in the second embodiment of the invention.

(FIG. 9A) FIG. 9A is a plan view showing the radiant air conditioning device shown in FIG. 8.

(FIG. 9B) FIG. 9B is an enlarged view showing a portion C in FIG. 9A.

(FIG. 10) FIG. 10 is a main part perspective view showing an example of a portion at which the heat exchange mats and the curtain member are attached.

(FIG. 11A) FIG. 11A is a cross-sectional view taken along line E-E of FIG. 12, showing an example of the installed state of the radiant air conditioning device constituting the radiant air conditioning system in Modification 1.

(FIG. 11B) FIG. 11B is an enlarged view showing a portion D in FIG. 11A.

(FIG. 12) FIG. 12 is a plan view showing the radiant air conditioning device shown in FIG. 11A.

(FIG. 13) FIG. 13 is a main part front view showing an example of the installed state of the radiant air conditioning device constituting the radiant air conditioning system in Modification 2.

(FIG. 14) FIG. 14 is a main part plan view showing Modification 3.

(FIG. 15) FIG. 15 is a cross-sectional view taken along the line B-B shown in FIG. 1A, showing the curtain member in Modification 4.

(FIG. 16) FIG. 16 is a perspective view showing an example of the second attachment portion to attach the curtain member in Modification 4.

(FIG. 17) FIG. 17 is a front view showing the radiant air conditioning system in Modification 6.

(FIG. 18A) FIG. 18A is a plan view showing the radiant air conditioning device shown in FIG. 17.

(FIG. 18B) FIG. 18B is an enlarged view showing a portion F in FIG. 18A.

(FIG. 19A) FIG. 19A is a schematic perspective view showing the radiant air conditioning device in Modification 7 as viewed obliquely from above.

(FIG. 19B) FIG. 19B is a schematic perspective view showing the radiant air conditioning device in Modification 7 as viewed obliquely from below.

(FIG. 19C) FIG. 19C is a schematic perspective view showing the radiant air conditioning device when a roll-up curtain is lowered in FIG. 19A.

(FIG. 20) FIG. 20 is a plan view showing a unit of the radiant air conditioning device shown in FIG. 19A.

(FIG. 21A) FIG. 21A is a cross-sectional view taken along line G-G of FIG. 20.

(FIG. 21B) FIG. 21B is an enlarged view showing a portion H in FIG. 21A.

Description of Embodiments

[0010] Embodiments of the invention will be described below with reference to the drawings.

In each drawing, constituent elements having substantially the same functions are denoted by the same reference numerals and overlapping explanations thereof will be omitted.

[0011] (First embodiment)

FIGS. 1A, 1B and 2 show an example of an installed state of a radiant air conditioning device constituting a radiant air conditioning system in the first embodiment of the invention, wherein

FIG. 1A is a front view, FIG. 1B is a cross-sectional view taken along line A-A of FIG. 1A, and FIG. 2 is a plan view.

[0012] In FIG. 1A, the reference signs a and b indicate radiant heat (also referred to as radiation heat) such as infrared or far infrared, and c indicates convection. The directions of the radiant heat a and b shown here are the directions during a cooling operation mode, but are opposite to those in FIG. 1A during a heating operation mode. In the present specification and the drawings, X indicates a longitudinal direction of a heat exchange mat 2 and a curtain member 3 (which are described later), Xa indicates one side in the longitudinal direction X (the left side in FIGS. 1A and 2), and Xb indicates the other side in the longitudinal direction X (the right side in FIGS. 1A and 2). In addition, Y indicates a lateral direction of the heat exchange mat 2 and the curtain member 3 which is orthogonal to the longitudinal direction X, Ya indicates one side in the lateral direction Y (the left side in FIG. 1B and the front side in FIG. 2), and Yb indicates the other side in the lateral direction Y (the right side in FIG. 1B and the back side in FIG. 2).

[0013] This radiant air conditioning system 10 includes, e.g., plural radiant air conditioning devices 1 (two in the first embodiment) arranged side by side in a room 100, and a heat source machine 11 that causes a heat medium such as water, whose temperature and flow rate are controlled and which is heated or cooled to a predetermined temperature, to circulate through first and second heat exchange mats 2A and 2B (hereinafter, these are also collectively referred to as the “heat exchange mats 2”) constituting the radiant air conditioning devices 1.

[0014] The radiant air conditioning system 10 has the function of heating and cooling the inside of the room 100 by heat exchange through radiation and convection (also referred to as airflow). The room 100 is, e.g., a bedroom or living room, etc., in a building such as a residential house, a housing complex, or a hospital. The indoor space where the radiant air conditioning devices 1

are installed may be an indoor space in an office building, a factory or a public facility, etc., other than the room 100. The room 100 is an example of an indoor space.

[0015] The radiant air conditioning device 1 includes the first heat exchange mat 2A that is arranged in a region smaller than a surface of a ceiling 101 (hereinafter, referred to as the “ceiling surface 101a”) with a first space Sa (e.g., a gap of 300 mm at the center in the longitudinal direction X) provided between itself and the ceiling surface 101a, the second heat exchange mat 2B that is arranged in a region smaller than the ceiling surface 101a on a side of the first heat exchange mat 2A opposite to the ceiling surface 101a, and the fabric curtain member 3 that is arranged in a region smaller than the ceiling surface 101a, with a second space Sb (e.g., a gap of 200 mm at the center in the longitudinal direction X) provided between itself and the second heat exchange mat 2B, so as to expose a radiant surface 3a which is located on a side of the second heat exchange mat 2B opposite to the ceiling surface 101a and radiates or absorbs infrared rays.

[0016] The second heat exchange mat 2B is shown as being in contact with the first heat exchange mat 2A in FIG. 1A but may be arranged so as not to be in contact with the first heat exchange mat 2A as shown in FIG. 1B. Here, the first heat exchange mat 2A is an example of a first tubular member. The second heat exchange mat 2B is an example of a second tubular member. The curtain member 3 is an example of a radiant member. The first heat exchange mat 2A and the second heat exchange mat 2B are an example of tubular members that have plural flow path portions and are arranged in layers in a direction toward the ceiling surface 101a (in the up-down direction). For example, the radiant air conditioning device 1 may include not less than three heat exchange mats 2, with heat exchange pipes 23 (described later) arranged in layers in the direction toward the ceiling surface 101a (in the up-down direction). The heat

exchange pipe 23 is an example of a flow path portion. Alternatively, instead of providing the heat exchange mats 2 in layers, a single heat exchange mat 2 may be used. The same applies to the other embodiments and Modifications.

[0017] The radiant air conditioning system 10 also includes an air conditioning unit 8 such as air conditioner that produce air with regulated temperature and humidity, a dew-point temperature sensor 91 that detects a dew point temperature around the first heat exchange mat 2A or the second heat exchange mat 2B of one of the two radiant air conditioning devices 1, and a control device 9 (described later) that controls temperature based on the dew point temperature detected by the dew-point temperature sensor 91. The air conditioning unit 8 is an example of an airflow generator. In this regard, the air conditioning unit 8 is not an essential component, and may not be provided depending on condensation occurrence conditions. In addition, the air conditioning unit 8 may produce air which is regulated for at least one of temperature and humidity.

[0018] The dew-point temperature sensor 91 is arranged near the heat exchange mat 2 farther from an indoor unit of the air conditioning unit 8 as shown in FIG. 2 to suppress occurrence of condensation over a wide range, but the dew-point temperature sensors 91 may be arranged near both the heat exchange mat 2 closer to the indoor unit of the air conditioning unit 8 and the farther heat exchange mat 2 and an average value of two detected dew point temperatures may be used. In addition, two beds 110 are arranged in the first embodiment as shown in FIG. 2, but only one bed 110 may be arranged. In this case, to suppress occurrence of condensation on a side closer to the bed 110, the dew-point temperature sensor 91 may be arranged near the heat exchange mat 2 closer to the bed 110. In addition, the dew-point temperature sensor 91 is arranged near the second heat exchange mat 2B in FIG. 1 but may be arranged near the first heat

exchange mat 2A, or the dew-point temperature sensors 91 may be arranged both near the first heat exchange mat 2A and near the second heat exchange mat 2B and an average value of two detected dew point temperatures may be used.

[0019] The air conditioning unit 8 includes, as components constituting the indoor unit, a substantially box-shaped housing 80, a fan 81 arranged in the housing 80 to blow temperature- and humidity-regulated air, an air outlet 82 to discharge the air blown from the fan 81 as an airflow, and airflow control plates 83a, 83b that are provided around the air outlet 82 to cause the air blown from the fan 81 to be generated as an airflow d and to cause the airflow d to pass along the radiant surface 3a of the curtain member 3 and also to be blown toward the heat exchange mats 2 through openings of the curtain member 3. The air conditioning unit 8 further includes an outdoor unit (not shown) that is installed outdoors and exchanges heat between a refrigerant from the indoor unit and the outside air, and a remote controller (not shown). In addition, the air conditioning unit 8 is configured such that instruction to turn on or off the air conditioning unit 8 and temperature and humidity settings of the blown air can be made by the remote controller. As shown in FIG. 2, the airflow d discharged from the air conditioning unit 8 flows not only toward the closest curtain member 3 but also toward the adjacent curtain member 3. When there is a risk of condensation forming on the surfaces of the heat exchange pipes 23 of the heat exchange mats 2 during the cooling operation mode, etc., the formation of condensation on the surfaces of the heat exchange pipes 23 may be suppressed by controlling one or both of the temperature and humidity of the airflow d blown toward the heat exchange mats 2, or by controlling the temperature of the heat medium supplied from the heat source machine 11 to the heat exchange mats 2 using a control unit 90 (described later).

[0020] In the first embodiment, two beds 110 are arranged on a surface of a floor 103

(hereinafter, referred to as the “floor surface 103a”) in the room 100 and one radiant air conditioning device 1 is arranged above each bed 110, as shown in FIG. 2. A futon may be used instead of the bed 110. The bed 110 and the futon here are examples of bedding. In addition, the bed 110 is a single bed in the drawing but may be a semi-double bed or a double bed. The heat exchange mat 2 and the curtain member 3 have a larger area than the bed 110 in plan view. However, the heat exchange mat 2 and the curtain member 3 may have an area (full length $\times$ width) corresponding to the area (full length $\times$ width) of the bed 110, i.e., may have an area approximately the same area as the area of the bed 110. Approximately the same area means that a difference of about 30% is acceptable for both the sizes in length and width. In addition, the shapes of the heat exchange mat 2 and the curtain member 3 in plan view are not limited to a rectangle which is long in the longitudinal direction X, and may be a square. The same applies to the other embodiments and Modifications.

[0021] As shown in FIG. 1B, the second heat exchange mat 2B is arranged so as to be shifted on one side Ya in the lateral direction Y with respect to the first heat exchange mat 2A by half the distance between the heat exchange pipes 23 (described later). This increases the area of the heat exchange pipes 23 facing the floor surface 103a (the projected area onto the floor surface 103a), allowing a radiation component to be increased by about 1.6 times as compared to a configuration in which the second heat exchange mat 2B is not shifted in the lateral direction Y. The heat exchange pipes 23 are arranged substantially parallel to the ceiling surface 101a so that the heat medium flows substantially parallel to the ceiling surface 101a. Substantially parallel does not mean parallel in a strict sense, but means that an inclination of several degrees is allowable, and also means that the heat exchange pipe 23 having a shape along a catenary due to gravity when the heat exchange pipe 23 is supported at both ends is allowable.

[0022] To exhibit high radiation performance, it is preferable that the curtain member 3 have an emissivity of not less than 70% and a thermal conductivity of not less than $0.3 \text{ W}/(\text{m}\cdot\text{K})$. In addition, the percentage of open area of the curtain member 3 is preferably not less 3%, more preferably not less than 10%, to not obstruct the passage of the convection c and the airflow d. Examples of such a curtain member 3 include a silk cloth formed of 100% silk, a resin slit sheet mainly formed of polyethylene, a hemp cloth formed of 100% hemp, and cupra formed of 100% cotton. A mixture of plural types of materials such as silk, resin, hemp and cotton may also be used.

[0023] (Attachment structure of the heat exchange mat and the curtain member)

The radiant air conditioning device 1 also includes plural (e.g., two) first attachment portions 4A to attach both ends of the first heat exchange mat 2A and the second heat exchange mat 2B in the longitudinal direction X to walls 102, and plural (e.g., two) second attachment portions 4B to attach both ends of the curtain member 3 in the longitudinal direction X to the walls 102. The first attachment portion 4A and the second attachment portion 4B are examples of an attachment portion and a positioning portion to position the first heat exchange mat 2A, the second heat exchange mat 2B and the curtain member 3 in the indoor space. The wall 102 is an example of a side wall of the indoor space.

[0024] The first attachment portion 4A includes a pair of wall attachment members 40 attached to the wall 102, and a mat attachment member 41 to attach the first heat exchange mat 2A and the second heat exchange mat 2B to the pair of wall attachment members 40 while applying tension in the longitudinal direction X to the first heat exchange mat 2A and the second heat exchange mat 2B. The second attachment portion 4B includes a pair of wall attachment members 40 attached to the wall 102, and a curtain attachment member 42 to attach the curtain

member 3 to the pair of wall attachment members 40 while applying tension in the longitudinal direction X to the curtain member 3. The details of the first attachment portion 4A and the second attachment portion 4B will be described later with reference to FIGS. 4 and 5. The positioning portion positions the first heat exchange mat 2A, the second heat exchange mat 2B and the curtain member 3 in the room 100 so that a third space Sc is provided between the first heat exchange mat 2A, the second heat exchange mat 2B, the curtain member 3 and the side walls 102 of the indoor space to allow airflow generated by temperature difference in the room 100 to pass through the first space Sa, the second space Sb, the third space Sc and a fourth space Sd which is located on the floor surface 103a side of the curtain member 3. The tension may be applied to the curtain member 3 only in the lateral direction Y, or tension may be applied in both the longitudinal direction X and the lateral direction Y. The same applies to the other embodiments and Modifications. In addition, the first heat exchange mat 2A and the second heat exchange mat 2B may be supported at a middle portion in the longitudinal direction X. The same applies to the other embodiments and Modifications.

[0025] (Configuration of the heat source machine)

The heat source machine 11 includes, e.g., a compressor, a condenser, an evaporator, and a motor, etc., and is configured to switch between the cooling operation mode and the heating operation mode by reversing the flow of refrigerant using a four-way valve. The heat source machine 11 is connected to the first heat exchange mats 2A and the second heat exchange mats 2B through a supply line 12 and a return line 13.

[0026] The heat source machine 11 supplies a cooled heat medium to the first heat exchange mats 2A and the second heat exchange mats 2B through the supply line 12 during the cooling operation mode, and supplies a heated heat medium to the first heat exchange mats 2A and the

second heat exchange mats 2B through the supply line 12 during the heating operation mode.

The heat medium that has passed through the first heat exchange mats 2A and the second heat exchange mats 2B returns to the heat source machine 11 through the return line 13. Although one heat source machine 11 is provided for plural radiant air conditioning devices 1 in the drawing, one heat source machine 11 may be provided for each radiant air conditioning device 1.

[0027] (Configuration of the heat exchange mat)

FIG. 3 is a diagram illustrating an example configuration of the heat exchange mat 2. The heat exchange mat 2 includes a supply-side main pipe 20 arranged on one side Xa in the longitudinal direction X and on a heat medium supply side, a turnaround-side main pipe 21 arranged on the other side Xb in the longitudinal direction X, i.e., on a side where the heat medium turns back, a return-side main pipe 22 arranged on the one side Xa in the longitudinal direction X and on a heat medium return side, plural heat exchange pipes 23 connecting the supply-side main pipe 20 and the return-side main pipe 22 to the turnaround-side main pipe 21, and plural holding members 24 that maintain spacing between the heat exchange pipes 23. In this regard, the holding members 24 may not be provided. The arrows shown in FIG. 3 indicate the flow of the heat medium. Here, the supply-side main pipe 20 and the return-side main pipe 22 are examples of a first main pipe. The turnaround-side main pipe 21 is an example of a second main pipe.

[0028] The heat exchange mat 2 is formed of, e.g., a thermoplastic resin such as polypropylene, and is formed by respectively extruding the supply-side main pipe 20, the turnaround-side main pipe 21, the return-side main pipe 22 and the heat exchange pipes 23 and assembling these pipes using welding. The heat exchange mat 2 may be integrally formed by injection molding, etc.

The supply-side main pipe 20, the turnaround-side main pipe 21 and the return-side main pipe 22

have inner diameters larger than the inner diameter of the heat exchange pipes 23.

[0029] To increase the surface area and exhibit high radiation performance, the number of the heat exchange pipes 23 is preferably increased by reducing the pitch. The pitch of the heat exchange pipes 23 is, e.g., preferably 10 to 50 mm, more preferably 10 to 20 mm. The percentage of open area of the heat exchange mat 2 as a whole is about 10 to 94% due to the presence of gaps between the heat exchange pipes 23 adjacent to each other. When, e.g., the heat exchange pipes 23 have an outer diameter of 3.4 mm and are arranged at a pitch of 8 to 20 mm, the percentage of open area is 58 to 83%.

[0030] Since the thermoplastic resin, which is the material of the heat exchange mat 2, has a lower thermal conductivity than metal, it is necessary to form the heat exchange pipes 23 with a small wall thickness. It is also necessary to form the heat exchange pipes 23 with a small outer diameter to maintain strength against internal pressure. For this reason, the outer diameter of the heat exchange pipes 23 is preferably, e.g., 3 to 15 mm, more preferably 3 to 8 mm.

[0031] The supply-side main pipe 20 has a supply port 20a at one end. The return-side main pipe 22 has a discharge port 22a at one end. The supply line 12 from the heat source machine 11 is connected to the supply port 20a of the supply-side main pipe 20. The return line 13 from the heat source machine 11 is connected to the discharge port 22a of the return-side main pipe 22. The supply-side and return-side main pipes 21, 22 and the turnaround-side main pipe 21 are arranged parallel to each other, but do not need to be parallel. The supply-side main pipe 20 and the return-side main pipe 22 may be connected at end faces facing each other.

[0032] Since the lengths of the supply line 12 and the return line 13 connected to the heat source machine 11 can be reduced by arranging the supply-side main pipe 20 having the supply port 20a and the return-side main pipe 22 having the discharge port 22a on the same side (on the one side

Xa) opposite to the turnaround-side main pipe 21, the weight is reduced by shortening the pipe route and the burden of installation work can thereby be reduced.

[0033] (Configuration of the attachment portion to attach the heat exchange mat)

FIG. 4 is a main part perspective view showing an example of the first attachment portion 4A to attach the first heat exchange mat 2A and the heat second exchange mat 2B. This drawing shows the first attachment portion 4A to attach ends of the first heat exchange mat 2A and the second heat exchange mat 2B on the other side Xb in the longitudinal direction X to the wall 102. The first attachment portion 4A to attach ends of the first heat exchange mat 2A and the second heat exchange mat 2B on the one side Xa in the longitudinal direction X to the wall 102 also has the same configuration as that shown in the drawing.

[0034] The first attachment portion 4A includes the pair of wall attachment members 40 attached to the wall 102 by screws 40a, etc., and the mat attachment member 41 to attach the first heat exchange mat 2A and the second heat exchange mat 2B to the pair of wall attachment members 40 while applying tension in the longitudinal direction X to the first heat exchange mat 2A and the second heat exchange mat 2B. Since the direction of the tension applied to the heat exchange mats 2 coincides with the direction of the heat exchange pipes 23 (the longitudinal direction X), deformation or damage to the heat exchange pipes 23 can be suppressed.

[0035] The mat attachment member 41 includes a pipe 410 fixed to a circumferential surface of the turnaround-side main pipe 21 of the first heat exchange mat 2A on the upper side by binding bands 411 such as tie wraps or strings, a wire 412 inserted through the inside of the pipe 410, a fixing portion 413 that fixes an end of the wire 412 inserted through an opening 40b of one of the wall attachment members 40, and an adjustment portion 414 that fixes the other end of the wire 412 inserted through the opening 40b of the other wall attachment member 40 in such a manner

that the length of the wire 412 between the pair of wall attachment members 40 can be adjusted.

[0036] In the drawing, the binding bands 411 also fix the turnaround-side main pipe 21 of the second heat exchange mat 2B on the lower side. By adjusting the length of the wire 412 between the pair of wall attachment members 40, the tension applied to the first heat exchange mat 2A and the second heat exchange mat 2B can be adjusted. Attaching the first heat exchange mat 2A and the second heat exchange mat 2B to the wall attachment members 40 using the mat attachment member 41 causes the first heat exchange mat 2A and the second heat exchange mat 2B to have a shape along the catenary.

[0037] (Configuration of the attachment portion to attach the curtain member)

FIG. 5 is a main part perspective view showing an example of the second attachment portion 4B to attach the curtain member 3. This drawing shows the second attachment portion 4B to attach an end of the curtain member 3 on the other side Xb in the longitudinal direction X to the wall 102. The second attachment portion 4B to attach an end of the curtain member 3 on the one side Xa in the longitudinal direction X to the wall 102 also has the same configuration as that shown in the drawing.

[0038] The second attachment portion 4B includes the pair of wall attachment members 40 attached to the wall 102 by screws 40a, etc., and the curtain attachment member 42 to attach the curtain member 3 to the pair of wall attachment members 40 while applying tension in the longitudinal direction X to the curtain member 3.

[0039] The curtain attachment member 42 includes a pipe 420 inserted through the inside of a pocket-shaped portion of the curtain member 3 formed at an end 3b in the longitudinal direction X, a wire 422 inserted through the inside of the pipe 420, a fixing portion 423 that fixes an end of the wire 422 inserted through the opening 40b of one of the wall attachment members 40, and

an adjustment portion 424 that fixes the other end of the wire 422 inserted through the opening 40b of the other wall attachment member 40 in such a manner that the length of the wire 422 between the pair of wall attachment members 40 can be adjusted. By adjusting the length of the wire 422 between the pair of wall attachment members 40, the tension applied to the curtain member 3 can be adjusted and the distance from the heat exchange mat 2 can be adjusted. Attaching the curtain member 3 to the wall attachment members 40 using the curtain attachment member 42 causes the curtain member 3 to have a shape along the catenary.

[0040] (Configuration of the control device)

FIG. 6 is a block diagram illustrating an example configuration of the control device 9. The control device 9 includes the control unit 90, and the dew-point temperature sensor 91 and an operating portion 92 that are connected to the control unit 90.

[0041] The control unit 90 includes a memory which stores a program and various data, etc., and a CPU that operates according to the program and controls the heat source machine 11. The control unit 90 controls the temperature of the heat medium sent from the heat source machine 11 to the heat exchange mats 2 based on a table stored in the memory and showing a relationship between the temperature at the time the heat medium is sent out and the dew point temperature, so that the temperature around the heat exchange mats 2 does not become lower than the dew point temperature detected by the dew-point temperature sensor 91.

[0042] The dew-point temperature sensor 91 can be, e.g., a chilled-mirror or capacitive dew-point temperature sensor. The operating unit 92 can be, e.g., a touch panel display, etc., and is configured such that an operation performed on a button displayed on the touch panel display causes the control unit 90 to switch the four-way valve of the heat source machine 11, allowing for switching between the cooling operation mode and the heating operation mode.

[0043] (Functions of the first embodiment)

Next, an example of the operation of the radiant air conditioning system 10 in the first embodiment will be described with reference to FIG. 7. FIG. 7 is a schematic plan view showing an example of the heat medium path between the heat source machine 11 and the heat exchange mats 2. The arrows shown in FIG. 7 indicate the direction in which the heat medium flows. The holding members 24 are omitted in this drawing.

[0044] The heat medium with controlled temperature and flow rate is introduced from the heat source machine 11 through the supply line 12 into the supply ports 20a of the supply-side main pipes 20 of the two first heat exchange mats 2A located on the upper side and the two second heat exchange mats 2B located on the lower side. After that, as indicated by the arrows in FIG. 7, the heat medium flows toward the end opposite to the supply ports 20a of the supply-side main pipes 20 and branches into the heat exchange pipes 23. The heat medium branched into the heat exchange pipes 23 turns back at the turnaround-side main pipes 21 and branches into the heat exchange pipes 23 again. The heat medium branched into the heat exchange pipes 23 merges at the return-side main pipes 22 and returns to the heat source machine 11 from the discharge ports 22a of the return-side main pipes 22 through the return line 13. Heat exchange takes place in the heat exchange pipes 23 during when the heat medium passes through the heat exchange pipes 23.

[0045] In, e.g., the cooling operation mode, the radiant heat a is radiated from a person P toward the curtain member 3 and the radiant heat b is radiated from the curtain member 3 toward the heat exchange pipes 23 as shown in FIG. 1A during when heat exchange is taking place in the heat exchange pipes 23. In addition, due to the temperature difference in the room 100, the convection c occurs between the heat exchange pipes 23 of the first heat exchange mat 2A and

the second heat exchange mat 2B and through the openings of the curtain member 3, as shown in FIG. 1A. When, e.g., cold water is supplied as a heat medium to the first heat exchange mat 2A and the second heat exchange mat 2B during the cooling operation mode, the air around the first heat exchange mat 2A and the second heat exchange mat 2B is cooled, this causes the surrounding air to have an increase density and thus descend, and continuation of this generates the convection c as a downward airflow. The curtain member 3 is cooled by the convection c from the first heat exchange mat 2A and the second heat exchange mat 2B and by the radiant heat b to the first heat exchange mat 2A and the second heat exchange mat 2B, and the radiant heat a from the person P is absorbed by the radiant surface 3a of the curtain member 3. The person P sleeping on the bed 110 in the room 100 not only benefits from absorption of the radiant heat a, but also receives the convection c through the openings of the curtain member 3. The person P may also receive the convection c that passes around the curtain member 3.

[0046] (Effects of the first embodiment)

The radiant air conditioning system 10 in the first embodiment exerts the following effects.

[0047] (a) Since the known metal panels to support the heat exchange mats 2 from below are not used, it is light in weight and easy to handle. This makes it possible to reduce the workload involved in transport and installation, etc. of the radiant air conditioning device 1, thereby reducing costs and shortening the work period. When assuming that, e.g., the unit weight of the known metal panel is 1.94 kg/m^2 , the unit weight of the frame member supporting the metal panel is 1.30 kg/m^2 , the unit weight of the heat exchange mat 2 is 1.09 kg/m^2 , the unit weight of the curtain member 3 (0.004 kg/m^2) is ignored because it is small, and the unit weight of the first attachment portion 4A and the second attachment portion 4B calculated by converting their weight (0.8 kg) using an installation area equivalent to the heat exchange mat 2 is 0.4 kg/m^2 ,

then Total unit weight of the known technique/Total unit weight of the present embodiment = $(1.94 + 1.30 + 1.09) / (1.09 + 0.4) = 2.91$, meaning that the unit weight in the first embodiment can be reduced to about one-third of the known technique. Furthermore, the overall weight can be reduced by arranging the radiant air conditioning device 1 in an area corresponding to the area of the bedding, rather than arranging on the entire ceiling.

[0048] (b) The total capacity (total cooling capacity or total heating capacity) is higher than the configuration using the known metal panel. Therefore, the feed water temperature in order for the first embodiment to achieve the same capacity as when using the known metal panel can be favorably moderated (higher when cooling and lower when heating). For example, in the cooling operation mode, the feed water temperature can be moderated from 16°C to 18 - 20°C. Therefore, high capacity of indoor dehumidification as a measure against condensation is not required or only low dehumidification capacity is sufficient, which can realize cost and energy savings in performing dehumidification. In addition, the operating efficiency of the heat source machine 11 is improved, which can also realize energy savings.

[0049] (c) In the cooling operation mode, the person P sleeping on the bed 110 can not only benefit from absorption of the radiant heat a, but also can receive the convection c through the openings of the curtain member 3, meaning that comfortable radiant air conditioning can be provided. That is, since the convection component with respect to the total capacity (total cooling capacity or total heating capacity) is higher as compared to the configuration using the known metal panel, it is possible to provide an environment in which the person P feels comfortable (e.g., an environment in which the predicted mean vote PMV is $-0.5 < PMV < +0.5$). In addition, the airflow similar to the gentle breeze creates a fluctuating effect in the sleeping space and an effect of recovering from fatigue is obtained (see, e.g., “All fatigue is

caused by Brain Vol. 2” by Osami Kajimoto, published by Shueisha Inc. on December 21, 2016, p117, etc.).

[0050] (d) By blowing the airflow d of the air, which is regulated for one or both of temperature and humidity and is discharged from the air conditioning unit 8, toward the heat exchange mats 2 through the curtain member 3, it is possible to increase the dew point temperature around the heat exchange pipes 23 of the heat exchange mats 2 and thereby possible to suppress occurrence of condensation around the heat exchange mats 2 during the cooling operation mode.

[0051] (Second embodiment)

FIGS. 8, 9A and 9B show an example of the installed state of the radiant air conditioning device constituting the radiant air conditioning system in the second embodiment of the invention, wherein FIG. 8 is a front view, FIG. 9A is a plan view, and FIG. 9B is an enlarged view showing a portion C in FIG. 9A. The second embodiment is different from the first embodiment in that one bed 110 is arranged in the room 100 and a curtain 6 which surrounds a space between the bed 110 and the curtain member 3 facing thereto (hereinafter, referred to as the “sleeping space”) is provided. The differences from the first embodiment will be mainly described below.

[0052] This radiant air conditioning system 10 includes two radiant air conditioning devices 1 arranged side by side in the room 100, the heat source machine 11 that supplies a heat medium such as water, which is heated or cooled to a predetermined temperature, to the first and second heat exchange mats 2A and 2B constituting the radiant air conditioning devices 1, and the air conditioning unit 8, in the same manner as the first embodiment.

[0053] The radiant air conditioning system 10 also includes a frame 5 arranged on the floor surface 103a so as to surround the bed 110, and the curtain 6 supported by the frame 5. That is, as shown in FIG. 8, one bed 110 is arranged on the floor surface 103a in the room 100, one of the

two radiant air conditioning devices 1 is arranged above the bed 110, and the other radiant air conditioning device 1 is arranged adjacent to the one radiant air conditioning device 1. The sleeping space above the one bed 110 is surrounded by the curtain 6. To make the person P less likely to be affected by the airflow d that is blown out, the air conditioning unit 8 is arranged on a side where one of the radiant air conditioning devices 1, which is surrounded by the curtain 6, is located. In this regard, plural beds 110 may be arranged in the room 100, with each surrounded by a curtain.

[0054] The second heat exchange mat 2B may be arranged close to the first heat exchange mat 2A (e.g., less than 50 mm at the center in the longitudinal direction X), or may be arranged with a predetermined distance (e.g., 50 to 150 mm at the center in the longitudinal direction X) from the first heat exchange mat 2A. As shown in FIG. 8, the airflow d discharged from the air conditioning unit 8 not only passes along the radiant surface 3a of the curtain member 3 but is also blown toward the second heat exchange mat 2B and the first heat exchange mat 2A through the openings of the curtain member 3, and then flows along the first heat exchange mat 2A and the second heat exchange mat 2B toward the other side Xb in the longitudinal direction X.

[0055] The dew-point temperature sensor 91 is arranged between the second heat exchange mat 2B and the curtain member 3 in the same manner as the first embodiment, but may be arranged between the first heat exchange mat 2A and the second heat exchange mat 2B or between the ceiling surface 101A and the first heat exchange mat 2A.

[0056] (Configuration of the frame)

The frame 5 includes an upper frame 50, and four frame posts 51 that support four corners of the upper frame 50 from the floor surface 103a. The upper frame 50 is configured to have a quadrangular shape in plan view. The upper frame 50 and the frame posts 51 are formed of,

e.g., a metal material such as aluminum. To reduce the weight, the upper frame 50 and the frame posts 51 may be formed of, e.g., square or round pipe members. The upper frame 50 is connected to the frame posts 51 by a known connection method such as welding or bolting.

The upper frame 50 may have a structure in which the four corners are curved in plan view. In addition, the frame 5 is supported from the floor surface 103a, but the upper frame 50 may be supported from the ceiling 101 or the wall 102 without using the frame posts 51.

[0057] (Configuration of the curtain)

The curtain 6 is, e.g., a horizontal pull-type curtain and includes a curtain rail 60 attached to a lower surface of the upper frame 50, and a curtain fabric 61 that is hung from the curtain rail 60 using a hanging device so as to be openable and closable. The hanging device includes rollers that move on the curtain rail 60, and fixing portions to fix the curtain fabric 61.

[0058] The curtain rail 60 is configured to have a quadrangular shape with four curved corners in plan view. For example, the space may be partitioned with a single curtain fabric 61 over the entire perimeter or may be partitioned with plural curtain fabrics 61 over the entire perimeter.

[0059] The material of the curtain fabric 61 preferably has a function of blocking or suppressing the ingress of radiant heat or airflow from the outside into the sleeping space. The material of the curtain fabric 61 may be, e.g., chemical fiber such as polyester or acrylic, a natural material such as silk, cotton or hemp, or a lace material.

[0060] The partition member forming the sleeping space may be a roll-up curtain or a plate member, other than the horizontal pull-type curtain mentioned above. The roll-up curtain is configured such that, e.g., a curtain can be taken up and pulled out from a take-up shaft. When blocking or suppressing radiant heat due to sunlight, the curtain fabric 61 may be provided only on the side where the sunshine hits. When blocking or suppressing external airflow from an air

conditioner, etc., the curtain fabric 61 may be provided only on the side from which the airflow enters the sleeping space. In addition, the curtain fabric 61 on the side where the bed 110 is close to the wall 102 (in the example shown in FIG. 9, on the other side Xb in the longitudinal direction X as well as on the other side Yb in the lateral direction Y) may be omitted.

[0061] (Configuration of the attachment portion)

FIG. 10 is a main part perspective view showing an example of a portion at which the heat exchange mats 2 and the curtain member 3 are attached. This drawing shows an attachment portion 4C to attach the ends of the heat exchange mats 2 and the curtain member 3 on the other side Xb in the longitudinal direction X to the wall 102. The attachment portion 4C to attach the ends of the heat exchange mats 2 and the curtain member 3 on the one side Xa in the longitudinal direction X to the wall 102 also has the same configuration as that shown in the drawing. The attachment portions 4C are to attach the first heat exchange mat 2A, the second heat exchange mat 2B and the curtain member 3 to the walls 102. The attachment portion 4C is an example of the positioning portion.

[0062] The attachment portion 4C includes three pipes 430 along the lateral direction Y that are arranged on both end sides of the first heat exchange mat 2A, the second heat exchange mat 2B and the curtain member 3 in the longitudinal direction X, commercially-available pipe fasteners 431 used to respectively fix both ends of each pipe 430 to the wall 102, and plural binding bands 432 such as tie wraps or strings to fix the turnaround-side main pipes 21 of the heat exchange mats 2 to the pipes 430. The pipe fastener 431 has a base portion having an opening for fixation to the wall 102 with a screw, etc., and a gripping portion to grip the pipe 430. The binding bands 432 fix the pipes 430 respectively on both end sides but may fix at plural locations between the two ends. The pipe 430 can be a commercially-available pipe formed of a metal

such as aluminum or a resin such as polyvinyl chloride (PVC). Alternatively, solid round or square rods formed of metal, resin, or wood, etc. may be used instead of the pipes 430.

[0063] (Effects of the second embodiment)

The radiant air conditioning system 10 in the second embodiment exerts the following effects.

(a) It is light in weight and easy to handle, the feed water temperature can be moderated, and it is possible to provide an environment in which the person P can feel comfortable, in the same manner as the first embodiment.

(b) The two radiant air conditioning devices 1 can provide radiant air conditioning for the entire room 100, and the curtain 6 can create a space in which radiant heat and airflow from the sides (excluding the gap between the top end of the curtain 6 and the curtain member 3) into the sleeping space above the bed 110 is blocked or suppressed. For example, by surrounding the bed 110 with the curtain 6, radiant heat (e.g., radiant heat due to sunlight) and airflow (e.g., airflow of the air conditioning unit 8 or another air conditioner) from the sides other than the heat exchange mats 2 and the curtain member 3 can be blocked or suppressed, allowing an ideal sleeping space to be obtained.

[0064] (Summary of the effects of the embodiments)

Comparison of the effects between the first embodiment, the second embodiment and Known Example will be described with reference to Table 1. Table 1 shows comparison of the effects between Known Example implemented using a metal panel as the radiant member, the first embodiment, the second embodiment, Reference Example 1 implemented without using the curtain member 3 in the first embodiment, and Reference Example 2 implemented using one heat exchange mat 2 and without using the curtain member 3 in the first embodiment.

[0065] The effect items subjected to comparison are “Total capacity”, “Radiation component”,

“Radiation effect on people”, “Feed water temperature”, and “Prevention of condensation”.

“Total capacity” refers to total cooling capacity or total heating capacity. “Radiation

component” refers to a proportion of the radiation component to the total capacity. “Radiation

effect on people” refers to the radiation component acting on the person P. “Feed water

temperature” refers to the temperature when the feed water temperature is adjusted under the

same conditions of the indoor temperature and humidity and the flow rate to achieve the same

total cooling capacity. “Prevention of condensation” refers to the resistance to condensation

formation. The degree of effectiveness is indicated by A, B, C, D, and E in descending order of

effectiveness. In addition, in Table 1, a circle mark indicates that the component is used, and a

cross mark indicates that the component is not used. The signs in brackets for “Air

conditioning unit” and “Prevention of condensation” indicate the case where the air conditioner 8

is OFF.

[0066] (Table 1)

		Known Example	First embodiment	Second embodiment	Reference Example 1	Reference Example 2
Component	Radiant member	Metal panel	Curtain member	Curtain member	×	×
	Heat exchange mat	One	Two	Two	Two	One
	Curtain	×	×	○	×	×
	Air conditioning unit	×	○ (×)	○ (×)	○ (×)	○ (×)
Effect items	Total capacity	E	B	B	A	D
	Radiation component	A	B	B	D	E
	Radiation effect on people	A	C	B	D	E
	Feed water temperature	E	B	B	A	D

	Prevention of condensation	E	A (B)	A (B)	A (A)	A (B)
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[0067] (a) In the first and second embodiments, since two heat exchange mats 2 are used, the total capacity can achieve Rank B which is higher than Rank D rated for Reference Example 2 (using one heat exchange mat 2). As a result, the feed water temperature can be moderated (higher when cooling and lower when heating) to achieve Rank A or B. When, e.g., the feed water temperature during the cooling operation mode is 16°C in Known Example, it can be set to 18 to 20°C in the first and second embodiments.

(b) In the first embodiment, by using the curtain member 3 as the radiant member, the radiation component can achieve Rank B which is higher than Rank D rated for Reference Example 1 (without the curtain member 3) since the entire curtain member 3 is cooled by the cooling (radiation and convection) effect from the heat exchange mats 2.

(c) In the second embodiment, by using the curtain 6, the mean radiant temperature (MRT) in the sleeping space above the bed 110 is easily lowered and the radiation effect on the person P is increased since heat rays from the surroundings are blocked and also the curtain 6 is cooled by the cooling effect of the heat exchange mats 2 and the curtain member 3.

(d) In the first and second embodiments, since the feed water temperature can be moderated, Prevention of condensation can be ranked up to achieve B, and when the air conditioning unit 8 is ON, Prevention of condensation can be ranked up to achieve A. Condensation occurs when the surface temperature of the heat exchange mat 2 is lower than the indoor dew point temperature. Therefore, the higher the surface temperature of the heat exchange mat 2 (the feed water temperature) is, the less frequently the temperature becomes lower than the indoor dew point temperature, hence, the possibility of condensation occurrence is reduced.

[0068] Although the embodiments of the invention have been described, the invention is not intended to be limited to the above-mentioned embodiments, and the various kinds of modifications can be implemented as described below.

[0069] (Modification 1)

FIG. 11A is a cross-sectional view taken along line E-E of FIG. 12, showing an example of the installed state of the radiant air conditioning device constituting the radiant air conditioning system in Modification 1, and FIG. 11B is an enlarged view showing a portion D in FIG. 11A.

FIG. 12 is a plan view showing the radiant air conditioning device shown in FIG. 11A. In the second embodiment, the heat exchange mats 2 and the curtain member 3 are attached to the walls 102 and the curtain 6 is attached to the frame 5. In contrast, in Modification 1, the heat exchange mats 2, the curtain member 3 and the curtain 6 are formed as a single unit.

[0070] In Modification 1, a unit 14A, in which the heat exchange mats 2, the curtain member 3 and the curtain 6 are formed as a single unit, is provided. The unit 14A includes a metal frame 140A having a T-shaped cross-section and arranged so as to surround the heat exchange mats 2 and the curtain member 3, two attachment members 141 to attach the frame 140A to the ceiling surface 101a, and the same attachment portions 4C as those in the second embodiment that are provided to attach the heat exchange mats 2 and the curtain member 3 to the frame 140A. The curtain 6 is attached to a lower surface of the frame 140A. The unit 14A is an example of a radiant unit. The frame 140A is an example of a frame body formed in a rectangular shape so as to surround an inner region in plan view. The frame 140A has a pair of surfaces 140c facing each other with a predetermined distance therebetween. The heat exchange mats 2 and the curtain member 3 are attached to the pair of surfaces 140c of the frame 140A so as to be located in the inner region of the frame 140A.

[0071] As shown in FIG. 12, the frame 140A includes an outer plate 140a configured to have a rectangular shape with four curved corners in plan view, and an inner plate 140b joined to the outer plate 140a on the inner side by welding, etc. The frame 140A and the attachment members 141 are fixed to each other by, e.g., fastening parts such as bolts and nuts. The attachment member 141 has an opening to fix the unit 14A to the ceiling surface 101a with a screw, etc. The frame 140A may be formed of a metal such as aluminum, a resin such as polycarbonate, or wood, etc. The configuration may be such that the heat exchange mats 2 and the curtain member 3 are formed as a single unit and the curtain 6 can be retrofitted if needed. The frame 140A, the attachment member 141 and the attachment portion 4C are examples of the positioning portion to position the heat exchange mats 2 and the curtain member 3 in the indoor space.

[0072] The attachment portion 4C includes three pipes 430, commercially-available pipe fasteners 431 used to respectively fix both ends of each pipe 430 to the inner surface of the outer plate 140a of the frame 140A, and plural binding bands 432 such as tie wraps or strings to fix the turnaround-side main pipes 21 of the heat exchange mats 2 to the pipes 430, in the same manner as the second embodiment.

[0073] The curtain 6 is, e.g., a horizontal pull-type curtain and includes the curtain rail 60 attached to a lower surface of the inner plate 140b of the frame 140A, and the curtain fabric 61 that is hung from the curtain rail 60 using a hanging device 62 so as to be openable and closable. The hanging device 62 includes rollers that move on the curtain rail 60, and fixing portions to fix the curtain fabric 61.

[0074] In Modification 1, since the heat exchange mats 2, the curtain member 3 and the curtain 6 are formed as a single unit, the unit 14A formed by attaching the heat exchange mats 2, the

curtain member 3 and the curtain rail 60 to the frame 140A can be easily attached to the ceiling surface 101a using the attachment members 141. In addition, since the space which the heat exchange mats 2 and the curtain member 3 are intended to target is a small space above the bed 110 (the sleeping space) surrounded by the curtain 6, it is possible to realize energy savings. In addition, by attaching the curtain member 3 to the frame 140A while applying tension not only in the longitudinal direction X but also in the lateral direction Y, a design which is taut when looking up from the bed 110 can be presented. A space may be provided between ends of the curtain member 3 in the lateral direction Y and the frame 140A when the curtain member 3 is attached to the frame 140A while applying tension in the lateral direction Y.

[0075] (Modification 2)

FIG. 13 is a front view showing an example of the installed state of the radiant air conditioning device constituting the radiant air conditioning system in Modification 2. The bed 110 and the person P, which are shown in FIG. 1A, are omitted in this drawing. In this embodiment, the curtain member 3 is attached to the walls 102 by the second attachment portions 4B so that the curtain member 3 is in contact with the second heat exchange mat 2B located on the lower side. In Modification 2, heat can be transferred from the heat exchange mats 2 to the curtain member 3 not only by radiation and convection but also by conduction. Although the total capacity (total cooling capacity or total heating capacity) is lower than the first embodiment, the proportion of the radiation component to the total capacity can be increased.

[0076] (Modification 3)

FIG. 14 is a main part plan view showing Modification 3. The holding members 24 are omitted in FIG. 14. In the first embodiment, the heat exchange mats 2 are fixed to the walls 102 by the first attachment portions 4A so that tension is applied to the heat exchange mats 2. In contrast,

in Modification 3, the heat exchange mats 2 are supported from below by a net 7 so that no tension is applied to the heat exchange mats 2. The net 7 is an example of a receiving member. The first heat exchange mat 2A and the second heat exchange mat 2B may be stacked and placed on the net 7, or two nets 7 may be used in such a manner that the first heat exchange mat 2A is placed on one net 7 and the second heat exchange mat 2B is placed on the other net 7.

[0077] The net 7 has a higher percentage of open area (e.g., not less than 80%) than the heat exchange mat 2, is formed of metal or resin, and is attached to the walls 102 at both ends in the longitudinal direction X by the first attachment portions 4A. The first attachment portion 4A to attach the net 7 includes wall attachment members 43 attached to the wall 102 with screws, etc., and an attachment member 44 to which the net 7 is attached. Attaching the net 7 to the wall attachment members 43 using the attachment member 44 causes the net 7 to have a shape along the catenary and thus also causes the heat exchange mats 2 placed on the net 7 to have a shape along the catenary.

[0078] In Modification 3, since no tension is applied to the heat exchange mats 2, damage to the heat exchange mats 2 due to excessive tension can be suppressed.

[0079] (Modification 4)

FIG. 15 is a cross-sectional view taken along the line B-B shown in FIG. 1A, showing the curtain member 3 in Modification 4. The curtain member 3 may be formed in a corrugated wave shape with continuous periodic curves, as shown in FIG. 15. The pitch between ridges of the corrugated wave shape is, e.g., 10 to 100 mm, and the length between a ridge and a groove is, e.g., 10 to 100 mm.

[0080] FIG. 16 is a perspective view showing an example of the second attachment portion 4B to attach the curtain member 3 in Modification 4. An end of the corrugated wave-shaped curtain

member 3 on the other side Xb in the longitudinal direction X may be attached to the wall 102 by the second attachment portion 4B, as shown in FIG. 16. That is, by applying tension to the curtain member 3 in the longitudinal direction X using the pipe 420 formed in a corrugated wave shape, the curtain member 3 becomes corrugated and follows the corrugated wave shape of the pipe 420. The second attachment portion 4B to attach the end of the curtain member 3 on the one side Xa in the longitudinal direction X to the wall 102 also has the same configuration as that shown in FIG. 16. The curtain member 3 may be formed in a shape with continuous periodic bends. For example, the curtain member 3 sewn into an accordion-fold shape in the similar manner to a window curtain may be used.

[0081] In Modification 4, since the surface area of the curtain member 3 is increased, the total capacity (total cooling capacity or total heating capacity) can be further increased.

[0082] (Modification 5)

In Modification 5, double-layered curtain members 3 are provided. In Modification 5, the heat exchange function by the curtain member 3 can be enhanced over the first and second embodiments. The number of layered curtain members 3 is not limited to two and may be not less than three.

[0083] (Modification 6)

FIG. 17 is a front view showing the radiant air conditioning system in Modification 6, FIG. 18A is a plan view showing the radiant air conditioning device shown in FIG. 17, and FIG. 18B is an enlarged view showing a portion F in FIG. 18A. In the second embodiment, the first heat exchange mat 2A, the second heat exchange mat 2B and the curtain member 3 are attached at both ends in the longitudinal direction X to the walls 102 by the attachment portions 4C. In contrast, in Modification 6, the first heat exchange mat 2A, the second heat exchange mat 2B and

the curtain member 3 are attached to the frame 5 by the attachment portions 4C. The frame 5 and the attachment portion 4C are examples of the positioning portion to position the heat exchange mats 2 and the curtain member 3 in the indoor space. The frame 5 to which the heat exchange mats 2 and the curtain member 3 are attached is an example of the radiant unit.

[0084] The frame 5 includes the upper frame 50, and the four frame posts 51 that support the four corners of the upper frame 50 from the floor surface 103a, in the same manner as the second embodiment. The upper frame 50 is formed in a quadrangular shape in plan view. The curtain 6 is attached to the lower surface of the upper frame 50, in the same manner as the second embodiment. The curtain 6 includes the curtain rail 60 and the curtain fabric 61. In this regard, the curtain 6 is not essential and may be provided as necessary. The upper frame 50 is an example of the frame body formed in a rectangular shape so as to surround an inner region in plan view. The upper frame 50 has a pair of surfaces 50a facing each other with a predetermined distance therebetween. The upper frame 50 may be formed of a metal such as aluminum, a resin such as polycarbonate, or wood, etc. The heat exchange mats 2 and the curtain member 3 are attached to the pair of surfaces 50a of the upper frame 50 so as to be located in the inner region of the upper frame 50. In addition, the upper frame 50, the first heat exchange mat 2A, the second heat exchange mat 2B, the curtain member 3 and the attachment portions 4C may be formed as a single unit, and this unit may be supported, as an example of the radiant unit, by the four frame posts 51.

[0085] As shown in FIGS. 18A and 18B, the attachment portions 4C in Modification 6 attach both ends of the first heat exchange mat 2A, the second heat exchange mat 2B and the curtain member 3 in the longitudinal direction X to the inner surfaces 50a of the upper frame 50 which face each other in the longitudinal direction X. The attachment portion 4C includes three pipes

430, six pipe fasteners 431, and four binding bands 432, as shown in FIG. 10.

[0086] In Modification 6, even when the wall 102 has a structure which does not allow the pipe fasteners 431, etc., to be attached thereto, the radiant air conditioning device 1 can be easily installed at the existing bed 110 since the first heat exchange mat 2A, the second heat exchange mat 2B and the curtain member 3 can be attached to the frame 5 which is arranged so as to surround the bed 110. In addition, a comfortable air-conditioned space can be provided, allowing for comfortable sleep on the bed 110. In addition, by attaching the curtain member 3 to the upper frame 50 while applying tension not only in the longitudinal direction X but also in the lateral direction Y, a design which is taut when looking up from the bed 110 can be presented. A space may be provided between the ends of the curtain member 3 in the lateral direction Y and the upper frame 50 when the curtain member 3 is attached to the upper frame 50 while applying tension in the lateral direction Y.

[0087] (Modification 7)

FIG. 19A is a schematic perspective view showing the radiant air conditioning device in Modification 7 as viewed obliquely from above, FIG. 19B is a schematic perspective view showing the radiant air conditioning device in Modification 7 as viewed obliquely from below, and FIG. 19C is a schematic perspective view showing the radiant air conditioning device when a roll-up curtain is lowered in FIG. 19A. FIG. 20 is a plan view showing a unit 14B of the radiant air conditioning device 1 shown in FIG. 19A, and FIG. 21A is a cross-sectional view taken along line G-G of FIG. 20. FIG. 21B is an enlarged view showing a portion H in FIG. 21A.

[0088] As shown in FIGS. 19A, 19B and 19C, this radiant air conditioning device 1 is a freestanding type configured such that the unit 14B, which is obtained by forming the first heat

exchange mat 2A, the second heat exchange mat 2B, the curtain member 3 and a frame 140B as a single unit, is supported by a stand portion 200 having an overhanging structure (a cantilever structure) so that the first heat exchange mat 2A, the second heat exchange mat 2B and the curtain member 3 are located directly above a bed 210. The stand portion 200 is an example of the positioning portion.

[0089] The bed 210 includes casters 211 provided on the floor surface 103a side so as to be able to move on the floor surface 103a, but the casters 211 may not be provided. In addition, the case where the freestanding-type radiant air conditioning device 1 is installed in a private room, a ward with plural beds, or a dialysis room, etc., of a hospital will be described in Modification 7, but it is not limited thereto and the device may also be installed in a bedroom, etc.

[0090] The stand portion 200 supports the unit 14B from the floor surface 103a, has an L-shape as a whole when viewed from a side, and includes a base portion 201 placed on the floor surface 103a, and a post portion 202 substantially perpendicularly connected to the base portion 201.

As shown in FIG. 21A, a base end portion of the frame 140B is fixed to an upper portion of the post portion 202 by, e.g., a fastening member such as bolt.

[0091] The stand portion 200 is, e.g., formed mainly of a metal such as aluminum. The stand portion 200 is configured such that the distance from the floor surface 103a to the curtain member 3 is, e.g., 1700 to 2000 mm. The base portion 201 has a width which fits under the bed 210 (e.g., 500 to 700 mm). The base portion 201 may be fixed to the floor surface 103a by a fixing unit such as an anchor bolt.

[0092] As shown in FIG. 20, the unit 14B includes the frame 140B formed in a rectangular shape so as to surround an inner region in plan view and having a pair of surfaces 140c facing each other with a predetermined distance therebetween, and the same attachment portions 4C as those

in the second embodiment that are provided to attach both ends of the first heat exchange mat 2A, the second heat exchange mat 2B and the curtain member 3 in the longitudinal direction X to the pair of surfaces 140c of the frame 140B. The heat exchange mats 2 and the curtain member 3 are attached to the pair of surfaces 140c of the frame 140B so as to be located in the inner region of the frame 140B. The frame 140B may be formed of a metal such as aluminum, a resin such as polycarbonate, or wood, etc. The unit 14B is an example of the radiant unit. The frame 140B is an example of the frame body.

[0093] The frame 140B does not necessarily need to be parallel to the floor surface 103a and, for example, a tip end thereof may be lifted in advance in such a manner that the frame 140B becomes parallel to the floor surface 103a when the first heat exchange mat 2A, the second heat exchange mat 2B and the curtain member 3 are attached. In addition, the frame 140B may be supported at the tip end from the ceiling by a wire, etc., or may be supported from the floor surface 103a by a support rod. This makes it possible to prevent the heat exchange mat 2, etc. from coming off or falling off from the frame 140B even if a large external force due to earthquake, etc. is applied, allowing the frame 140B to be formed thinner and lighter.

[0094] Roll-up curtains 16 are attached to the frame 140B respectively on three peripheral sides other than the periphery on the post portion 202 side. The roll-up curtain 16 is composed of e.g., a take-up shaft and a curtain 161 coupled there to so as to be able to be taken up and pulled out. The material of the fabric of the curtain 161 may be, e.g., chemical fiber such as polyester or acrylic, a natural material such as silk, cotton or hemp, or a lace material.

[0095] In Modification 7, the radiant air conditioning device 1 is a self-standing type and can thus be easily installed at the existing bed 210. In addition, a comfortable air-conditioned space can be provided, allowing for comfortable sleep on the bed 210. In addition, since the space

which the heat exchange mats 2 and the curtain member 3 are intended to target is a small space above the bed 210 (the sleeping space) surrounded by the curtain 161, it is possible to realize energy savings. In addition, by attaching the curtain member 3 to the frame 140B while applying tension not only in the longitudinal direction X but also in the lateral direction Y, a design which is taut when looking up from the bed 210 can be presented. A space may be provided between the ends of the curtain member 3 in the lateral direction Y and the frame 140B when the curtain member 3 is attached to the frame 140B while applying tension in the lateral direction Y.

Reference Signs List

[0096] 1 RADIANT AIR CONDITIONING DEVICE

2A FIRST HEAT EXCHANGE MAT

2B SECOND HEAT EXCHANGE MAT

3 CURTAIN MEMBER

3a RADIANT SURFACE

3b END

4A FIRST ATTACHMENT PORTION

4B SECOND ATTACHMENT PORTION

4C ATTACHMENT PORTION

5 FRAME

6 CURTAIN

7 NET

8 AIR CONDITIONING UNIT

9 CONTROL DEVICE

10 RADIANT AIR CONDITIONING SYSTEM

11 HEAT SOURCE MACHINE

12 SUPPLY LINE

13 RETURN LINE

14A, 14B UNIT

16 ROLL-UP CURTAIN

20 SUPPLY-SIDE MAIN PIPE

20a SUPPLY PORT

21 TURNAROUND-SIDE MAIN PIPE

22 RETURN-SIDE MAIN PIPE

22a DISCHARGE PORT

23 HEAT EXCHANGE PIPE

24 HOLDING MEMBER

40 WALL ATTACHMENT MEMBER

40a SCREW

40b OPENING

41 MAT ATTACHMENT MEMBER

42 CURTAIN ATTACHMENT MEMBER

43 WALL ATTACHMENT MEMBER

44 ATTACHMENT MEMBER

50 UPPER FRAME

50a SURFACE

51 FRAME POST

60 CURTAIN RAIL

61 CURTAIN FABRIC

62 HANGING DEVICE

90 CONTROL UNIT

91 DEW-POINT TEMPERATURE SENSOR

92 OPERATING PORTION

100 ROOM

101 CEILING

101a CEILING SURFACE

102 WALL

103 FLOOR

103a FLOOR SURFACE

110 BED

140A, 140B FRAME

140a OUTER PLATE

140b INNER PLATE

140c SURFACE

141 ATTACHMENT MEMBER

161 CURTAIN

200 STAND PORTION

201 BASE PORTION

202 POST PORTION

210 BED

211 CASTER

410, 420 PIPE

411 BINDING BAND

412, 422 WIRE

413, 423 FIXING PORTION

414, 424 ADJUSTMENT PORTION

430 PIPE

431 PIPE FASTENER

432 BINDING BAND

a, b RADIANT HEAT

c CONVECTION

d AIRFLOW

X LONGITUDINAL DIRECTION

Xa ONE SIDE IN LONGITUDINAL DIRECTION

Xb OTHER SIDE IN LONGITUDINAL DIRECTION

Y LATERAL DIRECTION

Ya ONE SIDE IN LATERAL DIRECTION

Yb OTHER SIDE IN LATERAL DIRECTION

P PERSON

CLAIMS

(Claim 1) A radiant air conditioning device, comprising:

a tubular member that is arranged in a region smaller than a ceiling surface of an indoor space, with a first space provided between the tubular member and the ceiling surface, and that comprises a plurality of flow path portions through which a heat medium flows substantially parallel to the ceiling surface; and

a fabric radiant member that is arranged in a region smaller than the ceiling surface, with a second space provided between the radiant member and the tubular member, so as to expose a radiant surface thereof on a side of the tubular member opposite to the ceiling surface and that directly exchanges heat with the tubular member.

(Claim 2) The radiant air conditioning device according to claim 1, wherein the plurality of flow path portions of the tubular member extend in a longitudinal direction and the tubular member is arranged so that tension is applied thereto in the longitudinal direction, and wherein the radiant member is arranged so that tension is applied thereto at least in the longitudinal direction.

(Claim 3) The radiant air conditioning device according to claim 2, wherein a fabric constituting the radiant member has an emissivity of not less than 70%.

(Claim 4) The radiant air conditioning device according to claim 3, wherein the fabric has a thermal conductivity of not less than 0.3 W/(m·k).

(Claim 5) The radiant air conditioning device according to claim 4, the fabric comprises silk.

(Claim 6) The radiant air conditioning device according to claim 2, further comprising:

another tubular member that comprises the plurality of flow path portions extending in the longitudinal direction and is arranged in a region smaller than the ceiling surface on a side of the tubular member opposite to the ceiling surface,

wherein the tubular member and the other tubular member are arranged so that the flow path portions are arranged at regular intervals in a lateral direction perpendicular to the longitudinal direction and the flow path portions of the other tubular member are located between the flow path portions of the tubular member in plan view, and

wherein the radiant member is arranged with a second space provided between the radiant member and the other tubular member.

(Claim 7) A radiant unit, comprising:

a frame body formed in a rectangular shape so as to surround an inner region in plan view;

a tubular member that comprises a plurality of flow path portions with a heat medium flowing therethrough and is attached to the frame body so as to be located in the inner region of the frame body; and

a fabric radiant member that is attached to the frame body in the inner region of the frame body, with a space provided between the radiant member and the tubular member, so as to expose a radiant surface thereof on one side of the tubular member and that directly exchanges heat with the tubular member.

(Claim 8) The radiant unit according to claim 7, wherein the frame body comprises a pair of surfaces facing each other with a predetermined distance therebetween, wherein the plurality of flow path portions of the tubular member extend in a longitudinal direction and the tubular member is attached to the pair of surfaces so that tension is applied thereto in the longitudinal direction, and wherein the radiant member is attached to the pair of surfaces so that tension is applied thereto at least in the longitudinal direction.

(Claim 9) A radiant air conditioning device, comprising:

the radiant unit according to claim 8; and

a positioning portion to position the radiant unit in an indoor space so that the tubular member is located in a region smaller than a ceiling surface of the indoor space and a space is provided between the tubular member and the ceiling surface.

(Claim 10) A radiant air conditioning device with a function of cooling and heating an indoor space by heat exchange through radiation and convection, the radiant air conditioning device comprising:

a fabric radiant member comprising a first surface that receives radiant heat, and a second surface that is provided on the opposite side to the first surface, receives the radiant heat and radiates radiant heat.

(Claim 11) A radiant air conditioning system, comprising:

a plurality of the radiant air conditioning devices according to claim 1, 2, 3, 4, 5, 6, 9 or

10; and

a heat source machine that causes the heat medium with controlled temperature and flow rate to circulate through the tubular members of the plurality of the radiant air conditioning devices.