

[DESCRIPTION]

[Title of Invention] AIRFLOW FORMATION SYSTEM AND METHOD OF PRODUCING AIRFLOW FORMATION SYSTEM

[Technical Field]

5 [0001]

The present invention relates to an airflow formation system and a method of producing the airflow formation system.

[Background Art]

[0002]

10 Patent Literature (PTL) 1 discloses a ventilation system that includes a plurality of ventilation devices provided in a single target space, and each of the ventilation devices includes a carbon dioxide sensor.

[Citation List]

15 [Patent Literature]

[0003]

[PTL 1]

Japanese Unexamined Patent Application Publication No. 2018-119752

20 [Summary of Invention]

[Technical Problem]

[0004]

25 The present invention provides, for example, an airflow formation system that easily reduces a risk of infection to an infectious disease in a target space.

[Solution to Problem]

[0005]

30 An airflow formation system according to an aspect of the present invention includes an air conditioning system and a circulation mechanism. The air conditioning system supplies air to a target space from an upper space above a ceiling of the target space, and discharges the air from the target space to the upper space. The circulation mechanism forms a circulation path in which the air in the target space is taken from a position closer to a floor than the ceiling
35 of the target space, and the air taken is circulated to the upper space.

[0006]

An airflow formation system according to an aspect of the present invention includes an air conditioning system and a circulation mechanism. The air conditioning system supplies air to a target space from an upper space above a ceiling of the target space, and discharges the air from the target space to the upper space. The circulation mechanism forms a circulation path in which the air in the target space is taken from a floor of the target space, and the air taken is circulated to a space above a ceiling of a downstairs room, the space being below the floor. The circulation mechanism includes an opening that introduces the air from the target space to a lower space below the floor, and introduces the air from the lower space to the space above the ceiling of the downstairs room.

[0007]

A method of producing an airflow formation system according to an aspect of the present invention places a circulation mechanism in a target space for which an air conditioning system has been provided. The air conditioning system supplies air to the target space from an upper space above a ceiling of the target space and discharges the air from the target space to the upper space. The circulation mechanism forms a circulation path in which the air in the target space is taken from a position closer to a floor than the ceiling of the target space, and the air taken is circulated to the upper space.

[0008]

A method of producing an airflow formation system according to an aspect of the present invention places an air conditioning system for a target space, and a circulation mechanism. The air conditioning system supplies air to the target space from an upper space above a ceiling of the target space, and discharges the air from the target space to the upper space. The circulation mechanism forms a circulation path in which the air in the target space is taken from a position closer to a floor than the ceiling of the target space, and the air taken is circulated to the upper space.

[Advantageous Effects of Invention]

[0009]

An airflow formation system and the like according to an aspect of the present invention can easily reduce a risk of infection to an infectious disease in a target space.

[Brief Description of Drawings]

5 [0010]

[FIG. 1]

FIG. 1 is a diagram showing a first configuration example of an airflow formation system according to Embodiment 1.

[FIG. 2]

10 FIG. 2 is a diagram showing an example of a circulation path in the airflow formation system according to Embodiment 1.

[FIG. 3]

FIG. 3 is a diagram showing a second configuration example of the airflow formation system according to Embodiment 1.

15 [FIG. 4]

FIG. 4 is a diagram showing a third configuration example of the airflow formation system according to Embodiment 1.

[FIG. 5]

20 FIG. 5 is a block diagram showing a functional configuration of a first control example of the airflow formation system according to Embodiment 1.

[FIG. 6]

25 FIG. 6 is a block diagram showing a functional configuration of a second control example of the airflow formation system according to Embodiment 1.

[FIG. 7A]

FIG. 7A is an explanatory diagram showing airflow formed by an airflow formation system according to Comparative Example.

[FIG. 7B]

30 FIG. 7B is an explanatory diagram showing airflow formed by the airflow formation system according to Embodiment 1.

[FIG. 8]

FIG. 8 is a diagram showing a configuration example of an airflow formation system according to Embodiment 2.

35 [Description of Embodiments]

[0011]

Hereinafter, embodiments are specifically described with reference to the drawings. It should be noted that each of the embodiments described below shows a comprehensive or a specific example. A numerical value, a shape, a material, a structural component, an arrangement position of the structural component, a connection form of the structural components, a step, an order of the steps, and so on are examples, and are not intended to restrict the present invention. Structural components that are not recited in independent claims among structural components described in the embodiments below will be described as optional structural components.

[0012]

It should be noted that each drawing is a schematic diagram, and thus is not strictly illustrated. In addition, substantially the same configurations are allocated by the same reference sign, and the duplicate description may be omitted or simplified.

[0013]

[Embodiment 1]

[Configuration]

First, a configuration of airflow formation system 100 according to Embodiment 1 is described. FIG. 1 is a diagram showing a first configuration example of airflow formation system 100 according to Embodiment 1. As shown in FIG. 1, airflow formation system 100 forms airflow in target space 4. Target space 4 is a room in a facility, such as an office building, for example. Target space 4 is not limited to a single large room, but may be a plurality of rooms separated by a wall and so on. The facility is not limited to office buildings, but may be other facilities. In the example shown in FIG. 1, target space 4 includes a plurality of (two in this case) spaces (first indoor space 4a and second indoor space 4b). Although no wall is provided at a boundary of first indoor space 4a and second indoor space 4b (see an alternate long and short dash line in FIG. 1) in the example shown in FIG. 1, a wall may be provided. Target space 4 may not include a plurality of spaces, but may be a single space.

[0014]

Each Arrow A1 shown in FIG. 1 indicates airflow. The same applies to other drawings. Airflow formation system 100 forms airflow (downflow) from an upper side to a lower side in target space 4 (each of first indoor space 4a and second indoor space 4b in this case). If the downflow is formed in an office where people density fluctuation is great, for example, fine particles (aerosol) floating in the air are blown down to floor 42. If fine particles to which infectious substances (viruses and so on) are attached float in the air and no measure is taken, for example, an infectious disease may spread. Meanwhile, in airflow formation system 100 according to Embodiment 1, fine particles are brown down to floor 42 by the downflow. Accordingly, an effect of preventing the spread of the infectious disease due to fine particles floating in the air can be expected.

[0015]

Airflow formation system 100 includes air conditioning system 1 and circulation mechanism 2. Airflow formation system 100 further includes controller 3 for controlling airflow. Controller 3 will be described in detail in paragraphs for "Controller" below.

[0016]

Air conditioning system 1 supplies air to target space 4 from upper space 44 above ceiling 41 of target space 4, and discharges the air from target space 4 to upper space 44. Specifically, air conditioning system 1 supplies air to target space 4 from upper space 44 through air supply ports 46 provided in ceiling 41. In addition, air conditioning system 1 discharges air to upper space 44 from target space 4 through air discharge port 47 provided in ceiling 41. Although one first air supply port 46a and one first air discharge port 47a are provided in first indoor space 4a in the example shown in FIG. 1, first air supply port 46a and first air discharge port 47a may be respectively provided in plural numbers. Furthermore, although one second air supply port 46b and one second air discharge port 47b are provided in second indoor space 4b, second air supply port 46b and second air discharge port 47b may be respectively provided in plural

numbers. Air conditioning system 1 includes air handling unit (AHU) 11 and circulation machine 12.

[0017]

AHU 11 takes outside air and a part of circulated air from target space 4, cools or heats the taken air, and then supplies the air to target space 4. Specifically, AHU 11 supplies air to upper space 44 above ceiling 41 of target space 4. AHU 11 includes air filter 111, air conditioning device 112, humidifier 113, and air blower 114. Air filter 111 is, for example, a high efficiency particulate air (HEPA) filter, and removes foreign substances, such as dust, from air that passes through air filter 111. Air conditioning device 112 has, for example, a vapor coil for warming and a cold-water coil for cooling, and causes air to pass through positions where these coils are provided to generate warm air or cool air. Humidifier 113 humidifies the air that has passed through air conditioning device 112, depending on the necessity. Air blower 114 takes the cool air or the warm air that has passed through humidifier 113, and supplies the taken cool air or warm air to upper space 44 above ceiling 41 of target space 4 through air supply duct 5.

[0018]

Circulation machine 12 takes the air discharged from upper space 44 above ceiling 41 of target space 4, supplies a part of the taken air to AHU 11 through air circulation duct 6, and discharges remaining air to the outside of a facility.

[0019]

Circulation mechanism 2 circulates air that is supplied from air conditioning system 1 to target space 4, toward upper space 44 above ceiling 41 of target space 4, so as to form, in target space 4, airflow from an upper side to a lower side. Specifically, circulation mechanism 2 forms circulation path 20 in which air in target space 4 is taken from a position closer to floor 42 than ceiling 41 of target space 4, and the taken air is circulated to upper space 44.

[0020]

FIG. 2 shows an example of circulation path 20 in airflow formation system 100 according to Embodiment 1. The example

shown in FIG. 2 is constituted by combining the first configuration example and a second configuration example, which are described later. In the example, a bottom end portion of duct 23 is connected to lower space 43 below floor 42. As shown in FIG. 2, circulation path 20 is embodied by duct 23 placed in target space 4 in Embodiment 1. Duct 23 has a rectangular cylindrical shape vertically elongated, and is attached to ceiling 41 of target space 4 so that an upper end portion of duct 23 is connected to upper space 44. Accordingly, air taken from target space 4 can be introduced in upper space 44 through an inside of duct 23. It is preferable, in installation, that duct 23 is covered by wall material 23a at a corner of target space 4 (around a pillar in a corner of a room, for example) so as to be inconspicuous to a person who stays in target space 4.

[0021]

Hereinafter, specific configuration examples of airflow formation system 100 are enumerated. Airflow formation system 100 can form airflow from the upper side to the lower side in target space 4, even if whichever is adopted among the first configuration example to a third configuration example described below.

[0022]

FIG. 1 shows the first configuration example of airflow formation system 100 according to Embodiment 1. In the first configuration example, circulation mechanism 2 includes first opening 21 and fan 24, as shown in FIG. 1. First opening 21 is provided in a position closer to floor 42 than ceiling 41, and introduces air from target space 4 to circulation path 20. Specifically, first opening 21 is provided in the bottom end portion of duct 23 serving as circulation path 20, and allows target space 4 and the inside of duct 23 to be connected. Fan 24 sucks air toward upper space 44 through circulation path 20. Specifically, fan 24 is placed in the inside of duct 23, takes the air from target space 4 through first opening 21, and supplies the taken air to upper space 44 above ceiling 41 of target space 4, through the inside of duct 23.

[0023]

In the first configuration example, air supplied from air

conditioning system 1 to target space 4 passes through air supply ports 46, a region along floor 42, first opening 21, the inside of duct 23, and upper space 44 in this order. With this configuration, airflow from the upper side to the lower side is formed in target space 4, in the first configuration example.

[0024]

FIG. 3 shows the second configuration example of airflow formation system 100 according to Embodiment 1. In the second configuration example, circulation mechanism 2 includes second openings 22 and fan 24, as shown in FIG. 3. Second openings 22 are provided in floor 42, and introduce air from target space 4 to circulation path 20 through lower space 43 below floor 42. Specifically, each of second openings 22 is a ventilation hole provided in floor 42, and is configured in a manner that a grille (a mesh structure) or the like is set, for example, to allow target space 4 and lower space 43 to be connected to each other. In the example shown in FIG. 3, one second opening 22 is provided in each of first indoor space 4a and second indoor space 4b. Fan 24 is placed in the inside of duct 23, alike the first configuration example. Here, in the second configuration example, the bottom end portion of duct 23 is attached to floor 42 so as to connect to lower space 43. Accordingly, air taken from target space 4 toward lower space 43 can be introduced in upper space 44 through the inside of duct 23. Then, fan 24 takes the air from target space 4 through second openings 22, and supplies the taken air to upper space 44 through the inside of duct 23.

[0025]

In the second configuration example, air supplied from air conditioning system 1 to target space 4 passes through air supply ports 46, second openings 22, lower space 43, the inside of duct 23, and upper space 44 in this order. With this configuration, in the second configuration example, airflow from the upper side to the lower side is formed in target space 4.

[0026]

FIG. 4 shows the third configuration example of airflow formation system 100 according to Embodiment 1. In the third

configuration example, circulation mechanism 2 further includes intake fans 25 that take air from target space 4 toward second opening 22, as shown in FIG. 4. Intake fan 25 is placed in the vicinity of each second opening 22 in lower space 43 below floor 42, takes the air from target space 4 through second opening 22, and supplies the taken air to the inside of duct 23 through lower space 43. In the example shown in FIG. 4, one intake fan 25 is provided in each of second openings 22.

[0027]

In the third configuration example, air supplied from air conditioning system 1 to target space 4 passes through air supply port 46, second opening 22, intake fan 25, lower space 43, the inside of duct 23, and upper space 44 in this order. With this configuration, airflow from the upper side to the lower side is formed in target space 4, in the third configuration example. In addition, in the third configuration example, air is taken from target space 4 by intake fan 25. Accordingly, airflow from the upper side to the lower side can be formed easily, as compared with the second configuration example.

[0028]

Here, when a plurality of second openings 22 are provided in target space 4, it is preferable that an opening area of each second opening 22 increases in direct proportion to a distance from fan 24. With this configuration, volumes of air taken from the respective second openings 22 tend to be uniformed, so that uniform airflow from the upper side to the lower side is easily formed in target space 4.

[0029]

[Controller]

Hereinafter, controller 3 included in airflow formation system 100 is described in detail. Controller 3 is a control device that mainly controls AHU 11, circulation machine 12, and fan 24 in air conditioning system 1. In addition, controller 3 also controls intake fan 25, in a case where airflow formation system 100 includes intake fan 25. Controller 3 is a local controller placed in a facility, but may be embodied by a cloud server that is set outside the facility. Controller

3 includes communicator 31, information processor 32, and storage 33.

[0030]

Communicator 31 is a communication circuit (in other words, a communication module) for allowing communication among AHU 11, circulation machine 12, and fan 24. Furthermore, if airflow formation system 100 includes intake fan 25 or one of barometer 34 (see FIG. 5) and differential pressure gauge 35 (see FIG. 6), communicator 31 performs communication with these gauges. A communication standard for the communication performed by communicator 31 is not particularly limited.

[0031]

Information processor 32 performs information processing for controlling airflow that is to be formed in target space 4. Information processor 32 may be embodied by, for example, a microcomputer, and may also be embodied by a processor. Information processor 32 has obtainer 321 and control unit 322 as functional components. Functions of obtainer 321 and control unit 322 are embodied in a manner that a microcomputer or the like configuring information processor 32 executes a computer program stored in storage 33.

[0032]

Obtainer 321 obtains, via communicator 31, a measurement result of barometer 34 or differential pressure gauge 35, or a control parameter of circulation machine 12. Specifically, if control unit 322 follows a first control example described later, obtainer 321 obtains the measurement result of barometer 34. Here, barometer 34 is a machine that measures air pressure in upper space 44. If control unit 322 follows a second control example described later, obtainer 321 obtains the measurement result of differential pressure gauge 35. Here, differential pressure gauge 35 is a machine that measures a difference between the air pressure in upper space 44 and air pressure in target space 4. If control unit 322 follows a third control example described later, obtainer 321 obtains the control parameter of circulation machine 12 included in air conditioning system 1.

[0033]

Control unit 322 controls fan 24. Specifically, control unit 322 controls fan 24 so that a volume of air sucked by fan 24 does not exceed a volume of air discharged by air conditioning system 1. Specifically, control unit 322 performs control to cause the air pressure in upper space 44 to be a negative pressure. In other words, control unit 322 performs control to cause the air pressure in upper space 44 to be lower than or equal to the air pressure in target space 4. With such control, air less likely flows backwards to target space 4 from upper space 44 via air discharge ports 47, so that formation of airflow from the upper side to the lower side is less likely disturbed. Hereinafter, control examples by control unit 322 onto fan 24 are enumerated.

[0034]

FIG. 5 is a block diagram showing a functional configuration of the first control example of airflow formation system 100 according to Embodiment 1. In the first control example, control unit 322 controls fan 24 based on a measurement result of barometer 34, so as to implement control of limiting a volume of air sucked by fan 24 to be lower than or equal to a volume of air discharged by air conditioning system 1. In other words, control unit 322 controls fan 24 so that a measurement value of barometer 34 does not exceed a standard value. Here, the standard value is set in advance to a value that the air pressure in target space 4 would be, during an operation of air conditioning system 1, for example. Accordingly, when the measurement value of barometer 34 exceeds the standard value, control unit 322 causes a volume of the air sucked by fan 24 to be small. With this control, the measurement value of barometer 34 is maintained to be lower than or equal to the standard value, and the air pressure in upper space 44 is maintained to be lower than or equal to the air pressure in target space 4.

[0035]

FIG. 6 is a block diagram showing a functional configuration of the second control example of airflow formation system 100 according to Embodiment 1. In the second control example, control unit 322 controls fan 24 based on a measurement result of differential pressure

gauge 35, so as to implement a control in which the volume of air sucked by fan 24 does not exceed the volume of air discharged by air conditioning system 1. In other words, control unit 322 controls fan 24 so that the measurement value of differential pressure gauge 35 is zero (0) or lower. Here, the measurement value of differential pressure gauge 35 is obtained by subtracting the air pressure in target space 4 from the air pressure in upper space 44. Accordingly, if the measurement value of differential pressure gauge 35 is zero or lower, the air pressure in upper space 44 becomes lower than or equal to the air pressure in target space 4. Thus, when the measurement value of differential pressure gauge 35 exceeds zero, control unit 322 performs control to cause the volume of air sucked by fan 24 to be small. With this control, the measurement value of differential pressure gauge 35 is maintained to be zero or lower, and the air pressure in upper space 44 is maintained to be lower than or equal to the air pressure in target space 4.

[0036]

In the third control example, control unit 322 calculates a volume of the discharged air, using a control parameter of circulation machine 12, which is obtained by obtainer 321. Here, the control parameter of circulation machine 12 may include the rotation number of a fan included in circulation machine 12, an operation frequency of an inverter included in circulation machine 12, or power consumption of circulation machine 12, for example. Control unit 322 calculates a volume of air taken by circulation machine 12, i.e., a volume of air discharged by air conditioning system 1, based on the control parameter of circulation machine 12. Then, control unit 322 compares the volume of air sucked by fan 24 and the calculated volume of the discharged air, and controls fan 24 so that the volume of the sucked air does not exceed the volume of the discharged air. With this control, the air pressure in upper space 44 is maintained to be lower than or equal to the air pressure in target space 4.

[0037]

If target space 4 includes a plurality of spaces (first indoor space 4a and second indoor space 4b in this case), control unit 322

can control a volume of the air, i.e., an airflow intensity, to be supplied to each of the spaces in target space 4. Specifically, control unit 322 controls regulator 7 that is placed in air supply duct 5 extending from air conditioning system 1 to air supply port 46, so as to control the volume of the air (airflow intensity) to be supplied to target space 4. Regulator 7 is, for example, a variable air volume (VAV) control device. It should be noted that regulator 7 may be an air volume regulating damper.

[0038]

In the example shown in FIG. 1, air is supplied to first indoor space 4a through first air supply duct 5a and first air supply port 46a. The volume of air to be supplied to first indoor space 4a is controlled in a manner that control unit 322 controls first regulator 7a placed in first air supply duct 5a. Air is supplied to second indoor space 4b through second air supply duct 5b and second air supply port 46b. The volume of air to be supplied to second indoor space 4b is controlled in a manner that control unit 322 controls second regulator 7b placed in second air supply duct 5b.

[0039]

Furthermore, control unit 322 can control airflow, depending on the number of people in target space 4 or density of the people (the number of people per a unit area). It can be considered that the higher the density of people in target space 4 is, the higher the possibility of floating of fine particles (droplets, and so on), which contain infectious substances, in the air is. In other words, it can be considered that a risk of infection to an infectious disease due to fine particles floating in the air is high in target space 4. In view of the above, airflow formation system 100 controls the airflow depending on the number of people or the density of people in target space 4, thereby effectively forming airflow depending on the infection risk, in place of forming airflow on average, within the device's ability for forming the airflow.

[0040]

The number of people or the density of people in target space 4 can be estimated by placing a camera in target space 4, for example.

The camera is, for example, a surveillance camera, and is a device that takes an image (a moving image or a still image) of target space 4, and sends image information of the taken image to communicator 31 of controller 3. Control unit 322 performs image processing on the obtained image information via communicator 31, to estimate the number of people who stays in target space 4. Control unit 322 performs face recognition processing on the image information, for example, and estimates the number of the recognized faces as the number of people. Furthermore, control unit 322 may estimate the number of people from the image information, using template matching or other existing methods. In addition, if a floor area of target space 4 is in advance stored in storage 33, control unit 322 may calculate the density of people in target space 4, using the floor area. Then, control unit 322 controls regulator 7 so that the volume (airflow intensity) of air supplied to target space 4 increases in direct proportion to increase in the number of people or the density of people.

[0041]

The number of people or the density of people in target space 4 can be estimated by placing a carbon dioxide concentration censor in target space 4, for example. The carbon dioxide concentration censor is a device that measures the concentration of carbon dioxide in target space 4 and sends a measurement value to communicator 31 of controller 3. Control unit 322 estimates the number of people who stays in target space 4, based on the measurement value of the carbon dioxide concentration which is obtained through communicator 31. In other words, control unit 322 estimates that the higher the concentration of the carbon dioxide is, the greater the number of people who stay in target space 4 becomes. In addition, if a floor area of target space 4 is in advance stored in storage 33, control unit 322 may calculate the density of people in target space 4 by using the floor area. Then, control unit 322 controls regulator 7 so that the greater the number of people is or the higher the density of people is, the greater the volume of air (airflow intensity) supplied to target space 4 becomes.

[0042]

If target space 4 includes a plurality of spaces (first indoor space 4a and second indoor space 4b in this case), and the number of people or the density of people can be estimated for each of the spaces, control unit 322 may naturally control the airflow, depending on the number or density of people, in each of the spaces. In Embodiment 1, a camera or a carbon dioxide concentration sensor may be placed in each of first indoor space 4a and second indoor space 4b, for example.

[0043]

Storage 33 is a storage device in which various information, a computer program, and so on which are necessary for information processor 32 to perform formation or control of airflow in target space 4. Storage 33 is embodied by, for example, a semiconductor memory, and so on.

[0044]

[Producing method]

Hereinafter, a method of producing airflow formation system 100 according to Embodiment 1 is described. Here, it is assumed that air conditioning system 1 for target space 4 has already been placed in a facility. It is needless to say that air conditioning system 1 may not have been placed, and may be newly placed. In such a case, a constructor can perform steps of providing air conditioning system 1 for target space 4 in the method of producing airflow formation system 100 described below.

[0045]

The method of producing airflow formation system 100 is performed by providing circulation mechanism 2 in target space 4 for which air conditioning system 1 has been placed. Air conditioning system 1 supplies air to target space 4 from upper space 44 above ceiling 41 of target space 4, and discharges the air from target space 4 to upper space 44, as described above. Circulation mechanism 2 forms circulation path 20 in which air in target space 4 is taken from a position closer to floor 42 than ceiling 41 of target space 4, and the taken air is circulated toward upper space 44, as described above.

[0046]

In a case where airflow formation system 100 corresponding to the first configuration example is produced, for example, a constructor performs steps of placing duct 23 that corresponds to circulation path 20 at any position in target space 4, and connecting an upper end of duct 23 with upper space 44 above ceiling 41. The position where duct 23 is placed is preferably a corner of a room that is target space 4, for example. A constructor performs steps of providing, in duct 23, a hole at a position closer to floor 42 than ceiling 41, so as to provide first opening 21. The closer to floor 42 the position of first opening 21 is, the better it is. Then, the constructor performs steps of placing fan 24 in the inside of duct 23. Accordingly, airflow formation system 100 corresponding to the first configuration example that includes air conditioning system 1 and circulation mechanism 2 (duct 23, first opening 21, and fan 24) is produced.

[0047]

In addition, in a case where airflow formation system 100 corresponding to the second configuration example is produced, for example, a constructor performs steps of placing duct 23 corresponding to circulation path 20 at any position in target space 4, and connecting the upper end of duct 23 with upper space 44 above ceiling 41, as the above case. Then, the constructor performs steps of connecting a bottom end of duct 23 with lower space 43 below floor 42. Furthermore, the constructor performs steps of placing fan 24 in the inside of duct 23, as the above case. The constructor further performs steps of providing a hole in floor 42 of target space 4, removing a floor panel of floor 42, or other steps, so as to provide second opening 22. Accordingly, airflow formation system 100 corresponding to the second configuration example that includes air conditioning system 1 and circulation mechanism 2 (duct 23, second opening 22, and fan 24) is produced.

[0048]

Furthermore, in a case where airflow formation system 100 corresponding to the third configuration example is produced, for

example, a constructor performs steps of further placing intake fan 25 in the steps of producing airflow formation system 100 corresponding to the second configuration example. It is preferable that intake fan 25 is placed in the vicinity of second opening 22 in lower space 43 below floor 42, i.e., immediately below second opening 22, for example. Accordingly, airflow formation system 100 corresponding to the third configuration example that includes air conditioning system 1 and circulation mechanism 2 (duct 23, second opening 22, intake fan 25, and fan 24) is produced.

[0049]

[Advantage]

Hereinafter, advantages of airflow formation system 100 according to Embodiment 1 is described with reference to a comparison with an airflow formation system according to Comparative Example. FIG. 7A is an explanatory diagram showing airflow formed by the airflow formation system according to Comparative Example. FIG. 7B is an explanatory diagram showing airflow formed by airflow formation system 100 according to Embodiment 1. In the example shown in FIG. 7B, second opening 22 is provided in floor 42, as in the second configuration example. The airflow formation system according to Comparative Example is simple air conditioning system 1 that does not include circulation mechanism 2, and thus is different from airflow formation system 100 according to Embodiment 1.

[0050]

The airflow formation system according to Comparative Example does not include circulation mechanism 2 as shown in FIG. 7A, so that air in target space 4 is taken from air discharge port 47 in ceiling 41 toward upper space 44. Accordingly, in the airflow formation system of Comparative Example, airflow from an upper side to a lower side is not formed in target space 4. Thus, if fine particles to which infectious substances (viruses, and so on) are attached float in the air, the fine particles are hardly blown down to floor 42. As a result, fine particles tend to stay in target space 4 for a relatively long period of time in the airflow formation system according to

Comparative Example. Therefore, it has been unfortunately difficult to prevent spread of an infectious disease caused by fine particles floating in the air, thereby hardly reducing a risk of infection to the infectious disease in target space 4.

5 [0051]

In contrast, in airflow formation system 100 according to Embodiment 1, airflow (downflow) from the upper side to the lower side in target space 4 can be formed as shown in FIG. 7B. Accordingly, in airflow formation system 100 according to
10 Embodiment 1, even if fine particles to which infectious substances (viruses, and so on) are attached float in the air, the fine particles are blown down to floor 42 by the downflow. Therefore, it can be expected in airflow formation system 100 according to Embodiment 1 that the spread of an infectious disease caused by fine particles
15 floating in the air is effectively prevented, thereby easily reducing a risk of infection to the infectious disease in target space 4.

[0052]

In the method of producing airflow formation system 100 according to Embodiment 1, airflow from the upper side to the lower
20 side in target space 4 can be formed by only adding circulation mechanism 2 to air conditioning system 1. Therefore, there is another advantage that the system is easily constituted. For example, air conditioning system 1 may be in advance placed in a facility. In such a case, a constructor merely performs steps of
25 placing circulation mechanism 2 in target space 4, to construct airflow formation system 100. In the method of producing airflow formation system 100 according to Embodiment 1, there is no need to construct a system from the beginning, in a case where airflow from the upper side to the lower side should be implemented in target space 4.
30 Accordingly, the system can be easily constructed using existing air conditioning system 1, with reducing a cost.

[0053]

[Embodiment 2]

[Configuration]

35 Hereinafter, a configuration of airflow formation system 100A

according to Embodiment 2 is described. FIG. 8 is a diagram showing a configuration example of airflow formation system 100A according to Embodiment 2. Airflow formation system 100A according to Embodiment 2 is provided with circulation mechanism 2A in place of circulation mechanism 2, and thus is different from airflow formation system 100 according to Embodiment 1. Specifically, circulation mechanism 2A forms circulation path 20A in which air in target space 4 is taken from floor 42 of target space 4 and circulates the taken air to space 45 above a ceiling of a downstairs room below floor 42. Furthermore, circulation mechanism 2A includes openings 26 that introduce air from target space 4 to lower space 43 below floor 42, and also introduce air from lower space 43 to space 45 above the ceiling of the downstairs room.

[0054]

Specifically, openings 26 include a ventilation hole provided in floor 42, and a ventilation hole provided in building material 48 that separates a floor where target space 4 exists and the downstairs. A grille or the like is set, for example, to each of the ventilation holes. In the example shown in FIG. 8, one opening 26 is provided in each of first indoor space 4a and second indoor space 4b.

[0055]

In circulation mechanism 2A, circulation path 20A is formed using another air conditioning system 1A downstairs. Air conditioning system 1A has a configuration same as that of air conditioning system 1, except that target space 4A is a space of a lower floor from target space 4. In other words, air conditioning system 1A that is different from air conditioning system 1 supplies air to target space 4A from an upper space (space 45 above a ceiling) above ceiling 41A of target space 4A, and discharges the air from target space 4A to the upper space. Circulation mechanism 2A forms circulation path 20A in which air circulates through target space 4, openings 26, space 45 above a ceiling of a downstairs room, and air conditioning system 1A different from air conditioning system 1 in this order, using airflow from target space 4A to air conditioning system 1A different from air conditioning system 1 through space 45 above

the ceiling of the downstairs room. Although air conditioning system 1A different from air conditioning system 1 does not constitute circulation mechanism 2 (or circulation mechanism 2A) and airflow formation system 100 (or airflow formation system 100A) in the example shown in FIG. 8, conditioning system 1A may constitute them.

[0056]
[Producing method]

Hereinafter, a method of producing airflow formation system 100A according to Embodiment 2 is described. Here, it is assumed that air conditioning system 1 for target space 4 has already been placed in a facility. It is needless to say that air conditioning system 1 may not have been placed, and may be newly placed. In such a case, a constructor may perform steps of providing air conditioning system 1 for target space 4 in a method of producing airflow formation system 100A described below.

[0057]

The method of producing airflow formation system 100A is performed by placing circulation mechanism 2A in target space 4 for which air conditioning system 1 has been placed. Air conditioning system 1 supplies air to target space 4 from upper space 44 above ceiling 41 of target space 4, and discharges the air from target space 4 to upper space 44, as already described. Circulation mechanism 2A forms circulation path 20 in which air in target space 4 is taken from floor 42 of target space 4 and circulates the taken air to space 45 above a ceiling of a downstairs room below floor 42, as already described. Circulation mechanism 2A includes openings 26 that introduce air from target space 4 to lower space 43 below floor 42 and also introduce air from lower space 43 to space 45 above the ceiling of the downstairs room.

[0058]

Specifically, a constructor performs steps of providing opening 26 by, for example, making a hole that leads from floor 42 of target space 4 to space 45 above a ceiling of a downstairs room below floor 42. Accordingly, airflow formation system 100A including air conditioning system 1 and circulation mechanism 2A (opening 26) is

produced.

[0059]

[Advantages]

5 In airflow formation system 100A according to Embodiment 2, airflow (downflow) from the upper side to the lower side in target space 4 can be formed, in the same manner as in Embodiment 1. Accordingly, a risk of infection to an infectious disease can be easily reduced in target space 4. In airflow formation system 100A according to Embodiment 2, circulation path 20A is formed using
10 additional air conditioning system 1A downstairs. Accordingly, there is no need to place duct 23 and fan 24 in target space 4.

[0060]

[Variation]

15 Although Embodiments 1 and 2 are described as above, the present invention is not limited to Embodiments 1 and 2. Hereinafter, variations of Embodiments 1 and 2 are enumerated. Variations described below may be combined appropriately.

[0061]

20 Although controller 3 controls air conditioning system 1 in addition to the control of fan 24 in Embodiments 1 and 2, the function of controller 3 is not limited thereto. For example, controller 3 may control fan 24. In such a case, air conditioning system 1 is controlled by a controller separately provided in addition to controller 3.

[0062]

25 Although air discharge ports 47 that discharge air from target space 4 to upper space 44 above ceiling 41 is provided in ceiling 41 in Embodiments 1 and 2, air discharge ports 47 may not be provided. The reason is as follows. If existing air conditioning system 1 is used before air formation system 100 is placed, air conditioning system 1
30 performs ventilation by discharging air in target space 4 from air discharge ports 47 provided in ceiling 41. In this case, air discharge ports 47 may be closed or may not be closed when airflow formation system 100 is constituted using existing air conditioning system 1. In a case where air discharge ports 47 is closed, a path for discharging
35 air in target space 4 is limited, thereby improving an efficiency of

taking air from target space 4 to circulation path 20. Accordingly, airflow from the upper side to the lower side is easily formed.

[0063]

An arrangement or the like of AHU 11, fan 24, and intake fan 25 in Embodiment 1 is an example. Fan 24 is merely required to form airflow from circulation path 20 to upper space 44, for example. Thus, fan 24 may be placed not only in the inside of duct 23 but also in lower space 43 below floor 42, and may be placed in upper space 44 above ceiling 41. Similarly, intake fan 25 is merely required to form airflow from target space 4 to circulation path 20. Thus, fan 25 may be placed not only in lower space 43 below floor 42 but also in the inside of duct 23, for example. Furthermore, fan 24 and intake fan 25 may be added or omitted depending on the necessity.

[0064]

An arrangement or the like of first opening 21 and second opening 22 in Embodiment 1 and an arrangement or the like of opening 26 in Embodiment 2 are each an example. For example, although one first opening 21 is provided in each of first indoor space 4a and second indoor space 4b in the example shown in FIG. 1, a plurality of first openings 21 may be provided in each of them. Similarly, although one second opening 22 is provided in each of first indoor space 4a and second indoor space 4b in the examples shown in FIGS. 2 and 3, a plurality of second openings 22 may be provided in each of them. Although one opening 26 is provided in each of first indoor space 4a and second indoor space 4b in the example shown in FIG. 8, a plurality of openings 26 may be provided in each of them.

[0065]

First opening 21 and second opening 22 in Embodiment 1 and opening 26 in Embodiment 2 may be formed so that an air intake volume from target space 4 can be varied by allowing opening areas to be variable. Such embodiments can be embodied by providing, for example, an air volume regulating damper in first opening 21, second opening 22, or opening 26.

[0066]

It is considerable that a wind pressure of airflow is controlled

so that the airflow is not blown down with a large air volume at a level of causing people in target space 4 to feel uncomfortable. Specifically, it is considerable that a wind pressure of blowing air from air supply port 6 is controlled so that the wind pressure of the airflow at a time of reaching floor 42 of target space 4 is naturally attenuated to a level not uncomfortable for people. As an example, the wind pressure of the blown air from air supply port 46 is controlled by measuring, in advance, a distance from ceiling 41 to floor 42 in target space 4 (i.e., the height of target space 4), and referring to the measured value by air conditioning system 1.

[0067]

As another example, the wind pressure of the blown air from air supply port 46 may also be controlled by installing a laser marking device in target space 4, automatically measuring a distance from ceiling 41 to a floor surface (floor 42 is included) immediately below ceiling 41 by the laser marking device, and referring to the measured value by air conditioning system 1. In this control example, even if a layout of furniture such as a desk or a table is changed in target space 4 and the furniture is positioned immediately below air supply port 46, an appropriate wind pressure depending on the distance from air supply port 46 to the floor surface (a surface of the furniture, in this case) can be automatically set as the wind pressure of the blown wind from air supply port 46. In other word, in the control example, an operation of setting the pressure of wind blown from air supply port 46 depending on the change in layout of furniture in target space 4 can be automated, so that a troublesome operation is not required.

[0068]

Furthermore, as a method of controlling a wind pressure of the airflow, a method of controlling a wind rate of airflow to be circulated to circulation mechanism 2 (or circulation mechanism 2A) can be considered, in addition to a method of controlling the wind pressure of blown air from air supply port 46, as described above. In other words, it is possible to control a wind pressure of the airflow in target space 4 also by regulating a wind rate of the airflow to be circulated in circulation mechanism 2 (or circulation mechanism 2A), while a

wind pressure of the blown air from air supply port 46 is at constant. In this case, air that is not circulated by circulation mechanism 2 (or circulation mechanism 2A) is discharged to upper space 44 through air discharge port 47 in ceiling 41, for example.

5 [0069]

Although control unit 322 is embodied by a single device in Embodiments 1 and 2, control unit 322 may be embodied by a plurality of devices, for example. If control unit 322 is embodied by a plurality of devices, functional components included in control unit
10 322 may be allocated to the plurality of devices in any ways.

[0070]

A communication method among devices in Embodiments 1 and 2 above is not particularly limited. If two of the devices perform communication in Embodiments 1 and 2 above, a relay device that is
15 not shown may be interposed between the two devices.

[0071]

In Embodiments 1 and 2 above, structural components of controller 3 may be embodied by executing software programs respectively suitable for the components. Each of the components
20 may be embodied in a manner that a program executer, such as a CPU and a processor, reads a software program recorded in a recording medium, such as a hard disk or a semiconductor memory, to execute the program.

[0072]

Each of the components of controller 3 may be embodied by hardware. For example, each of the components may be a circuit (or an integrated circuit). These circuits may configure a single circuit as a whole, or may be separated circuits. Each of the circuits may be a general circuit, or a dedicated circuit.

30 [0073]

In addition, the present invention involves an embodiment obtained by applying various modification conceivable by a person skilled in the art to each of the embodiments, or an embodiment embodied by combining components and functions in the above
35 embodiments, within a scope without departing from the gist of the

present invention.

[0074]

[Summary]

As described above, airflow formation system 100 includes air
5 conditioning system 1 and circulation mechanism 2. Air conditioning
system 1 supplies air to target space 4 from upper space 44 above
ceiling 41 of target space 4, and discharges the air from target space
4 to upper space 44. Circulation mechanism 2 forms circulation path
20 in which air in target space 4 is taken from a position closer to
10 floor 42 than ceiling 41 of target space 4, and the taken air is
circulated to upper space 44.

[0075]

According to such airflow formation system 100, airflow from
the upper side to the lower side can be formed in in target space 4.
15 Accordingly, a risk of infection to an infectious disease can be easily
reduced in target space 4.

[0076]

In addition, in airflow formation system 100, circulation
mechanism 2 includes first opening 21 and fan 24, for example. First
20 opening 21 is provided in a position closer to floor 42 than ceiling 41,
and introduces air from target space 4 to circulation path 20. Fan 24
sucks the air toward upper space 44 through circulation path 20.

[0077]

According to such airflow formation system 100, there is an
25 advantage that airflow from the upper side to the lower side can be
formed in target space 4 by providing a relatively simple configuration
including first opening 21 and fan 24.

[0078]

In addition, in airflow formation system 100, circulation
30 mechanism 2 includes second opening 22 and fan 24, for example.
Second opening 22 is provided in floor 42, and introduces air from
target space 4 to circulation path 20 through lower space 43 below
floor 42. Fan 24 sucks the air toward upper space 44 through
circulation path 20.

35 [0079]

According to such airflow formation system 100, there is an advantage that airflow from the upper side to the lower side can be formed in target space 4 by providing a relatively simple configuration including second opening 22 and fan 24.

5 [0080]

Furthermore, in air formation system 100, circulation mechanism 2 further includes intake fan 25 that takes air from target space 4 toward second opening 22.

[0081]

10 According to such airflow formation system 100, air is taken by intake fan 25 from target space 4 toward circulation path 20. Therefore, there is an advantage that airflow from the upper side to the lower side can be easily formed in target space 4.

[0082]

15 Furthermore, airflow formation system 100 further includes control unit 322 that controls fan 24. Control unit 322 controls fan 24 so that a volume of air sucked by fan 24 does not exceed a volume of air discharged by air conditioning system 1.

[0083]

20 According to such airflow formation system 100, air hardly flows backwards to target space 4 from upper space 44, so that formation of airflow the upper side to the lower side is less likely disturbed.

[0084]

25 Furthermore, airflow formation system 100 further includes barometer 34 that measures air pressure in upper space 44. Control unit 322 controls fan 24 so that a measurement value of barometer 34 does not exceed a standard value.

[0085]

30 According to such airflow formation system 100, air hardly flows backwards to target space 4 from upper space 44, so that formation of airflow from the upper side to the lower side is less likely disturbed.

[0086]

35 Furthermore, airflow formation system 100 further includes

differential pressure gauge 35 that measures a difference between air pressure in upper space 44 and air pressure in target space 4. Control unit 322 controls fan 24 so that a measurement value of differential pressure gauge 35 is zero (0) or lower.

5 [0087]

According to such airflow formation system 100, air hardly flows backwards from upper space 44 to target space 4, so that formation of airflow from the upper side to the lower side is less likely disturbed.

10 [0088]

Furthermore, airflow formation system 100 further includes obtainer 321 that obtains a control parameter of circulation machine 12 included in air conditioning system 1. Control unit 322 calculates a volume of discharged air, using the control parameter obtained by

15 obtainer 321.

[0089]

According to such airflow formation system 100, air hardly flows backwards from upper space 44 to target space 4, so that formation of airflow from the upper side to the lower side is less likely

20 disturbed.

[0090]

Furthermore, airflow formation system 100A includes air conditioning system 1 and circulation mechanism 2A, for example. Air conditioning system 1 supplies air to target space 4 from upper space 44 above ceiling 41 of target space 4, and discharges the air from target space 4 to upper space 44. Circulation mechanism 2A forms circulation path 20A in which air in target space 4 is taken from floor 42 of target space 4 and the taken air is circulated to space 45 above a ceiling of a downstairs room below floor 42. Circulation mechanism 2A includes opening 26 that introduces air from target space 4 to lower space 43 below floor 42 and also introduces the air from lower space 43 to space 45 above the ceiling of the downstairs room.

30

[0091]

35 According to such airflow formation system 100A, airflow from

the upper side to the lower side can be formed in target space 4. Accordingly, a risk of infection to an infectious disease can be easily reduced in target space 4.

[0092]

5 Furthermore, in a method of producing airflow formation system 100, circulation mechanism 2 is placed in target space 4 for which air conditioning system 1 has been placed. Air conditioning system 1 supplies air to target space 4 from upper space 44 above ceiling 41 of target space 4, and discharges the air from target space
10 4 to upper space 44. Circulation mechanism 2 forms circulation path 20 in which air in target space 4 is taken from a position closer to floor 42 than ceiling 41 of target space 4, and the taken air is circulated to upper space 44.

[0093]

15 According to such a method of producing airflow formation system 100, airflow from the upper side to the lower side can be formed in target space 4 only by adding circulation mechanism 2 to air conditioning system 1. Therefore, there is an advantage that a system is easily constituted.

20 [0094]

 Furthermore, in the method of producing airflow formation system 100, air conditioning system 1 is placed for target space 4, and circulation mechanism 2 is placed in target space 4. Air conditioning system 1 supplies air to target space 4 from upper space
25 44 above ceiling 41 of target space 4, and discharges the air from target space 4 to upper space 44. Circulation mechanism 2 forms circulation path 20 in which air in target space 4 is taken from a position closer to floor 42 than ceiling 41 of target space 4, and the taken air is circulated to upper space 44.

30 [0095]

 According to such a method of producing airflow formation system 100, airflow from the upper side to the lower side can be formed in target space 4 only by adding air conditioning system 1 and circulation mechanism 2. Therefore, there is an advantage that a
35 system is easily constituted.

[Reference Signs List]

[0096]

	1, 1A	Air conditioning system
	12	Circulation machine
5	2, 2A	Circulation mechanism
	20, 20A	Circulation path
	21	First opening
	22	Second opening
	24	Fan
10	25	Intake fan
	26	Opening
	321	Obtainer
	322	Control unit
	34	Barometer
15	35	Differential pressure gauge
	4, 4A	Target space
	41, 41A	Ceiling
	42	Floor
	43	Lower space
20	44	Upper space
	45	Space above ceiling of downstairs room
	100, 100A	Airflow formation system

[CLAIMS]

[Claim 1]

An airflow formation system comprising:

an air conditioning system that supplies air to a target space
5 from an upper space above a ceiling of the target space, and
discharges the air from the target space to the upper space; and
a circulation mechanism that forms a circulation path in which
the air in the target space is taken from a position closer to a floor
than the ceiling of the target space, and the air taken is circulated to
10 the upper space.

[Claim 2]

The airflow formation system according to claim 1, wherein
the circulation mechanism includes:

15 a first opening that is provided in a position closer to the floor
than the ceiling, and introduces the air from the target space to the
circulation path; and
a fan that sucks the air toward the upper space through the
circulation path.

20

[Claim 3]

The airflow formation system according to claim 1, wherein
the circulation mechanism includes:

a second opening that is provided in the floor, and introduces
25 the air from the target space to the circulation path through a lower
space below the floor; and
a fan that sucks the air toward the upper space through the
circulation path.

30 [Claim 4]

The airflow formation system according to claim 3, wherein
the circulation mechanism further includes an intake fan that
sucks the air from the target space to the second opening.

35 [Claim 5]

The airflow formation system according to any one of claims 2 to 4, further comprising:

a controller that controls the fan, wherein

the controller controls the fan so that a volume of the air sucked by the fan does not exceed a volume of the air discharged by the air conditioning system.

[Claim 6]

The airflow formation system according to claim 5, further comprising:

a barometer that measures air pressure in the upper space, wherein

the controller controls the fan so that a measurement value of the barometer does not exceed a standard value.

[Claim 7]

The airflow formation system according to claim 5, further comprising:

a differential pressure gauge that measures a difference between air pressure in the upper space and air pressure in the target space, wherein

the controller controls the fan so that a measurement value of the differential pressure gauge is zero or lower.

[Claim 8]

The airflow formation system according to claim 5, further comprising:

an obtainer that obtains a control parameter of a circulation machine included in the air conditioning system, wherein

the controller calculates the volume of the air discharged, from the control parameter obtained by the obtainer.

[Claim 9]

An airflow formation system comprising:

an air conditioning system that supplies air to a target space

from an upper space above a ceiling of the target space, and discharges the air from the target space to the upper space; and

a circulation mechanism that forms a circulation path in which the air in the target space is taken from a floor of the target space, and the air taken is circulated to a space above a ceiling of a downstairs room, the space being below the floor, wherein

the circulation mechanism includes an opening that introduces the air from the target space to a lower space below the floor, and introduces the air from the lower space to the space above the ceiling of the downstairs room.

[Claim 10]

A method of producing an airflow formation system, the method comprising:

placing, in a target space provided with an air conditioning system that supplies air to the target space from an upper space above a ceiling of the target space and discharges the air from the target space to the upper space, a circulation mechanism that forms a circulation path in which the air in the target space is taken from a position closer to a floor than the ceiling of the target space, and the air taken is circulated to the upper space.

[Claim 11]

A method of producing an airflow formation system, the method comprising:

placing, for a target space, an air conditioning system that supplies air to the target space from an upper space above a ceiling of the target space, and discharges the air from the target space to the upper space; and

placing a circulation mechanism that forms a circulation path in which the air in the target space is taken from a position closer to a floor than the ceiling of the target space, and the air taken is circulated to the upper space.