

DESCRIPTION

TITLE OF INVENTION: SERVER COOLING SYSTEM

TECHNICAL FIELD

5 [0001]

The present disclosure relates to a server cooling system.

Priority is claimed on Japanese Patent Application No. 2023-181545, filed October 23, 2023, the content of which is incorporated herein by reference.

BACKGROUND ART

10 [0002]

Since a server is sensitive to heat, prolonged exposure to a high temperature in a server room causes issues such as a failure of the server or a shortened server lifespan.

In order to safely manage the server, it is necessary to control air conditioning in the server room where the server is installed to cool the inside of the server room.

15 [0003]

Patent Document 1 discloses an air conditioning duct system for whole-house air conditioning and heating in a house. In the air conditioning duct system, a chimney is formed that penetrates from a first floor through a roof and has an upper end portion protruding above the roof. Further, a vertical duct is disposed in the chimney.

20 Citation List

Patent Document

[0004]

Patent Document 1: Japanese Unexamined Patent Application, First Publication No. H7-4732

25 SUMMARY OF INVENTION

Technical Problem

[0005]

When the vertical duct as disclosed in Patent Document 1 is used for exhausting air in the server room, for example, the high-temperature exhaust air from the inside of the server room causes the temperature inside the duct to become higher than that outside the duct. As a result, the air inside the duct becomes lighter than the air outside the duct, and an upward flow is generated inside the duct. The air outside the duct is drawn into the duct by the upward flow generated inside the duct. This phenomenon is called a chimney effect. Due to the chimney effect, the high-temperature air in the server room is drawn into the duct and exhausted. However, the exhaust flow rate resulting from the chimney effect is low, and it has been considered that the inside of the server room cannot be sufficiently cooled.

[0006]

The present disclosure has been made to solve the above-described problem, and an object of the present disclosure is to provide a server cooling system capable of ensuring sufficient cooling performance.

Solution to Problem

[0007]

In order to solve the above-described problem, a server cooling system according to the present disclosure includes: a duct that has a cylindrical shape extending in a vertical direction and has an air discharge port formed at an upper portion; an exhaust introduction section configured to introduce exhaust air from a server room into a portion below the air discharge port in the duct; a fan that is provided in the duct and is rotationally driven so that air is discharged from the air discharge port; and a control device, in which the control device includes a fan operation unit configured to rotate the

fan from a stopped state when the exhaust air is introduced into the duct, and a fan stop unit configured to stop the fan when a natural circulation condition is satisfied after the fan has rotated.

[0008]

5 A server cooling system according to the present disclosure includes: a duct that has a cylindrical shape extending in a vertical direction and has an air introduction port formed at a lower portion and an air discharge port formed at an upper portion; a refrigerant introduction section configured to introduce a circulating refrigerant from a server room into a space between the air introduction port and the air discharge port in
10 the duct; a fan that is provided in the duct and is rotationally driven so that air is discharged from the air discharge port; and a control device, in which the refrigerant introduction section includes a heat exchange unit disposed in the duct to perform heat exchange between the circulating refrigerant and air in the duct, and the control device includes a fan operation unit configured to rotate the fan from a stopped state when the
15 circulating refrigerant is introduced into the duct, and a fan stop unit configured to stop the fan when a natural circulation condition is satisfied after the fan has rotated.

Advantageous Effects of Invention

[0009]

 According to the server cooling system of the present disclosure, it is possible to
20 ensure sufficient cooling performance.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

[FIG. 1] A configuration diagram of a server cooling system according to a first embodiment of the present disclosure.

[FIG. 2] A perspective view showing the general shape of a duct according to the first embodiment of the present disclosure.

[FIG. 3] A functional block diagram of a control device according to the first embodiment of the present disclosure.

5 [FIG. 4] A flowchart showing an operation procedure of the server cooling system according to the first embodiment of the present disclosure.

[FIG. 5] A diagram showing temporal changes in an exhaust flow path and a duct temperature according to the first embodiment of the present disclosure.

[FIG. 6] A configuration diagram of a server cooling system according to a
10 second embodiment of the present disclosure.

[FIG. 7] A functional block diagram of a control device according to the second embodiment of the present disclosure.

[FIG. 8] A flowchart showing an operation procedure of the server cooling system according to the second embodiment of the present disclosure.

15 [FIG. 9] A configuration diagram of a refrigerant introduction section according to a modification example of the second embodiment of the present disclosure.

[FIG. 10] A configuration diagram of a server cooling system according to a third embodiment of the present disclosure.

[FIG. 11] A flowchart showing an operation procedure of the server cooling
20 system according to the third embodiment of the present disclosure.

[FIG. 12] A configuration diagram of a server cooling system according to a modification example of the third embodiment of the present disclosure.

[FIG. 13] A configuration diagram of a server cooling system according to another embodiment of the present disclosure.

[FIG. 14] A configuration diagram of a server cooling system according to another embodiment of the present disclosure.

[FIG. 15] A cross-sectional view of a duct along a horizontal plane according to another embodiment of the present disclosure.

5 [FIG. 16] A configuration diagram of a server cooling system according to another embodiment of the present disclosure.

[FIG. 17] A hardware configuration diagram showing a configuration of a computer according to each embodiment of the present disclosure.

DESCRIPTION OF EMBODIMENTS

10 [0011]

<First Embodiment>

(Configuration of Server Cooling System)

Hereinafter, a server cooling system 100 according to a first embodiment of the present disclosure will be described with reference to FIGS. 1 to 5. In FIGS. 1 and 2, a
15 flow of air is shown by arrows.

A server 2 is installed in a server room 1. The server 2 generates heat during operation. The temperature inside the server room 1 becomes high due to the heat of the server 2. The server cooling system 100 is used for cooling the server room 1. As shown in FIG. 1, the server cooling system 100 includes a duct 10, an exhaust
20 introduction section 20, a fan 3, a damper 30, a temperature sensor 4, a control device 40, and a display unit 5.

The server room 1 is formed with an intake port 1b. Air outside the server room 1 is supplied into the server room 1 through the intake port 1b. The high-temperature air in the server room 1 heated by the server 2 is exhausted through the
25 exhaust introduction section 20 and the duct 10, which will be described below.

[0012]

(Duct)

The duct 10 has a cylindrical shape extending in a vertical direction Dv. The duct 10 is disposed along a side wall 1a of the server room 1 extending in the vertical direction Dv. A length of the duct 10 can be changed as appropriate. Note that the length of the duct 10 is, for example, preferably 1 m or more and 500 m or less. In the present embodiment, a lower end portion of the duct 10 is closed. An air discharge port 11 is formed at an upper portion of the duct 10. The duct 10 includes a first cylindrical portion 10a and a second cylindrical portion 10b. The first cylindrical portion 10a extends in the vertical direction Dv along the side wall 1a of the server room 1. The second cylindrical portion 10b is provided at an upper end of the first cylindrical portion 10a. The second cylindrical portion 10b communicates with the first cylindrical portion 10a. The second cylindrical portion 10b extends upward from the upper end of the first cylindrical portion 10a. The second cylindrical portion 10b extends such that the second cylindrical portion 10b gradually moves away from the side wall 1a in a horizontal direction as it goes upward. The second cylindrical portion 10b has an opening portion at an end portion opposite to the first cylindrical portion 10a. The opening portion is the air discharge port 11 of the duct 10. The air discharge port 11 slightly faces downward. That is, an opening direction of the air discharge port 11 has a downward direction component.

[0013]

The duct 10 has a fan discharge port 12 in the second cylindrical portion 10b. The fan discharge port 12 is provided separately from the air discharge port 11 and faces the side wall 1a of the server room 1. The fan discharge port 12 is provided to penetrate the duct 10 and allows the inside and the outside of the duct 10 to communicate with

each other. A plurality of (four in the present embodiment) fan discharge ports 12 are disposed in the horizontal direction.

[0014]

(Exhaust Introduction Section)

5 The exhaust introduction section 20 extends from the inside of the server room 1 to the first cylindrical portion 10a of the duct 10. The exhaust introduction section 20 is a pipe that penetrates the side wall 1a of the server room 1. The exhaust introduction section 20 introduces high-temperature exhaust air from the server room 1 into a portion below the air discharge port 11 in the duct 10. In the present embodiment, the exhaust
10 introduction section 20 is formed in a tubular shape extending in the horizontal direction. As shown in FIG. 2, a plurality of (four in the present embodiment) exhaust introduction sections 20 are disposed in the horizontal direction. The exhaust introduction section 20 communicates with the duct 10.

[0015]

15 (Fan)

The fan 3 is provided in the second cylindrical portion 10b of the duct 10. The fan 3 is disposed to face the side wall 1a of the server room 1. In addition, a plurality of (four in the present embodiment) the fans 3 are attached to the respective fan discharge ports 12 and are disposed in the horizontal direction. The fan 3 is rotationally driven so
20 that air is discharged from the air discharge port 11.

[0016]

(Damper)

The damper 30 is provided at the air discharge port 11 and opens and closes the air discharge port 11. Here, when a state in which the damper 30 opens the air
25 discharge port 11 is defined as an open state and a state in which the damper 30 closes

the air discharge port 11 is defined as a closed state, in FIG. 1, the open state of the damper 30 is shown by a solid line, and the closed state of the damper 30 is shown by a broken line.

[0017]

5 (Temperature Sensor)

The temperature sensor 4 detects the temperature inside the duct 10. The temperature sensor 4 is attached to an inner surface of the first cylindrical portion 10a of the duct 10.

[0018]

10 (Control Device)

The control device 40 is electrically connected to the server 2, the fan 3, the damper 30, and the temperature sensor 4. As shown in FIG. 3, the control device 40 includes the following functional units: an acquisition unit 41, a determination unit 42, a fan operation unit 43, a fan stop unit 44, a damper closing unit 45, and a damper opening
15 unit 46.

[0019]

The acquisition unit 41 acquires information from the outside. For example, the acquisition unit 41 acquires information on whether or not the server 2 is in operation. In addition, the acquisition unit 41 acquires the temperature inside the duct
20 10 detected by the temperature sensor 4.

[0020]

The determination unit 42 determines whether or not a natural circulation condition is satisfied. The natural circulation condition is a condition in which air of a volume sufficient to cool the server 2 can naturally circulate within the duct 10 only due
25 to a chimney effect caused by the temperature inside the duct 10 being higher than the

temperature outside the duct 10. The determination unit 42 of the present embodiment determines that the natural circulation condition is satisfied when the temperature detected by the temperature sensor 4 exceeds a predetermined threshold value.

[0021]

- 5 The fan operation unit 43 rotates the fan 3 from a stopped state when the exhaust air is introduced into the duct 10. In addition, the fan operation unit 43 can adjust the rotation speed of the fan 3 to adjust the exhaust flow rate of the fan 3.

The fan stop unit 44 stops the fan 3 when the natural circulation condition is satisfied after the fan 3 has rotated.

10 [0022]

The damper closing unit 45 operates the damper 30 to close the air discharge port 11, for example, before the fan 3 starts rotating.

The damper opening unit 46 operates the damper 30 to open the air discharge port 11, for example, after the fan 3 has rotated.

15 [0023]

(Display Unit)

The display unit 5 is connected to the control device 40. The state of the server cooling system 100 is displayed on the display unit 5 in real time. Examples of the information displayed on the display unit 5 include the temperature of the duct 10
20 detected by the temperature sensor 4 and the volume of air flowing through the duct 10. In the present embodiment, the exhaust flow rate by the fan 3 and the exhaust flow rate resulting from the chimney effect are displayed separately.

[0024]

(Operation of Server Cooling System)

Subsequently, an operation procedure of the server cooling system 100 will be described with reference to the flow in FIG. 4.

When the server 2 is operated, a room temperature of the server room 1 rises due to heat from the server 2. Then, the high-temperature exhaust air is introduced into the duct 10 from the server room 1. The acquisition unit 41 acquires information indicating that the server 2 is operated (step S11). Immediately after step S11, or after a predetermined time has elapsed, the damper closing unit 45 operates the damper 30 to close the air discharge port 11 (step S12). Immediately thereafter, the fan operation unit 43 rotates the fan 3 that is in a stopped state (step S13). Due to the rotation of the fan 3, the high-temperature air in the server room 1 is introduced into the duct 10. The high-temperature exhaust air introduced into the duct 10 is exhausted to the outside of the server room 1 through the fan discharge port 12. As described above, immediately after the server 2 is operated, the high-temperature air in the server room 1 is forcibly exhausted by the fan 3.

[0025]

Here, temporal changes in the exhaust flow rate and the temperature of the duct 10 from step S13 are as shown in FIG. 5. A horizontal axis in FIG. 5 indicates the elapsed time, and a vertical axis in FIG. 5 indicates the temperature of the duct 10 or the exhaust flow rate of the duct 10. In FIG. 5, the temperature of the duct 10 is displayed by a solid line. In addition, in FIG. 5, the exhaust flow rate by the fan 3 is displayed by a broken line, and the exhaust flow rate resulting from the chimney effect is displayed by a one-dot chain line. The temporal changes in the exhaust flow rate and the temperature of the duct 10 as shown in FIG. 5 are displayed on, for example, the display unit 5.

[0026]

In the present embodiment, the exhaust flow rate by the fan 3 is controlled while the temperature inside the duct 10 is monitored. When the rotation of the fan 3 is started, the exhaust flow rate by the fan 3 rapidly increases as shown in FIG. 5. As a result, the exhaust flow rate sent from the server room 1 to the duct 10 increases, causing the temperature inside the duct 10 to rise. When the temperature inside the duct 10 rises, an upward flow due to thermal convection occurs in the duct 10, and the exhaust flow rate of the duct 10 increases (chimney effect).

[0027]

When a predetermined time has elapsed from the start of the rotation of the fan 3, the rotation speed of the fan 3 is reduced. As a result, the exhaust flow rate by the fan 3 gradually decreases. In addition, as the temperature rises, the damper opening unit 46 operates the damper 30 to gradually increase an opening degree of the air discharge port 11 (step S14). As a result, the exhaust flow rate resulting from the chimney effect gradually increases. In this way, the forced exhaust by the fan 3 and the natural exhaust by the chimney effect are used in combination, and the proportion of the natural exhaust by the chimney effect increases over time.

[0028]

Thereafter, the determination unit 42 determines whether or not the natural circulation condition is satisfied in which air of a volume sufficient to cool the server 2 can naturally circulate within the duct 10 only by the chimney effect (step S15). In the present embodiment, the temperature inside the duct 10 becomes a substantially constant value (for example, 40°C) as time passes. The determination unit 42 uses the constant temperature inside the duct 10 as a threshold value, and determines that the natural circulation condition is satisfied when the temperature detected by the temperature sensor

4 exceeds a predetermined threshold value. The threshold value can be changed as appropriate depending on the condition.

[0029]

When the natural circulation condition is satisfied (step S15; YES), the damper opening unit 46 operates the damper 30 to completely open the air discharge port 11 (step S16). Thereafter, the fan stop unit 44 stops the fan 3 (step S17). In step S17, the forced exhaust by the fan 3 is completely switched to the natural exhaust by the chimney effect. After step S17, the high-temperature air in the server room 1 is exhausted by the natural circulation of the air in the duct 10 by the chimney effect. As a result, the inside of the server room 1 is cooled, so that the room temperature of the server room 1 is maintained constant.

The cooling system operates in the above procedure.

[0030]

The operation procedure of the server cooling system 100 can be changed as appropriate. For example, step S12 and step S13 may be performed simultaneously. In addition, step S16 and step S17 may be performed simultaneously.

[0031]

(Action and Effect)

In the present embodiment, the server cooling system 100 includes the duct 10, the exhaust introduction section 20, the fan 3, and the control device 40. The duct 10 has a cylindrical shape extending in the vertical direction D_v . The air discharge port 11 is formed at the upper portion of the duct 10. The exhaust introduction section 20 is provided in a portion below the air discharge port 11 in the duct 10. The exhaust introduction section 20 introduces exhaust air from the server room 1. The fan 3 is provided in the duct 10. The fan 3 is rotationally driven so that air is discharged from

the air discharge port 11. The control device 40 includes the fan operation unit 43 and the fan stop unit 44. The fan operation unit 43 rotates the fan 3 from a stopped state when the exhaust air from the server room 1 is introduced into the duct 10. The fan stop unit 44 stops the fan 3 when the natural circulation condition is satisfied after the fan 3
5 has rotated.

[0032]

With the above configuration, when the high-temperature exhaust air from the server room 1 is introduced into the duct 10, the control device 40 rotates the fan 3 that is in a stopped state. As a result, for a while after the start of exhaust, the air in the server
10 room 1 is forcibly exhausted by a blowing force of the fan 3.

The high-temperature exhaust air from the server room 1 is supplied into the duct 10, so that the temperature inside the duct 10 becomes higher than the temperature outside the duct 10. As a result, an upward flow occurs in the duct 10. The air in the server room 1 is drawn into the duct 10 by the upward flow. Such a phenomenon is
15 called a chimney effect. Immediately after the start of exhaust, the exhaust flow rate resulting from the chimney effect is small, but a large amount of the high-temperature exhaust air is forcibly supplied into the duct 10 by the fan 3. As a result, the temperature of the duct 10 rapidly rises, and the exhaust flow rate resulting from the chimney effect increases. Thereafter, the air is sufficiently exhausted from the server
20 room 1 only by the exhaust flow rate resulting from the chimney effect. A condition for such a state is referred to as a natural circulation condition. In the present aspect, when the natural circulation condition is satisfied, the control device 40 stops the fan 3. As a result, the high-temperature air in the server room 1 is sufficiently exhausted only by the chimney effect, so that the inside of the server room 1 is sufficiently cooled. Therefore,

according to the present embodiment, it is possible to ultimately ensure sufficient cooling performance by utilizing the natural circulation of the air through the chimney effect.

[0033]

In the present embodiment, the server cooling system 100 further includes the temperature sensor 4 that detects the temperature inside the duct 10. The control device 40 includes the determination unit 42 that determines whether or not the natural circulation condition is satisfied. The determination unit 42 determines that the natural circulation condition is satisfied when the temperature detected by the temperature sensor 4 exceeds a predetermined threshold value.

[0034]

As a result, the determination unit 42 can determine whether or not the natural circulation condition is satisfied based on the temperature of the duct 10. Therefore, the control device 40 can accurately determine the natural circulation condition.

[0035]

Note that the temperature sensor 4 does not need to be provided. In this case, for example, the determination unit 42 may determine that the natural circulation condition is satisfied when a predetermined time has elapsed since the fan 3 starts rotating.

[0036]

In this case, the determination unit 42 can determine whether or not the natural circulation condition is satisfied based on the time elapsed after the fan 3 starts rotating. In order to determine the natural circulation condition, it is not necessary to provide another device, and the configuration of the server cooling system 100 can be simplified.

[0037]

In the present embodiment, the server cooling system 100 further includes the damper 30 that opens and closes the air discharge port 11. The duct 10 further includes the fan discharge port 12 provided separately from the air discharge port 11. The fan 3 is attached to the fan discharge port 12. The control device 40 further includes the damper closing unit 45 and the damper opening unit 46. The damper closing unit 45 operates the damper 30 to close the air discharge port 11 before the fan 3 starts rotating. The damper opening unit 46 operates the damper 30 to open the air discharge port 11 after the fan 3 has rotated.

[0038]

As a result, when the fan 3 rotates, the server cooling system 100 can discharge the air in the duct 10 by using, as a main discharge port, the fan discharge port 12 where the fan 3 is installed. Therefore, the server cooling system 100 can efficiently exhaust air using the fan 3.

In addition, after the exhaust flow rate resulting from the chimney effect is sufficiently increased, the fan 3 is stopped, and the air discharge port 11 is opened to discharge the air in the duct 10 from both the fan discharge port 12 and the air discharge port 11. Therefore, when the fan 3 is stopped, the server cooling system 100 can increase an opening area of the discharge port and increase the exhaust flow rate.

Therefore, according to the present embodiment, the server cooling system 100 can efficiently exhaust the air in the duct 10 according to the timing, and the cooling efficiency of the server cooling system 100 is further improved.

[0039]

In the present embodiment, the duct 10 includes the first cylindrical portion 10a that extends in the vertical direction D_v , and the second cylindrical portion 10b that is provided at an upper end of the first cylindrical portion 10a and communicates with the

first cylindrical portion 10a. The second cylindrical portion 10b extends such that the second cylindrical portion 10b gradually moves away from the side wall 1a in a horizontal direction as it goes upward. The second cylindrical portion 10b has the air discharge port 11 at an end portion opposite to the first cylindrical portion 10a. The
5 second cylindrical portion 10b is curved such that the air discharge port 11 faces slightly downward.

As a result, rainwater or the like is prevented from entering the duct 10 through the air discharge port 11.

[0040]

10 <Second Embodiment>

(Configuration of Server Cooling System)

Hereinafter, a server cooling system 200 according to a second embodiment of the present disclosure will be described with reference to FIGS. 6 to 8. The same configurations as those of the above-described embodiment are denoted by the same
15 names and the same reference signs, and the description thereof will be omitted as appropriate. In FIG. 6, in addition to the flow of air, the flow of a circulating refrigerant R, which will be described below, is shown by an arrow.

[0041]

In the present embodiment, the server room 1 is formed with an exhaust port 1c
20 in addition to the intake port 1b. The exhaust port 1c exhausts the high-temperature air in the server room 1 to the outside of the server room 1.

[0042]

In addition, the duct 10 includes an air introduction port 13 formed at a lower portion in addition to the air discharge port 11 formed at an upper portion. The air
25 introduction port 13 is provided at a lower end of the first cylindrical portion 10a of the

duct 10. The air introduction port 13 penetrates the first cylindrical portion 10a in the vertical direction Dv. The air introduction port 13 supplies outside air into the duct 10. The air introduced into the duct 10 through the air introduction port 13 is discharged to the outside of the duct 10 through the air discharge port 11.

5 [0043]

(Refrigerant Introduction Section)

In addition, the server cooling system 200 includes a refrigerant introduction section 50 instead of the exhaust introduction section 20. The refrigerant introduction section 50 introduces the circulating refrigerant R from the server room 1 to a space
10 between the air introduction port 13 and the air discharge port 11 in the vertical direction Dv. The circulating refrigerant R absorbs heat within the server room 1 and is then supplied into the duct 10. The circulating refrigerant R is supplied into the duct 10, for example, after directly performing heat exchange with the server 2.

[0044]

15 The refrigerant introduction section 50 includes a heat exchange unit 51, a refrigerant supply pipe 52, and a refrigerant discharge pipe 53.

The heat exchange unit 51 is disposed in the duct 10 to perform heat exchange between the circulating refrigerant R and the air in the duct 10. In the present embodiment, the heat exchange unit 51 is disposed in the first cylindrical portion 10a of
20 the duct 10.

[0045]

The refrigerant supply pipe 52 extends in the horizontal direction from the server room 1 and is connected to the heat exchange unit 51. The refrigerant supply pipe 52 penetrates the side wall 1a of the server room 1 and the first cylindrical portion

10a of the duct 10. The refrigerant supply pipe 52 supplies the circulating refrigerant R that has absorbed the heat of the server room 1 to the heat exchange unit 51.

The refrigerant discharge pipe 53 extends in the horizontal direction from the heat exchange unit 51 and extends into the server room 1. The refrigerant discharge
5 pipe 53 penetrates the side wall 1a of the server room 1 and the first cylindrical portion 10a of the duct 10. The refrigerant discharge pipe 53 returns the circulating refrigerant R, which has been cooled by heat exchange with the air in the server 2 in the heat exchange unit 51, into the server room 1. The circulating refrigerant R returned into the server room 1 from the refrigerant discharge pipe 53 absorbs heat again within the server
10 room 1, and is then supplied to the heat exchange unit 51 through the refrigerant supply pipe 52.

[0046]

(Control Device)

As shown in FIG. 7, the control device 40 further includes a refrigerant
15 operation unit 47 as a functional unit.

The refrigerant operation unit 47 operates the refrigerant introduction section 50 to introduce the circulating refrigerant R into the duct 10.

In addition, the fan operation unit 43 of the present embodiment rotates the fan 3 from a stopped state when the circulating refrigerant R is introduced into the duct 10.

20 [0047]

(Operation of Server Cooling System)

Subsequently, an operation procedure of the server cooling system 200 will be described with reference to the flow in FIG. 8.

When the server 2 is operated, a room temperature of the server room 1 rises due
25 to heat of the server 2. The acquisition unit 41 acquires information indicating that the

server 2 is operated (step S21). Immediately after step S21, the refrigerant operation unit 47 operates the refrigerant introduction section 50 to introduce the circulating refrigerant R into the duct 10 (step S22). Immediately thereafter, or after a predetermined time has elapsed, the damper closing unit 45 operates the damper 30 to

5 close the air discharge port 11 (step S23). Immediately thereafter, the fan operation unit 43 rotates the fan 3 that is in a stopped state (step S24). Due to the rotation of the fan 3, the outside air is introduced into the duct 10 from the air introduction port 13. The air introduced into the duct 10 is discharged from the fan discharge port 12. As described above, immediately after the server 2 is operated, the air in the duct 10 is forcibly

10 exhausted by the fan 3. The outside air introduced into the duct 10 cools the circulating refrigerant R introduced into the duct 10 by the refrigerant introduction section 50. The circulating refrigerant R cooled in the duct 10 is returned to the server room 1.

[0048]

The heat transferred from the circulating refrigerant R increases the exhaust flow

15 rate sent from the server room 1 to the duct 10, causing the temperature inside the duct 10 to rise. When the temperature inside the duct 10 rises, an upward flow due to thermal convection occurs in the duct 10, and the exhaust flow rate of the duct 10 increases (chimney effect).

[0049]

20 In the present embodiment as well, the exhaust flow rate by the fan 3 is controlled while the temperature inside the duct 10 is monitored.

When a predetermined time has elapsed from the start of the rotation of the fan 3, the rotation speed of the fan 3 is reduced. As a result, the exhaust flow rate of the fan 3 gradually decreases. In addition, as the temperature rises, the damper opening unit 46

25 operates the damper 30 to gradually increase an opening degree of the air discharge port

11 (step S25). As a result, the exhaust flow rate resulting from the chimney effect gradually increases. In this way, the forced exhaust by the fan 3 and the natural exhaust by the chimney effect are used in combination, and the proportion of the natural exhaust by the chimney effect increases over time.

5 [0050]

Thereafter, the determination unit 42 determines whether or not the natural circulation condition is satisfied in which air of a volume sufficient to cool the server 2 can naturally circulate within the duct 10 only by the chimney effect (step S26). In the present embodiment as well, as in the first embodiment, the determination unit 42

10 determines that the natural circulation condition is satisfied when the temperature detected by the temperature sensor 4 exceeds a predetermined threshold value.

[0051]

When the natural condition is satisfied (step S26; YES), the damper opening unit 46 operates the damper 30 to completely open the air discharge port 11 (step S27).

15 Thereafter, the fan stop unit 44 stops the fan 3 (step S28). In step S28, the forced exhaust by the fan 3 is completely switched to the natural exhaust by the chimney effect. After step S28, fresh air continues to be supplied into the duct 10 by the natural circulation of the air in the duct 10 by the chimney effect. As a result, the circulating refrigerant that has absorbed the heat of the server room 1 is sufficiently cooled in the

20 duct 10. The circulating refrigerant R cooled in the duct 10 is returned to the server room 1 to cool the server room 1. As a result, the room temperature of the server room 1 is maintained constant.

The cooling system operates in the above procedure.

[0052]

The operation procedure of the server cooling system 200 can be changed as appropriate. For example, step S23 and step S24 may be performed simultaneously. In addition, step S27 and step S28 may be performed simultaneously.

[0053]

5 (Action and Effect)

In the present embodiment, the server cooling system 200 includes the duct 10, the refrigerant introduction section 50, the fan 3, and the control device 40. The duct 10 has a cylindrical shape extending in the vertical direction Dv. The air introduction port 13 is formed at the lower portion of the duct 10, and the air discharge port 11 is formed at
10 the upper portion of the duct 10. The refrigerant introduction section 50 introduces the circulating refrigerant R from the server room 1 to a space between the air introduction port 13 and the air discharge port 11 in the duct 10. The refrigerant introduction section 50 includes the heat exchange unit 51 that is disposed in the duct 10 to perform heat exchange between the circulating refrigerant R and the air in the duct 10. The fan 3 is
15 provided in the duct 10. The fan 3 is rotationally driven so that air is discharged from the air discharge port 11. The control device 40 includes the fan operation unit 43 and the fan stop unit 44. The fan operation unit 43 rotates the fan 3 from a stopped state when the circulating refrigerant R is introduced into the duct 10. The fan stop unit 44 stops the fan 3 when the natural circulation condition is satisfied after the fan 3 has
20 rotated.

[0054]

With the above configuration, when the high-temperature circulating refrigerant from the server room 1 is introduced into the duct 10, the control device 40 rotates the fan 3 that is in a stopped state. As a result, for a while after the start of exhaust, the air
25 in the duct 10 can be forcibly exhausted by the air blowing force of the fan 3.

The circulating refrigerant R is supplied into the duct 10 after recovering heat from within the server room 1. The refrigerant supplied into the duct 10 supplies heat to the air in the duct 10 through the heat exchange unit 51. Due to this heat, the air in the duct 10 is heated, and the temperature inside the duct 10 becomes higher than the temperature outside the duct 10. As a result, an upward flow occurs in the duct 10. Due to this upward flow, the air in the server room 1 is drawn into the duct 10 (chimney effect). Immediately after the start of exhaust, the exhaust flow rate resulting from the chimney effect is small, but the heat of the circulating refrigerant R heats the inside of the duct 10, causing the temperature of the duct 10 to rise rapidly. As a result, the exhaust flow rate resulting from the chimney effect increases. Thereafter, the air is sufficiently exhausted from the duct 10 only by the exhaust flow rate resulting from the chimney effect, and the natural circulation condition is satisfied. In the present embodiment, when the natural circulation condition is satisfied, the control device 40 stops the fan 3. As a result, the air in the duct 10 is sufficiently exhausted only by the chimney effect. Therefore, the heat exchange between the circulating refrigerant R and the air is efficiently performed, and the inside of the server room 1 can be sufficiently cooled by the air flowing through the duct 10 via the circulating refrigerant R.

Therefore, according to the present embodiment, it is possible to ultimately ensure sufficient cooling performance by utilizing the natural circulation of the air through the chimney effect.

[0055]

In addition, as shown in FIG. 9, the refrigerant introduction section 50 may further include fins 57 provided on an outer surface of the heat exchange unit 51. Specifically, the refrigerant introduction section 50 includes a supply-side header 54, a discharge-side header 55, a connection pipe 56, and the fins 57.

[0056]

The supply-side header 54 is connected to the refrigerant supply pipe 52. The circulating refrigerant is supplied to the supply-side header 54.

The discharge-side header 55 is connected to the refrigerant discharge pipe 53.

- 5 The discharge-side header 55 discharges the circulating refrigerant R, which has been cooled by heat exchange with the air in the duct 10 in the heat exchange unit 51, to the refrigerant discharge pipe 53.

[0057]

- 10 The connection pipe 56 connects the supply-side header 54 and the discharge-side header 55. A plurality of the connection pipes 56 are provided.

The fins 57 are attached to protrude from an outer peripheral surface of the connection pipe 56. The fins 57 are formed in a plate shape. A plurality of the fins 57 are provided. Each fin 57 is attached such that the plurality of connection pipes 56 pass therethrough.

- 15 [0058]

As described above, in the present modification example, the refrigerant introduction section 50 further includes the fins 57 provided on the outer surface of the heat exchange unit 51.

[0059]

- 20 As a result, the fins 57 increase a surface area of the heat exchange unit 51. Accordingly, the heat exchange efficiency of the heat exchange unit 51 is improved. Therefore, the cooling performance of the server cooling system 100 is further improved.

[0060]

- 25 In addition, in the present embodiment as well, as in the first embodiment, the temperature sensor 4 does not need to be provided. In this case, the determination unit

42 may determine that the natural circulation condition is satisfied when a predetermined time has elapsed since the fan 3 starts rotating.

[0061]

<Third Embodiment>

5 (Configuration of Server Cooling System)

Hereinafter, a server cooling system 300 according to a third embodiment of the present disclosure will be described with reference to FIGS. 10 and 11. The same configurations as those of the above-described embodiment are denoted by the same names and the same reference signs, and the description thereof will be omitted as appropriate. In FIG. 10, in addition to the flow of air, the flow of a circulating refrigerant R, which will be described below, is shown by an arrow.

[0062]

In the present embodiment, as shown in FIG. 10, the lower end portion of the first cylindrical portion 10a of the duct 10 is closed, as in the first embodiment.

15 In addition, the server cooling system 300 of the present embodiment includes the exhaust introduction section 20 of the first embodiment and the refrigerant introduction section 50 of the second embodiment.

The refrigerant introduction section 50 is provided below the exhaust introduction section 20. As in the second embodiment, the refrigerant introduction section 50 supplies the circulating refrigerant R that has absorbed the heat of the server room 1 into the duct 10, and performs heat exchange with the air in the duct 10 in the heat exchange unit 51.

[0063]

The circulating refrigerant R supplied into the duct 10 is cooled as its heat is absorbed by the air in the duct 10. Thereafter, the circulating refrigerant R is returned to the server room 1 again.

In a case where the circulating refrigerant R is not sufficiently cooled in the duct 10, the refrigerant discharge pipe 53 may be connected to a separate heat exchanger (not shown) such as a chiller to further cool the circulating refrigerant R.

[0064]

The fan operation unit 43 of the present embodiment rotates the fan 3 from a stopped state when the exhaust air from the server room 1 is introduced into the duct 10 and the circulating refrigerant R is introduced into the duct 10.

[0065]

(Operation of Server Cooling System)

Subsequently, an operation procedure of the server cooling system 300 will be described with reference to the flow in FIG. 11.

When the server 2 is operated, a room temperature of the server room 1 rises due to heat of the server 2. Then, the high-temperature exhaust air is introduced into the duct 10 from the server room 1. The acquisition unit 41 acquires information indicating that the server 2 is operated (step S31). Immediately after step S31, the refrigerant operation unit 47 operates the refrigerant introduction section 50 to introduce the circulating refrigerant into the duct 10 (step S32). Immediately thereafter, or after a predetermined time has elapsed, the damper closing unit 45 operates the damper 30 to close the air discharge port 11 (step S33). Immediately thereafter, the fan operation unit 43 rotates the fan 3 that is in a stopped state (step S34). Due to the rotation of the fan 3, the high-temperature air in the server room 1 is introduced into the duct 10. The high-temperature exhaust air introduced into the duct 10 is exhausted to the outside of the

server room 1 through the fan discharge port 12. As described above, immediately after the server 2 is operated, the high-temperature air in the server room 1 is forcibly exhausted by the fan 3.

[0066]

5 In the present embodiment as well, the exhaust flow rate by the fan 3 is controlled while the temperature inside the duct 10 is monitored. When the rotation of the fan 3 is started, the exhaust flow rate sent from the server room 1 to the duct 10 increases, causing the temperature in the duct 10 to rise.

In addition, the circulating refrigerant R that has absorbed the heat of the server room 1 is supplied into the duct 10. The air in the duct 10 is heated by the circulating refrigerant R from the server room 1, and the temperature in the duct 10 further rises.

[0067]

When the temperature in the duct 10 rises, an upward flow due to thermal convection occurs in the duct 10, and the exhaust flow rate of the duct 10 increases (chimney effect).

[0068]

When a predetermined time has elapsed from the start of the rotation of the fan 3, the rotation speed of the fan 3 is reduced. As a result, the exhaust flow rate of the fan 3 gradually decreases. In addition, as the temperature rises, the damper opening unit 46 operates the damper 30 to gradually increase an opening degree of the air discharge port 11 (step S35). As a result, the exhaust flow rate resulting from the chimney effect gradually increases. In this way, the forced exhaust by the fan 3 and the natural exhaust by the chimney effect are used in combination, and the proportion of the natural exhaust by the chimney effect increases over time.

25 [0069]

When a predetermined time has elapsed from the start of the rotation of the fan 3, the rotation speed of the fan 3 is reduced. As a result, the exhaust flow rate of the fan 3 gradually decreases. In addition, as the temperature rises, the damper opening unit 46 operates the damper 30 to gradually increase an opening degree of the air discharge port 11 (step S35). As a result, the exhaust flow rate resulting from the chimney effect gradually increases. In this way, the forced exhaust by the fan 3 and the natural exhaust by the chimney effect are used in combination, and the proportion of the natural exhaust by the chimney effect increases over time.

[0070]

10 Thereafter, the determination unit 42 determines whether or not the natural circulation condition is satisfied in which air of a volume sufficient to cool the server 2 can naturally circulate within the duct 10 only by the chimney effect (step S37). In the present embodiment as well, as in the first embodiment, the determination unit 42 determines that the natural circulation condition is satisfied when the temperature
15 detected by the temperature sensor 4 exceeds a predetermined threshold value.

[0071]

When the natural condition is satisfied (step S37; YES), the damper opening unit 46 operates the damper 30 to completely open the air discharge port 11 (step S37). Thereafter, the fan stop unit 44 stops the fan 3 (step S38). In step S38, the forced
20 exhaust by the fan 3 is completely switched to the natural exhaust by the chimney effect. After step S38, the high-temperature air in the server room 1 is exhausted by the natural circulation of the air in the duct 10 by the chimney effect. As a result, the inside of the server room 1 is cooled, so that the room temperature of the server room 1 is maintained constant.

25 The cooling system operates in the above procedure.

[0072]

The operation procedure of the server cooling system 300 can be changed as appropriate. For example, step S33 and step S34 may be performed simultaneously. In addition, step S37 and step S38 may be performed simultaneously.

5 [0073]

(Action and Effect)

In the present embodiment, the server cooling system 300 further includes the refrigerant introduction section 50. The refrigerant introduction section 50 introduces the circulating refrigerant R from the server room 1 to a space below the air discharge
10 port 11 in the duct 10. The refrigerant introduction section 50 includes the heat exchange unit 51. The heat exchange unit 51 is disposed in the duct 10 to perform heat exchange between the circulating refrigerant R and the air in the duct 10. The fan operation unit 43 rotates the fan 3 from a stopped state when the exhaust air from the server room 1 is introduced into the duct 10 and the circulating refrigerant R is
15 introduced into the duct 10.

[0074]

As a result, the circulating refrigerant R is supplied into the duct 10 after recovering heat from within the server room 1. The circulating refrigerant R supplied into the duct 10 supplies heat to the air in the duct 10 through the heat exchange unit 51.
20 Due to this heat, the air in the duct 10 is further heated, and the exhaust flow rate resulting from the chimney effect increases. Therefore, it is possible to exhaust a larger amount of high-temperature air from inside the duct 10, and the cooling performance is further improved.

[0075]

In addition, as shown in FIG. 12, the server cooling system 300 may further include a first earthquake-resistant member 6 and a second earthquake-resistant member 7.

[0076]

5 The first earthquake-resistant member 6 is provided at a connection portion between the exhaust introduction section 20 and the side wall 1a of the server room 1. The first earthquake-resistant member 6 is, for example, a rubber damper mounted on an outer peripheral surface of the exhaust introduction section 20. Contraction of the first earthquake-resistant member 6 enables absorption of vibrations transmitted to the duct 10 via the side wall 1a.

[0077]

 The second earthquake-resistant member 7 is provided at a connection portion between the refrigerant introduction section 50 and the side wall 1a of the server room 1. The second earthquake-resistant member 7 is, for example, a rubber damper mounted on
15 an outer peripheral surface of the refrigerant supply pipe 52 and an outer peripheral surface of the refrigerant discharge pipe 53. Contraction of the second earthquake-resistant member 7 enables absorption of vibrations transmitted to the duct 10 via the side wall 1a.

 As described above, even in a case where the duct 10 is provided to be spaced
20 apart from the side wall 1a of the server room 1, the first earthquake-resistant member 6 and the second earthquake-resistant member 7 can absorb the vibrations of the duct 10, thereby ensuring the earthquake resistance of the duct 10.

 The first earthquake-resistant member 6 and the second earthquake-resistant member 7 are not limited to the rubber damper. For example, the first earthquake-

resistant member 6 and the second earthquake-resistant member 7 may have a bellows structure to absorb vibrations.

[0078]

The first earthquake-resistant member 6 described above can be applied to the server cooling system 100 of the first embodiment. In addition, the second earthquake-resistant member 7 can be applied to the server cooling system 200 of the second embodiment.

[0079]

In addition, in the present embodiment as well, as in the first embodiment, the temperature sensor 4 does not need to be provided. In this case, the determination unit 42 may determine that the natural circulation condition is satisfied when a predetermined time has elapsed since the fan 3 starts rotating.

[0080]

In addition, in the present embodiment as well, as in the second embodiment, the heat exchange unit 51 of the refrigerant introduction section 50 may have the fins 57 on the outer peripheral surface. That is, the heat exchange unit 51 may have the supply-side header 54, the discharge-side header 55, the connection pipe 56, and the fins 57.

[0081]

(Other Embodiments)

The embodiments of the present disclosure have been described in detail with reference to the accompanying drawings, but the specific configuration is not limited to the embodiments, and design changes and the like are also included within the scope that does not deviate from the gist of the present disclosure.

[0082]

For example, as shown in FIG. 13, the server cooling system 100 may further include a heat insulating material 8. The heat insulating material 8 is provided on a side surface 10c of an outer peripheral surface of the duct 10, the side surface 10c facing a side opposite to the side wall 1a of the server room 1.

5 [0083]

The heat insulating material 8 suppresses heat dissipation of the air in the duct 10 to the outside of the duct 10. As a result, a decrease in temperature of the air in the duct 10 is suppressed. Therefore, according to the present embodiment, the server cooling system 100 can suppress a decrease in the exhaust flow rate resulting from the chimney effect.

[0084]

The installation location of the heat insulating material 8 can be changed as appropriate. For example, the heat insulating material 8 may be provided on the entire outer peripheral surface of the first cylindrical portion 10a of the duct 10. In addition, the heat insulating material 8 may be provided on an inner surface of the duct 10.

15 [0085]

In addition, for example, as shown in FIG. 14, the server cooling system 100 may further include a heating mechanism 60. The heating mechanism 60 is provided on the side surface 10c of the outer peripheral surface of the duct 10, the side surface 10c facing the side opposite to the side wall 1a of the server room 1. The heating mechanism 60 heats the air in the duct 10. The heating mechanism 60 is, for example, an absorber 61 that absorbs sunlight.

20 [0086]

The heating mechanism 60 heats the air in the duct 10. As a result, a decrease in temperature of the air in the duct 10 is suppressed. Therefore, according to the

25

present embodiment, the server cooling system 100 can suppress a decrease in the exhaust flow rate resulting from the chimney effect.

In addition, the heating mechanism 60 of the present modification example is the absorber 61 that absorbs sunlight. Therefore, the air in the duct 10 can be heated by the energy of sunlight.

[0087]

In addition, as shown in FIG. 15, the side surface 10c of the duct 10 on which the absorber 61 is installed is curved. As a result, a surface area of the absorber 61 can be increased as compared with a case where the side surface 10c is a flat surface.

Therefore, the absorber 61 can absorb a larger amount of sunlight.

[0088]

The installation location of the absorber 61 can be changed as appropriate. For example, the absorber 61 may be provided on the entire outer peripheral surface of the first cylindrical portion 10a of the duct 10.

In addition, instead of the absorber 61, a heater may be provided as the heating mechanism 60. In addition, the heater may be installed within the duct 10, for example.

[0089]

In addition, for example, as shown in FIG. 16, the server cooling system 100 may further include a solar panel 9. The solar panel 9 is provided on the side surface 10c of an outer peripheral surface of the duct 10, the side surface 10c facing the side opposite to the side wall 1a of the server room 1. The solar panel 9 converts sunlight emitted from outside the duct 10 into electric power and supplies the electric power to the fan 3.

[0090]

As a result, the server cooling system 100 can cover at least a portion of the electric power required for the operation of the fan 3 by solar power generation.

[0091]

In addition, the side surface 10c of the duct 10 on which the solar panel 9 is
5 installed may be curved as shown in FIG. 15. In this case, since a surface area of the solar panel 9 increases, the amount of power generated by the solar panel 9 can be increased.

In addition, the installation location of the solar panel 9 can be changed as appropriate. For example, the solar panel 9 may be provided on the entire outer
10 peripheral surface of the first cylindrical portion 10a of the duct 10.

[0092]

The heat insulating material 8, the heating mechanism 60, and the solar panel 9 described above can be applied not only to the server cooling system 100 of the first embodiment but also to the server cooling systems 200 and 300 of the second and third
15 embodiments.

[0093]

In each of the above-described embodiments, a case where the server cooling systems 100, 200, and 300 include the damper 30 has been described, but the present disclosure is not limited to this. The server cooling systems 100, 200, and 300 do not
20 need to include the damper 30.

[0094]

(Hardware Configuration)

The control device 40 in each of the above-described embodiments and the above-described modification examples is mounted on a computer 1100 shown in FIG.

17. The computer 1100 includes a processor 1110, a main memory 1120, a storage 1130, and an interface 1140.

[0095]

The operation of each of the above-described processing units of the control device 40 is stored in the storage 1130 in the form of a program. The processor 1110 reads the program from the storage 1130, loads the program into the main memory 1120, and executes the above-described processing in accordance with the program. In addition, the processor 1110 allocates a storage area corresponding to the above-described storage unit in the main memory 1120 in accordance with the program.

10 [0096]

The program may be a program for realizing some of the functions to be exhibited by the computer 1100. For example, the program may exhibit a function in combination with another program already stored in the storage 1130 or in combination with another program mounted on another device. In addition, the computer 1100 may include a custom large scale integrated circuit (LSI) such as a programmable logic device (PLD) in addition to or instead of the above-described configuration. Examples of the PLD include a programmable array logic (PAL), a generic array logic (GAL), a complex programmable logic device (CPLD), and a field programmable gate array (FPGA). In this case, some or all of the functions realized by the processor 1110 may be realized by the integrated circuit.

20

[0097]

Examples of the storage 1130 include a magnetic disk, a magneto-optical disk, and a semiconductor memory. The storage 1130 may be an internal medium directly connected to a bus of the computer 1100, or may be an external medium connected to the computer 1100 via the interface 1140 or a communication line. In addition, when this

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program is distributed to the computer 1100 via a communication line, the computer 1100 that has received the distribution may load the program into the main memory 1120 and execute the above-described processing. The storage 1130 may be a non-transitory tangible storage medium.

5 [0098]

In addition, the program may be a program for realizing some of the above-described functions. Further, the program may be a so-called differential file (differential program) that realizes the above-described functions in combination with another program already stored in the storage 1130.

10 [0099]

<Additional Notes>

The server cooling systems 100, 200, and 300 described in the respective embodiments are understood as follows, for example.

[0100]

15 (1) A server cooling system 100, 300 according to a first aspect includes a duct 10 that has a cylindrical shape extending in a vertical direction D_v and has an air discharge port 11 formed at an upper portion; an exhaust introduction section 20 configured to introduce exhaust air from a server room 1 into a portion below the air discharge port 11 in the duct 10; a fan 3 that is provided in the duct 10 and is rotationally
20 driven so that air is discharged from the air discharge port 11; and a control device 40, in which the control device 40 includes a fan operation unit 43 configured to rotate the fan 3 from a stopped state when the exhaust air is introduced into the duct 10, and a fan stop unit 44 configured to stop the fan 3 when a natural circulation condition is satisfied after the fan 3 has rotated.

25 [0101]

With the above configuration, when the high-temperature exhaust air from the server room 1 is introduced into the duct 10, the control device 40 rotates the fan 3 that is in a stopped state.

The high-temperature exhaust air from the server room 1 is supplied into the duct 10, so that the temperature inside the duct 10 becomes higher than the temperature outside the duct 10. As a result, an upward flow occurs in the duct 10. The air in the server room 1 is drawn into the duct 10 by the upward flow. Such a phenomenon is called a chimney effect. Immediately after the start of exhaust, the exhaust flow rate resulting from the chimney effect is small, but a large amount of the high-temperature exhaust air is forcibly supplied into the duct 10 by the fan 3. As a result, the temperature of the duct 10 rapidly rises, and the exhaust flow rate resulting from the chimney effect increases. Thereafter, the air is sufficiently exhausted from the server room 1 only by the exhaust flow rate resulting from the chimney effect. A condition for such a state is referred to as a natural circulation condition. In the present aspect, when the natural circulation condition is satisfied, the control device 40 stops the fan 3. As a result, the high-temperature air in the server room 1 is sufficiently exhausted only by the chimney effect, and the server room 1 is sufficiently cooled.

[0102]

(2) A cooling system 100, 300 according to a second aspect is the server cooling system 100, 300 according to the first aspect, in which may further include: a first earthquake-resistant member 6 that is provided at a connection portion between the exhaust introduction section 20 and the server room 1 and is capable of absorbing vibration.

[0103]

As a result, for example, when an earthquake occurs, the first earthquake-resistant member 6 can absorb vibrations transmitted to the duct 10.

[0104]

(3) A server cooling system 300 according to a third aspect is the server cooling
5 system 300 according to the first or second aspect, in which may further include: a
refrigerant introduction section 50 configured to introduce a circulating refrigerant R
from the server room 1 into a space below the air discharge port 11 in the duct 10, in
which the refrigerant introduction section 50 may include a heat exchange unit 51
disposed in the duct 10 to perform heat exchange between the circulating refrigerant R
10 and air in the duct 10, and the fan operation unit 43 may rotate the fan 3 from a stopped
state when the exhaust air is introduced into the duct 10 and the circulating refrigerant R
is introduced into the duct 10.

[0105]

As a result, the circulating refrigerant R is supplied into the duct 10 after
15 recovering heat from within the server room 1. The circulating refrigerant R supplied
into the duct 10 supplies heat to the air in the duct 10 through the heat exchange unit 51.
Due to this heat, the air in the duct 10 is further heated, and the exhaust flow rate
resulting from the chimney effect increases.

[0106]

20 (4) A server cooling system 200 according to a fourth aspect includes: a duct 10
that has a cylindrical shape extending in a vertical direction D_v and has an air
introduction port 13 formed at a lower portion and an air discharge port 11 formed at an
upper portion; a refrigerant introduction section 50 configured to introduce a circulating
refrigerant R from a server room 1 into a space between the air introduction port 13 and
25 the air discharge port 11 in the duct 10; a fan 3 that is provided in the duct 10 and is

rotationally driven so that air is discharged from the air discharge port 11; and a control device 40, in which the refrigerant introduction section 50 includes a heat exchange unit 51 disposed in the duct 10 to perform heat exchange between the circulating refrigerant R and air in the duct 10, and the control device 40 includes a fan operation unit 43
 5 configured to rotate the fan 3 from a stopped state when the circulating refrigerant R is introduced into the duct 10, and a fan stop unit 44 configured to stop the fan 3 when a natural circulation condition is satisfied after the fan 3 has rotated.

[0107]

With the above configuration, when the high-temperature circulating refrigerant
 10 from the server room 1 is introduced into the duct 10, the control device 40 rotates the fan 3 that is in a stopped state.

The circulating refrigerant R is supplied into the duct 10 after recovering heat from within the server room 1. The refrigerant supplied into the duct 10 supplies heat to the air in the duct 10 through the heat exchange unit 51. Due to this heat, the air in the
 15 duct 10 is heated, and the temperature inside the duct 10 becomes higher than that of the outside of the duct 10. As a result, an upward flow occurs in the duct 10. Due to this upward flow, the air in the server room 1 is drawn into the duct 10 (chimney effect). Immediately after the start of exhaust, the exhaust flow rate resulting from the chimney effect is small, but the heat of the circulating refrigerant R heats the inside of the duct 10,
 20 causing the temperature of the duct 10 to rise rapidly. As a result, the exhaust flow rate resulting from the chimney effect increases. Thereafter, the air is sufficiently exhausted from the duct 10 only by the exhaust flow rate resulting from the chimney effect, and the natural circulation condition is satisfied. In the present aspect, when the natural circulation condition is satisfied, the control device 40 stops the fan 3. As a result, the
 25 air in the duct 10 is sufficiently exhausted only by the chimney effect. Therefore, the

heat exchange between the circulating refrigerant R and the air is efficiently performed, and the inside of the server room 1 can be sufficiently cooled by the air flowing through the duct 10 via the circulating refrigerant R.

[0108]

- 5 (5) A server cooling system 200, 300 according to a fifth aspect is the server cooling system 200, 300 according to the third or fourth aspect, in which the refrigerant introduction section 50 may further include fins 57 that are provided on an outer surface of the heat exchange unit 51.

[0109]

- 10 As a result, the fins 57 increase a surface area of the heat exchange unit 51. Therefore, the heat exchange efficiency of the heat exchange unit 51 is improved.

[0110]

- (6) A server cooling system 200, 300 according to a sixth aspect is the server cooling system 200, 300 according to any one of the third to fifth aspects, in which may
15 further include: a second earthquake-resistant member 7 that is provided at a connection portion between the refrigerant introduction section 50 and the server room 1 and is capable of absorbing vibration.

[0111]

- As a result, for example, when an earthquake occurs, the second earthquake-
20 resistant member 7 can absorb vibrations transmitted to the duct 10.

[0112]

- (7) A server cooling system 100, 200, 300 according to a seventh aspect is the server cooling system 100, 200, 300 according to any one of the first to sixth aspects, in which may further include: a temperature sensor 4 configured to detect a temperature
25 inside the duct 10, in which the control device 40 may include a determination unit 42

configured to determine whether or not the natural circulation condition is satisfied, and the determination unit 42 may determine that the natural circulation condition is satisfied when the temperature detected by the temperature sensor 4 exceeds a predetermined threshold value.

5 [0113]

As a result, the determination unit 42 can determine whether or not the natural circulation condition is satisfied based on the temperature of the duct 10.

[0114]

(8) A server cooling system 100, 200, 300 according to an eighth aspect is the
10 server cooling system 100, 200, 300 according to any one of the first to sixth aspects, in which the control device 40 may include a determination unit 42 configured to determine whether or not the natural circulation condition is satisfied, and the determination unit 42 may determine that the natural circulation condition is satisfied when a predetermined time has elapsed since the fan 3 started rotating.

15 [0115]

As a result, the determination unit 42 can determine whether or not the natural circulation condition is satisfied based on the time elapsed after the fan 3 starts rotating.

[0116]

(9) A server cooling system 100, 200, 300 according to a ninth aspect is the
20 server cooling system 100, 200, 300 according to any one of the first to eighth aspects, in which may further include: a damper 30 configured to open and close the air discharge port 11, in which the duct 10 may further include a fan discharge port 12 that is provided separately from the air discharge port 11 and to which the fan 3 is attached, and the control device 40 may further include a damper closing unit 45 configured to operate the
25 damper 30 to close the air discharge port 11 before the fan 3 starts rotating, and a damper

opening unit 46 configured to operate the damper 30 to open the air discharge port 11 after the fan 3 has rotated.

[0117]

As a result, when the fan 3 rotates, the server cooling system 100 can discharge
5 the air in the duct 10 by using, as a main discharge port, the fan discharge port 12 where the fan 3 is installed. Therefore, the server cooling system 100 can efficiently exhaust air using the fan 3.

In addition, after the exhaust flow rate resulting from the chimney effect is sufficiently increased, the fan 3 is stopped, and the air discharge port 11 is opened to
10 discharge the air in the duct 10 from both the fan discharge port 12 and the air discharge port 11. Therefore, when the fan 3 is stopped, the server cooling system 100 can increase an opening area of the discharge port and increase the exhaust flow rate.

[0118]

(10) A server cooling system 100, 200, 300 according to a tenth aspect is the
15 server cooling system 100, 200, 300 according to any one of the first to ninth aspects in which may further include: a heat insulating material 8 that is provided on the duct 10.

[0119]

The heat insulating material 8 suppresses heat dissipation of the air in the duct 10 to the outside of the duct 10. As a result, a decrease in temperature of the air in the
20 duct 10 is suppressed.

[0120]

(11) A server cooling system 100, 200, 300 according to an eleventh aspect is the server cooling system 100, 200, 300 according to any one of the first to tenth aspects, in which may further include: a heating mechanism 60 that is provided on the duct 10 and is
25 configured to heat air in the duct 10.

[0121]

The heating mechanism 60 heats the air in the duct 10. As a result, a decrease in temperature of the air in the duct 10 is suppressed.

[0122]

- 5 (12) A server cooling system 100, 200, 300 according to a twelfth aspect is the server cooling system 100, 200, 300 according to any one of the first to eleventh aspects, in which may further include: a solar panel 9 that is provided on the duct 10 and that is configured to convert sunlight emitted from outside the duct 10 into electric power, in which the solar panel 9 may supply the electric power to the fan 3.

10 [0123]

As a result, the server cooling system 100 can cover at least a portion of the electric power required for the operation of the fan 3 by solar power generation.

INDUSTRIAL APPLICABILITY

[0124]

- 15 According to the server cooling system of the present disclosure, it is possible to ensure sufficient cooling performance.

REFERENCE SIGNS LIST

[0125]

- | | |
|----|----------------------|
| | 1 Server room |
| 20 | 1a Side wall |
| | 1b Intake port |
| | 1c Exhaust port |
| | 2 Server |
| | 3 Fan |
| 25 | 4 Temperature sensor |

	5 Display unit
	6 First earthquake-resistant member
	7 Second earthquake-resistant member
	8 Heat insulating material
5	9 Solar panel
	10 Duct
	10a First cylindrical portion
	10b Second cylindrical portion
	10c Side surface
10	11 Air discharge port
	12 Fan discharge port
	13 Air introduction port
	20 Exhaust introduction section
	30 Damper
15	40 Control device
	41 Acquisition unit
	42 Determination unit
	43 Fan operation unit
	44 Fan stop unit
20	45 Damper closing unit
	46 Damper opening unit
	47 Refrigerant operation unit
	50 Refrigerant introduction section
	51 Heat exchange unit
25	52 Refrigerant supply pipe

	53 Refrigerant discharge pipe
	54 Supply-side header
	55 Discharge-side header
	56 Connection pipe
5	57 Fin
	60 Heating mechanism
	61 Absorber
	100 Server cooling system
	200 Server cooling system
10	300 Server cooling system
	1100 Computer
	1110 Processor
	1120 Main memory
	1130 Storage
15	1140 Interface
	Dv Vertical direction

CLAIMS

[Claim 1] A server cooling system comprising:

a duct that has a cylindrical shape extending in a vertical direction and has an air discharge port formed at an upper portion;

5 an exhaust introduction section configured to introduce exhaust air from a server room into a portion below the air discharge port in the duct;

a fan that is provided in the duct and is rotationally driven so that air is discharged from the air discharge port; and

a control device,

10 wherein the control device includes

a fan operation unit configured to rotate the fan from a stopped state when the exhaust air is introduced into the duct, and

a fan stop unit configured to stop the fan when a natural circulation condition is satisfied after the fan has rotated.

15 [Claim 2] The server cooling system according to Claim 1, further comprising:

a first earthquake-resistant member that is provided at a connection portion between the exhaust introduction section and the server room and is capable of absorbing vibration.

[Claim 3] The server cooling system according to Claim 1, further comprising:

20 a refrigerant introduction section configured to introduce a circulating refrigerant from the server room into a space below the air discharge port in the duct,

wherein the refrigerant introduction section includes a heat exchange unit disposed in the duct to perform heat exchange between the circulating refrigerant and air in the duct, and

the fan operation unit rotates the fan from a stopped state when the exhaust air is introduced into the duct and the circulating refrigerant is introduced into the duct.

[Claim 4] A server cooling system comprising:

a duct that has a cylindrical shape extending in a vertical direction and has an air
5 introduction port formed at a lower portion and an air discharge port formed at an upper portion;

a refrigerant introduction section configured to introduce a circulating refrigerant from a server room into a space between the air introduction port and the air discharge port in the duct;

10 a fan that is provided in the duct and is rotationally driven so that air is discharged from the air discharge port; and

a control device,

wherein the refrigerant introduction section includes a heat exchange unit disposed in the duct to perform heat exchange between the circulating refrigerant and air

15 in the duct, and

the control device includes

a fan operation unit configured to rotate the fan from a stopped state when the circulating refrigerant is introduced into the duct, and

a fan stop unit configured to stop the fan when a natural circulation condition is
20 satisfied after the fan has rotated.

[Claim 5] The server cooling system according to Claim 3 or 4,

wherein the refrigerant introduction section further includes fins that are provided on an outer surface of the heat exchange unit.

[Claim 6] The server cooling system according to Claim 3 or 4, further comprising:

a second earthquake-resistant member that is provided at a connection portion between the refrigerant introduction section and the server room and is capable of absorbing vibration.

[Claim 7] The server cooling system according to any one of Claims 1 to 4, further comprising:

a temperature sensor configured to detect a temperature inside the duct,
wherein the control device includes

a determination unit configured to determine whether or not the natural circulation condition is satisfied, and

10 the determination unit determines that the natural circulation condition is satisfied when the temperature detected by the temperature sensor exceeds a predetermined threshold value.

[Claim 8] The server cooling system according to any one of Claims 1 to 4,
wherein the control device includes

15 a determination unit configured to determine whether or not the natural circulation condition is satisfied, and

the determination unit determines that the natural circulation condition is satisfied when a predetermined time has elapsed since the fan started rotating.

[Claim 9] The server cooling system according to any one of Claims 1 to 4, further comprising:

a damper configured to open and close the air discharge port,

wherein the duct further includes a fan discharge port that is provided separately from the air discharge port and to which the fan is attached, and

the control device further includes

a damper closing unit configured to operate the damper to close the air discharge port before the fan starts rotating, and

a damper opening unit configured to operate the damper to open the air discharge port after the fan has rotated.

5 [Claim 10] The server cooling system according to any one of Claims 1 to 4, further comprising:

a heat insulating material that is provided on the duct.

[Claim 11] The server cooling system according to any one of Claims 1 to 4, further comprising:

10 a heating mechanism that is provided on the duct and is configured to heat air in the duct.

[Claim 12] The server cooling system according to any one of Claims 1 to 4, further comprising:

a solar panel that is provided on the duct and that is configured to convert
15 sunlight emitted from outside the duct into electric power,

wherein the solar panel supplies the electric power to the fan.