

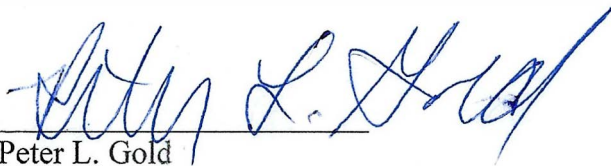
DECLARATION OF PETER L. GOLD

I, Peter L. Gold, pursuant to 28 U.S.C. § 1746, hereby declare as follows:

1. I am a freelance translator at TransPerfect, Inc.
2. I submit this declaration to certify the accuracy of the English translation of Ex 1007 - Verified Translation of JP2018041147A Fujitsu Tsuji.
3. My statements are based on personal knowledge and my review of Ex 1007 - Verified Translation of JP2018041147A Fujitsu Tsuji and its Japanese into English translation.
4. Ex 1007 - Verified Translation of JP2018041147A Fujitsu Tsuji Translation is a true and accurate translation of Ex 1006 - JP2018041147A Fujitsu Tsuji from Japanese into English.
5. All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. Further, I am aware that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001. I declare under penalty of perjury that the foregoing is true and correct.

* * *

Executed on 21 February 2025 at Washington, DC USA.


Peter L. Gold

[Title of the Invention] **ELECTRONIC DEVICE, COOLING FAN CONTROLLER, COOLING FAN CONTROL PROGRAM, AND COOLING FAN CONTROLLING METHOD**

[Abstract]

[Problem] To provide an electronic device capable of assigning an address associated with a position of each fan unit to each fan unit even when the fan unit is swapped.

[Solution] An electronic device includes an electronic apparatus, and a plurality of serially-connected fan units that cools the electronic apparatus. Each fan unit includes a controlling unit that assigns to its own fan unit an address that identifies its own fan unit among the plurality of fan units by associating the same with a connection position of its own fan unit among the plurality of fan units.

[Scope of Patent Claims]

[Claims]

1. An electronic device comprising:
an electronic apparatus, and
a plurality of fan units that cools a serially-connected electronic apparatus, wherein
each fan unit among the plurality of fan units includes
a controlling unit that assigns an address that identifies its own fan unit among the plurality of fan units to its own fan unit by associating the same with a connection position of its own fan unit among the plurality of fan units.
2. The electronic device as claimed in Claim 1 includes a management unit that identifies each fan unit among the plurality of the fan units based on the assigned address, and manages each fan unit.
3. The electronic device as claimed in Claim 1 or 2, wherein the plurality of fan units is configured so as to enable hot swapping of one fan unit among the plurality of fan units by adding and connecting an additional fan unit to one end side of the plurality of the fan units and pushing out a fan unit arranged on the other side of the plurality of the fan units from the other side, and
the controlling unit assigns to its own fan unit an address in accordance with the added connection of the additional fan unit.
4. The electronic device as claimed in Claim 3, wherein the controlling unit includes
a counter that counts a pulse signal received from a previous fan unit that is arranged before its own fan unit, and
delays the pulse signal received from the previous fan unit by a predetermined delay time and outputs thereof to the subsequent fan unit arranged after its own fan unit, and
assigns to its own fan unit a value in accordance with a countable value counted by the counter as the address.
5. The electronic device as claimed in Claim 4, wherein

two adjacent fan units among the plurality of the fan units transmit the pulse signal from one side to the other side, and are connected via an inter-fan unit connector that supplies power from one end to the other end.

6. The electronic device as claimed in Claim 5, wherein each fan unit among the plurality of the fan units includes

a power connector to which two or more power cables that can supply power to its own fan unit are connected when its own fan unit is arranged on one end side of the plurality of the fan units.

7. A cooling fan controller that controls a plurality of fan units that cools a serially connected electronic apparatus, comprising:

a controlling unit that assigns an address that identifies its own fan unit among the plurality of the fan units to its own fan unit by associating the same with a connection position of its own fan unit among the plurality of the fan units.

8. A cooling fan control program that causes a processor that controls the plurality of the fan units that cools the serially-connected electronic apparatus to execute a processing in which an address that identifies its own fan unit among the plurality of the fan units to its own fan unit is assigned by associating the same with a connection position of its own fan unit among the plurality of the fan units.

9. A cooling fan controlling method by using which a plurality of fan units that cools a serially-connected electronic apparatus is controlled by a processor, comprising:

assigning an address that identifies its own fan unit among the plurality of the fan units to its own fan unit by associating the same with a connection position of its own fan unit among the plurality of the fan units.

[Description]

[Technical Field]

[0001]

The present invention relates to an electronic device, a cooling fan controller, a cooling fan control program, and a cooling fan controlling method.

[Background Art]

[0002]

In cooling fans conventionally used in large-scale backbone servers, an ability to perform hot maintenance and swapping while maintaining a system operational state (energized state) is desirable. Accordingly, a fan unit that includes a cooling fan is often arranged on the front side or the rear side of a chassis that forms a server casing. However, in such a configuration, devices or connectors necessary for maintenance and swapping cannot be arranged on the front side or the rear side of the chassis.

[0003]

To solve such a problem, it is conceivable to adopt a structure that enables maintenance of the fan unit from upper / lower surfaces or a side surface of a server by pulling out each chassis from the server casing. However, when printed boards, cables, and the like that are in the energized state exist in a direction of installing / removing the fan unit, it is difficult to swap the fan unit while retaining the energized state of these components.

Therefore, it is difficult to arrange the fan unit near the center of the interior of the server casing so as to enable hot swapping.

[0004]

To solve such a problem, it is conceivable to adopt a structure that enables hot swapping by sliding one fan unit among the plurality of the fan units. In such a structure, the plurality of the fan units is sequentially arranged so as to pass from one side of the server casing through the other side thereof. Moreover, an additional fan unit is added on one end of the plurality of the fan units, and the fan unit arranged on the other end is pushed out from the other end.

[0005]

On the other hand, because cooling efficiency and lower power consumption is desirable in the servers in recent years, rotation speed control or state monitoring of each fan unit is performed by the management and monitoring unit of the entire server. Accordingly, it is conceivable to physically connect a control signal line of each fan unit to the management and monitoring unit to identify and control each fan unit inside the server casing. However, because the number of signal lines must be wired in accordance with the number of installed fan units in such a configuration, wiring of the signal lines becomes difficult as the number of installed fan units increases.

[0006]

To resolve such a problem, in a structure in which the fan units are hot-swappable by sliding operation as explained above, it is possible to adopt a serial interface capable of monitoring and controlling the fan units by using fewer signal lines. For example, the plurality of the fan units is connected in a daisy chain form by using a serial interface such as Inter-Integrated Circuit (I2C). In such a case, the management and monitoring unit monitors and controls each fan unit while identifying each fan unit by a unique address (ID; identification information) assigned to each fan unit beforehand.

[0007]

[Patent Literature 1] Japanese Unexamined Patent Application Publication No. H2010-205972

[Patent Literature 2] Japanese Unexamined Patent Application Publication No. H08-338676

[Patent Literature 3] Japanese Unexamined Patent Application Publication No. H06-244577

[Patent Literature 4] Japanese Unexamined Patent Application Publication No. H10-173376

[Summary of the Invention]

[Problem to be solved by the Invention]

[0008]

However, when adopting the serial interface in a structure that enables hot swapping of the fan units by sliding operation, the following problems may occur. The management and monitoring unit requires a unique address to identify each fan unit arranged inside the server casing. However, because the unique address thereof cannot be set and changed after the hot swapping of the fan unit is performed, an association between an installation position (connection position) and the address of each fan unit cannot be established. Accordingly, the management and monitoring unit cannot correctly recognize and monitor / control the fan unit.

[0009]

An object of the present invention is to provide an electronic device capable of assigning to each fan unit an address associated with a position of each fan unit even when the fan unit is swapped.

[Means to Solve the Problems]

[0010]

An electronic device of the present invention includes an electronic apparatus, and a plurality of serially-connected fan units that cools the electronic apparatus. Each fan unit includes a controlling unit that assigns to its own fan unit an address that identifies its own fan unit among the plurality of the fan units by associating the same with a connection position of its own fan unit among the plurality of the fan units.

[Advantageous Effect of the Invention]

[0011]

An address associated with a position of each fan unit can be assigned to each fan unit even when the fan unit is swapped.

[Brief Description of the Figures]

[0012]

FIG. 1 is a diagram showing a first example of a related technology.

FIG. 2 is a diagram showing a second example of the related technology.

FIG. 3 is a diagram showing a third example of the related technology.

FIG. 4 is a diagram showing a fourth example of the related technology.

FIG. 5 is a schematic perspective view of a connection structure of a server and fan units to which a technology according to the present embodiment is applied.

FIG. 6 is an enlarged perspective view of the connection structure of hot-swappable fan units shown in FIG. 5 explaining a connection structure of the fan units and a hot-swapping procedure of the fan units according to the present embodiment.

FIG. 7 (A) is a schematic perspective view of the fan unit according to the present embodiment, and (B) is a schematic front view of the fan unit according to the present embodiment.

FIG. 8 is a schematic perspective view of a connection structure explaining the hot-swapping procedure of the fan unit and a fault display according to the present embodiment.

FIG. 9 is another schematic perspective view of the connection structure explaining the hot-swapping procedure of the fan unit and the fault display according to the present embodiment.

FIG. 10 is a yet another schematic perspective view of the connection structure explaining the hot-swapping procedure of the fan unit and the fault display according to the present embodiment.

FIG. 11 is a yet another schematic perspective view of the connection structure explaining the hot-swapping procedure of the fan unit and the fault display according to the present embodiment.

FIG. 12 is a block diagram showing a hardware configuration of a server to which the technology according to the present embodiment is applied.

FIG. 13 is a diagram showing an I2C connection between a management unit (I2C master) and various fan units (I2C slaves) in the server to which the technology according to the present embodiment is applied.

FIG. 14 is a block diagram showing a configuration of each fan unit according to the present embodiment.

FIG. 15 is a block diagram showing a detailed configuration of a Light Emitting Diode (LED) lighting circuit shown in FIG. 14.

FIG. 16 is a block diagram showing a detailed configuration of an I2C bus switching circuit shown in FIG. 14.

FIG. 17 is a block diagram showing a detailed configuration of an edge generating circuit shown in FIG. 14.

FIG. 18 is a block diagram showing a detailed configuration of a pulse generating circuit shown in FIG. 14.

FIG. 19 is a time chart explaining an operation that is performed when the four fan units shown in FIG. 14

are serially connected.

FIG. 20 is a flowchart explaining the hot-swapping procedure of the fan units in the server to which the technology according to the present embodiment is applied.

[Best Mode(s) of Carrying Out the Invention]

[0013]

Exemplary embodiments of an electronic device, a cooling fan controller, a cooling fan control program, and a cooling fan controlling method disclosed in the present invention are explained below with reference to the accompanying drawings. However, the embodiments shown below are merely illustrative, and there is no intention to exclude various modifications and technical applications that are not explicitly described below. In other words, the present embodiment can be implemented with various modifications without departing from the essence of the present embodiment. Moreover, each of the drawings is not intended to include only the components shown in the drawing and can include other functions. Each of these embodiments can be appropriately combined within the scope that does not conflict with the details of the processing.

[0014]

1. Related technology

As explained above, in cooling fans used in large-scale backbone servers, an ability to perform hot maintenance and swapping while maintaining the system operational state (energized state) is desirable. Consequently, as shown in FIG. 1, for example, a fan unit 110 that includes a cooling fan is arranged on a front side or a rear side of a chassis that forms a casing of a server 100, and maintenance and swapping of the fan unit 110 is often performed from the direction of Arrow A1 shown in FIG. 1. In such a configuration, other devices or connectors necessary for maintenance and swapping cannot be arranged on the front side or the rear side of the chassis. Furthermore, FIG. 1 is a diagram showing a first example of a related technology. FIG. 1 shows an example in which a total of eight fan units 110, four on the left side and four on the right side, are arranged on the front side of server 100. The fan unit 110 shown in FIG. 1, for example, cools various types of electronic apparatus 101 mounted inside server 100.

[0015]

To resolve such a problem, it is conceivable to adopt a structure that enables maintenance of the fan unit 110 from an upper / lower surface (for example, direction of Arrow A2 or A3) or a left side / right side surface of server 100 as shown in FIG. 2 by pulling out each chassis from a casing of server 100. However, when an energized printed board or a cable exists in the direction from which the fan unit 110 is installed / removed, it is difficult to swap the fan unit 110 while retaining in the energized state. Therefore, it is difficult to arrange the fan unit 110 near the center of the interior of the casing of server 100 so as to enable hot swapping. Furthermore, FIG. 2 is a diagram showing a second example of the related technology. In FIG. 2, an example in which a total of eight fan units 110, four on the upper side and four on the lower side, are arranged near the center of a front-rear direction of server 100 is shown.

[0016]

Here, as shown in FIG. 3 or 4, it is conceivable to adopt a structure that enables hot swapping by sliding a plurality of the fan units 110. In such a structure, the fan units 110 are sequentially arranged so as to pass from one side (right side) of the casing of server 100 through the other side (left side) thereof.

[0017]

In FIG. 3, four fan units 110 are provided moveably in the horizontal direction by a pair of power rails 151

and 152 near the center of the interior of server 100. Furthermore, FIG. 3 is a diagram showing a third example of the related technology. The power rails 151 and 152 are connected to an internal power source 120 of server 100, and are configured so as to supply power to the fan units 110. In a configuration shown in FIG. 3, the left-side fan unit 110 is pushed out from the left side by pushing one fan unit 110 to be swapped from the right side while supplying power to each fan unit 110. By pushing out such fan units 110 one-by-one, one fan unit among the four fan units 110 can be hot-swapped. However, in the example shown in FIG. 3, contacts of the power rails 151 and 152 are exposed. Consequently, in such a configuration, in addition to requiring a large-scale structure, there is an issue of soiling and corrosion of contacts due to being near fan unit 110. Furthermore, upon performing the sliding operation of the fan units 110 in a state in which the power supply is on, there is an issue of electric voltage fluctuation due to fluctuation in the resistance value of the sliding properties, and the like.

[0018]

In FIG. 4, an example of a method in which hot swapping the fan unit 110 is performed without using the power rails shown in FIG. 3. Furthermore, FIG. 4 is a diagram showing a fourth example of the related technology. In FIG. 4, three serially-connected fan units 110 are moveably provided so as to slide in the horizontal direction. At the time of a normal operation, power is supplied from the internal power source 120 of server 100 to the three fan units 110 via a power cable 141. Power is supplied from the internal power source 130 to the three fan units 110, which are the units to be swapped, via a power cable 142. The adjacent fan units 110 are connected via a connector, and power is supplied between the fan units via the connector. In a configuration shown in FIG. 4, by pushing in the three fan units 110 to be swapped from the right side, the three fan units 110 arranged inside server 100 are pushed out from the left side. Subsequently, the power cable 141 is connected to the three fan units 110 that are pushed out so as to supply power from the internal power source 120. Accordingly, the three fan units 110 are hot-swapped. In the example shown in FIG. 4, hot swapping of the fan unit 110 can be performed without using the power rails as shown in FIG. 3. However, because the plurality of the fan units 110 are hot-swapped in a batch, only a part of the fan units 110 among the plurality of the fan units 110 cannot be hot-swapped. In other words, only the fan unit 110 that needs to be swapped cannot be swapped.

[0019]

On the other hand, because cooling efficiency and lower power consumption is desirable in server 100 in recent years as explained above, rotation speed control or state monitoring of each fan unit 110 is performed by a management and monitoring unit of the entire server. Therefore, it is conceivable to physically connect the control signal line of each fan unit 110 to the management and monitoring unit to identify and control each fan unit 110 arranged inside the casing of server 100. However, because the number of the signal lines must be wired in accordance with the number of installed fan units 110 in such a configuration, wiring of the signal lines becomes difficult as the number of installed fan units 110 increases.

[0020]

To resolve such a problem, in a structure in which the fan units 110 are hot-swappable by sliding operation, it is possible to use a serial interface capable of monitoring and controlling the fan units 110 by using fewer signal lines. For example, the plurality of the fan units 110 is connected in a daisy chain form by using a serial interface such as I2C. In such a case, the management and monitoring unit monitors and controls each fan unit 110 while identifying each fan unit 110 by using a unique address (ID; identification information) assigned to each fan unit 110 beforehand.

[0021]

However, when using the serial interface in a structure that enables hot swapping of the fan units 110 by sliding operation, the following problems may occur. The management and monitoring unit requires a unique address to identify each fan unit 110 arranged inside the casing of server 100. However, because the unique address thereof cannot be set and changed after the fan unit 110 is hot-swapped, an association between an installation position (connection position) and the address of each fan unit 110 cannot be established. Accordingly, the management and monitoring unit cannot correctly recognize and monitor or control fan unit 110. For example, correspondence (link) between a faulty fan unit 110 and a fault LED that should be lit on a fan fault external display panel cannot be established.

[0022]

Here, it is conceivable to provide a dip switch and the like in each fan unit 110, where a maintenance person can manually change the ID of each fan unit 110 by operating the dip switch. In such a configuration, among the plurality of the fan units 110, the only surface that is exposed to the outside of server 100 is one surface of the fan units 110 at both ends. Accordingly, the maintenance person cannot visually confirm the ID of each fan unit 110. Moreover, when the maintenance person sets the ID incorrectly, the fan unit cannot be monitored. When the ID is set in a duplicated manner, the entire server 100 cannot be managed and monitored.

[0023]

2. Overview of the present embodiment

The present embodiment discloses a technology that resolves various problems and issues of the related technology explained above while referring to FIGS. 1 to 4. Particularly, in the present embodiment, a technology that enables automatic assignment to each fan unit of the position and the associated address (ID) of each fan unit even after hot-swapping the fan unit in the electronic devices such as server is disclosed.

[0024]

In the present embodiment, for example, the technology used for hot-swapping the fan units in a system operating state in the server that includes a management and monitoring unit for the entire server casing that controls the rotation speed of each fan unit and monitors abnormal conditions is disclosed. In the technology, instead of assigning a special unique ID to the fan unit in advance, an ID unique to each fan unit linked to the installation position thereof is automatically assigned at the same time swapping of the fan unit is completed after a specific fan unit among the plurality of the fan units is hot-swapped. Accordingly, by using the technology, rotation speed control and abnormal conditions monitoring of the fan units in a same state as that before the swapping can be performed by the management and monitoring unit of the entire server casing.

[0025]

To realize the technology, server 1 as shown in FIG. 5 is disclosed in the present embodiment. In the present embodiment, server 1 is an example of an electronic device that includes an electronic apparatus that is cooled by a fan unit 10. The electronic device is not limited to a server, and can be a device that includes various electronic apparatus such as an information processing device, communication device that ought to be cooled. Furthermore, FIG. 5 is a schematic perspective view of a connection structure of server 1 and fan unit 10 to which the technology according to the present embodiment is applied. FIG. 6 is an enlarged perspective view of the connection structure of the hot-swappable fan units 10 shown in FIG. 5 explaining the connection structure of fan unit 10 and the hot-swapping procedure according to the present embodiment. [0026]

Server 1 according to the present embodiment includes electronic apparatus 101 and a plurality of serially-connected fan units 10 that cools the electronic apparatus 101. In the present embodiment, the number of fan units 10 provided is, for example, four.

[0027]

Each fan unit 10 includes a cooling fan 11 that is driven rotationally by a motor (not-shown), and a controlling unit (not-shown). The controlling unit controls each fan unit 10, and includes a fan controller 13, circuits 20, 30, 40, and 50, and a counter 60 (refer to FIG. 14) explained later. The fan controller 13 monitors and controls the operation of the cooling fan 11. Particularly, the controlling unit performs a function of assigning to its own fan unit (fan controller 13) an address that identifies its own fan unit among the plurality of fan units 10 (for example, I2C slave address) by corresponding thereof with the connection position of its own fan unit among the plurality of fan units 10.

[0028]

Moreover, server 1 includes a management unit 7 (refer to FIGS. 8 to 13). The management unit 7 identifies each fan unit 10 based on the address assigned thereto, and manages each fan unit 10. In the following explanation, management unit 7 may be referred to as a management and monitoring unit 7 of the entire server casing, or a management and monitoring unit 7, or a monitoring unit 7.

[0029]

As explained later by referring to FIGS. 5 to 11, the plurality of fan units 10 is configured so as to enable hot swapping of one fan unit among the plurality of fan units 10. In other words, the plurality of fan units 10 is configured so as to enable hot swapping of one fan unit among the plurality of fan units 10 by adding and connecting an additional fan unit 10 to one end side of the plurality of fan units 10 and pushing out a fan unit arranged on the other side of the plurality of fan units 10 from the other side.

[0030]

The controlling unit assigns to its own fan unit an address that identifies its own fan unit in accordance with the addition and connection of the additional fan unit. The controlling unit includes the counter 60 that counts a pulse signal received from a previous fan unit that is arranged before its own fan unit (refer to FIGS. 14 and 19). Moreover, the controlling unit delays the pulse signal received from the previous fan unit only for a predetermined delay time (DL4; refer to FIG. 19), outputs the same to a subsequent fan unit arranged after its own fan unit, and assigns to its own fan unit as an address a value according to the countable value counted by the counter 60.

[0031]

Moreover, each fan unit 10 on which hot swapping (swapping in the energized state) of fan unit 10 can be performed is configured as below. In other words, two adjacent fan units 10 among the plurality of fan units 10 are connected via inter-fan connectors CNC and CND that transmit the pulse signal from one end side to the other end side, and supplies power from one end side to the other end side (refer to FIGS. 5 to 11). Moreover, each fan unit 10 includes power connectors CNA and CNB to which two or more power cables capable of supplying power to its own fan unit are connected when its own fan unit is arranged on one end side of the plurality of fan units 10 (refer to FIGS. 5 to 7).

[0032]

According to server 1 explained above, a part of the fan units among the plurality of fan units 10 can be hot-swapped by the slide operation without using the exposed power rail configuration, as explained in detail below. Moreover, in such a case, immediately after the hot swapping is performed, an I2C slave address is automatically assigned by the controlling unit in each fan unit 10. In other words, an address associated with the position of each fan unit 10 can be assigned to each fan unit 10 even after fan unit 10 is hot-swapped.

[0033]

Accordingly, a link between the installation position of each fan unit 10 inside the casing of server 1 and the I2C slave address thereof can be established without performing any special operation, and the management unit 7 can correctly recognize each fan unit 10 and appropriately perform the rotation speed control or abnormality condition monitoring of each fan unit 10. For example, correspondence between the faulty fan unit 10 and fault LEDs 8a to 8d that should be lit on a fan fault external display panel 8 can be correctly established, as explained later by referring to FIGS. 8 to 11. In such a manner, according to server 1 of the present embodiment, problems and issues of the related technology explained above by referring to FIGS. 1 to 4 can be resolved.

[0034]

3. Connection structure and hot-swapping procedure of the fan units of the present embodiment

The connection structure and the hot-swapping procedure of the fan units used in the present embodiment that resolves various problems and issues of the related technology explained by referring to FIGS. 1 to 4 will be explained below while referring to FIGS. 5 to 11.

[0035]

Furthermore, as explained above, FIG. 5 is the schematic perspective view of the connection structure of server 1 and fan unit 10 according to the present embodiment, and FIG. 6 is the enlarged perspective view of the connection structure shown in FIG. 5. Moreover, FIG. 7 (A) is a schematic perspective view of fan unit 10 according to the present embodiment, and FIG. 7 (B) is a schematic front view of fan unit 10 according to the present embodiment. FIGS. 8 to 11 show schematic perspective views of the connection structure explaining the hot-swapping procedure of fan units 10 and the fault display according to the present embodiment.

[0036]

As shown in FIGS. 5 and 6, and FIGS. 8 to 11, in the present embodiment, the plurality of fan units 10 (four fan units in the figure) are arranged sequentially so as to pass from one side (right side in the figure) through the other side (left side in the figure) of the casing of server 1. Consequently, by adding a new fan unit 10 to one side of the plurality of fan units 10 and sliding the entire plurality of fan units 10 to the left side shown in the figure, fan unit 10 on the left side are pushed out to the other side (left side in the figure) of the casing.

[0037]

Each of fan unit 10 that form such a connection structure includes connectors CNA, CNB, CNC, CND for supplying power and transmitting a control signal / monitoring signal to the adjacent fan unit 10, as shown in FIGS. 5, 6, 7A, and 7B. Furthermore, in the following explanation, the control signal / monitoring signal may be referred to as a control / monitoring signal.

[0038]

In other words, a connector CNC (male) that enables power supply and live connection of the control signal / monitoring signal is provided by protruding on the right side surface when viewed from a front surface of each fan unit 10. A connector CND (female) that enables power supply and live connection of the control signal / monitoring signal is provided by recessing on the left side surface when viewed from the front surface of each fan unit 10. The two adjacent fan units 10 are connected so as to enable power supply and transmission of the control signal / monitoring signal by engaging the connector CNC of fan unit 10 on one side and the connector CND of fan unit 10 on the other end.

[0039]

Moreover, two connectors CNA and CNB (both female) that enable power supply and live connection of the control signal / monitoring signal are provided on one end of each fan unit 10 (right side when viewed from the front surface). The connector CNA on one side is arranged on a lower part of the front surface of each fan

unit 10 such that an end part plug (male) of a cable A is inserted from the front surface side so as to be live-connected. The connector CNB on the other side is arranged on an upper part of the rear surface of each fan unit 10 such that an end part plug (male) of a cable B is inserted from the rear surface side so as to be live-connected. The two cables A and B are connected to the connectors CNA and CNB, respectively, when fan unit 10 is arranged on a right-most side (one side) of the plurality of fan units 10 (when adding fan unit 10). The cables A and B each supply power from a power supplying unit (internal power source) 2 of server 1 and transmits the control signal / monitoring signal and the like received from the management unit 7 (refer to FIGS. 8 to 13).
[0040]

Furthermore, as shown in FIG. 7A, an insertable / removable indicator lamp 12 is provided on the right side surface when viewed from the front surface of each fan unit 10. Because the right side surface is exposed to the outside when fan unit 10 is arranged on the right-most side of the plurality of fan units 10 (when fan unit 10 is added), the maintenance person can check a lighting state of the insertable / removable indicator lamp 12. The insertable / removable indicator lamp 12 is, for example, a dual-colored LED. The lighting color (luminescent color) of the insertable / removable indicator lamp 12 is controlled by a later-explained LED lighting circuit 20 (refer to FIGS. 14 and 15). For example, when the cables A and B are respectively connected to the connectors CNA and CNB, that is, the cables A and B are in a insertable / removable state (a state in which the power supply is not interrupted even when one of the cables is removed), the insertable / removable indicator lamp 12 is controlled to be in a green color state (to lit up in green color). On the other hand, when only one of the cables A and B is connected to the connector CNA and CNB (hereinafter, a state in which the power supply is interrupted when a cable is removed), the insertable / removable indicator lamp 12 is controlled to be in a yellow color state (to lit up in yellow color).
[0041]

The power is supplied to the serially-connected plurality of fan units 10 from the power supplying unit 2 via the cables A and B and the connectors CNA, CNB, CNC, and CND explained above in a sequence. Moreover, the management unit 7 (I2C master; refer to FIGS. 8 to 13) and the fan controllers 13 of the plurality of fan units 10 (I2C slaves; refer to FIGS. 12 and 13) are connected in a daisy chain form by a serial interface such as I2C. Accordingly, the control signal (pulse signal) from the management unit 7 or the adjacent fan unit 10 is transmitted to the serially-connected plurality of fan units 10 via the cables A and B and the connectors CNA, CNB, CNC, and CND explained above. Therefore, fan unit 10 can be hot-swapped without having to stop the system (server 1).
[0042]

Next, the hot-swapping procedure of fan unit 10 according to the present embodiment will be explained while referring to FIG. 6. Here, an operation performed by the maintenance person when adding a new fan unit 10 on one side (right side) and sliding the already installed fan unit 10 in server 1 to push out fan unit 10 on the other end (left side) is explained. At the start of the operation, four serially- connected fan units 10 are installed in server 1 and the connectors CNA and CNB of the fan unit on the right-most side are connected to the cables A and B, respectively.
[0043]

At this time, the maintenance person confirms that the insertable / removable indicator lamp 12 provided on the right side of fan unit 10 arranged on the right-most side among the already installed fan units 10 inside server 1 is in the green color state. In other words, the maintenance person confirms that the connectors CNA and CNB of fan unit 10 arranged on the right-most side is connected to the cables A and B, and is in a state in which the

cable can be inserted / removed.

[0044]

Upon visually confirming the insertable / removable indicator lamp 12 and confirming that it is the state in which the cable can be inserted / removed, the maintenance person engages the connector CNC (male) of fan unit 10 on the right-most side with the connector CND of the new fan unit 10 (refer to Arrow (1) shown in FIG. 6). Accordingly, the new unit 10 is connected to fan unit 10 on the right-most side as a fifth fan unit 10.

[0045]

Subsequently, the maintenance person removes the cable A that is connected to the connector CNA of fan unit 10 on the right-most side, and connects the same to the connector CNA of the additionally- linked new fan unit 10, as shown by Arrow (2) of FIG. 6. At this step, the insertable / removable indicator lamp 12 switches from the green color state to the yellow color state when the cable A is removed, and switches back to the green color when the cable A is connected to the connector CNA of the new fan unit 10.

[0046]

Furthermore, the maintenance person removes the cable B that is connected to the connector CNB of fan unit 10 on the right-most side, and connects the same to the connector CNB of the additionally- linked new fan unit 10, as shown by Arrow (3) of FIG. 6. Even at this step, the insertable / removable indicator lamp 12 switches from the green color state to the yellow color state when the cable B is removed, and switches back to the green color when the cable B is connected to the connector CNB of the new fan unit 10.

[0047]

Subsequently, the maintenance person performs the sliding operation to move all five fan units 10 in which the new fan unit 10 is added on the right-most side in a direction of the Arrow (4) (left side) shown in FIG. 6. Accordingly, the new fan unit 10 is pushed inside server 1, and a fifth fan unit 10 from the right (left-most side) is pushed outside from server 1.

[0048]

At this time, when the pushed-out fan unit 10 is a faulty fan unit to be swapped (target fan unit), the pushed-out fan unit 10 is removed, and the swapping operation is completed. When the pushed-out fan unit 10 is not the target fan unit, the maintenance person adds and connects that pushed-out fan unit 10 on the right-most side and pushes thereof inside server 1 as the new fan unit 10 as explained above. The maintenance person repeats such an operation till the target fan unit is pushed out.

[0049]

In such a way, a specific fan unit among the serially-connected four fan units 10 (faulty fan unit) can be swapped with a new fan unit 10 without stopping the power supply to fan unit 10. Accordingly, swapping of fan unit 10 in a state in which rotation of the cooling fan 11 provided in each fan unit 10 is maintained as is, that is, swapping of fan unit 10 in the hot state can be performed.

[0050]

Incidentally, in the present embodiment, when the cables A and B are removed / inserted as explained above and the insertable / removable indicator lamp 12 returns to the green color state, that is, when the new fan unit 10 is added and connected, an address is automatically assigned by the controlling unit of each fan unit 10. In other words, the controlling unit of each fan unit 10 automatically assigns and sets the I2C slave address of the fan controller 13 (I2C slave; refer to FIGS. 12 to 14) of each fan unit 10 as explained below.

[0051]

For example, the smallest number (for example, 0) is assigned as the I2C slave address to a first fan unit 10

(arranged on the right-most side) to which the cables A and B are connected. The smallest number + 1 (for example, 1) is assigned to a second fan unit 10 from the right side as the I2C slave address. Similarly, the smallest number + 2, the smallest number + 3, the smallest number + 4 (for example, 2, 3, and 4) are assigned as the I2C slave addresses to a third, fourth, and fifth fan unit 10 from the right side, respectively.

[0052]

In such a way, an address that identifies each fan unit 10 can be assigned to each fan unit 10 in correspondence with the connection position of each fan unit 10 among the plurality of fan units 10.

[0053]

Furthermore, a method using an I2C slave address is automatically assigned and it is explained in more detail while referring to FIGS. 14 to 19.

[0054]

The management unit 7 (I2C master) identifies each fan unit 10 based on the I2C slave address that is automatically assigned and set to the fan controller 13 of the respective fan unit 10 as explained above, and manages each fan unit 10 (fan controller 13). The management unit 7 also controls a normal / faulty display for the plurality of fan units 10 explained below while referring to FIGS. 8 to 11. FIGS. 8 to 11 are views explaining the hot-swapping procedure of fan unit 10 and the fault display according to the present embodiment.

[0055]

As shown in FIGS. 8 to 11, a fan fault external display panel 8 is provided on a lower part of the front surface of server 1 according to the present embodiment. The fan fault external display panel 8 includes four LEDs (dual-colored LEDs) 8a, 8b, 8c, and 8d. The management unit 7 controls the lighting color of the LEDs 8a to 8d in accordance with the state of the four fan units 10 mounted inside server 1.

[0056]

The LED 8a shows the normal / faulty state of fan unit 10 on the left-most side, that is, the fourth fan unit 10 from the right side indicated by (1) in FIGS. 9 to 11. The LED 8b shows the normal / faulty state of the second fan unit 10 from the left side, that is, the third fan unit 10 from the right side indicated by (2) in FIGS. 9 to 11. The LED 8c shows the normal / faulty state of the third fan unit 10 from the left side, that is, the second fan unit 10 from the right side indicated by (3) in FIGS. 9 to 11. The LED 8d shows the normal / faulty state of the fourth fan unit 10 from left side, that is, fan unit 10 on the right-most side indicated by (4) in FIGS. 9 to 11.

[0057]

For example, each of the LEDs 8a to 8d are controlled to be in the green color state (a state in which the LED emits the green color) when the corresponding fan unit 10 are in the normal state. On the other hand, each of the LEDs 8a to 8d are controlled to be in the yellow color state (a state in which the LED emits the yellow color) when the corresponding fan unit 10 is in the faulty state.

[0058]

As shown in FIG. 8, when all fan units 10 are in the normal state, all the LEDs 8a to 8d of the fan fault external display panel 8 are caused to retain the green color state by the management unit 7.

[0059]

At this step, the management unit 7 and the fan controller 13 of each fan unit 10 are connected via I2C as shown in FIG. 13, and the management unit 7 becomes the I2C master and each fan controller 13 becomes the I2C slaves to which a unique address (I2C slave address) is assigned. Consequently, management unit 7 reads the state from each fan controller 13, and when the read state is the faulty state, transmits an external fault display signal (refer to FIG. 12) to the fan fault external display panel 8. Accordingly, the LED among the LEDs

8a to 8b that corresponds to the faulty fan unit 10 identified by the unique address is lit in the yellow color state. Therefore, it is necessary that the installation position and the I2C slave address of each fan unit 10 correspond to each other. In the present embodiment, by configuring fan unit 10 so as to include the controlling unit explained above of each fan unit 10 as shown in FIGS. 14 to 18, the installation position and the I2C slave address of the fan unit after fan unit 10 is pushed out and swapped can be automatically synchronized.

[0060]

For example, when the management unit 7 detects a fault of the fan unit (2) in a state shown in FIG. 8, the management unit 7 transmits the external fault display signal (refer to FIG. 12) related to the fan unit (2) to the fan fault external display panel 8. As shown in FIG. 9, the LED 8b on the fan fault external display panel 8 that corresponds to the fan unit (2) switches from the green color state to the yellow color state according to the external fault display signal. The maintenance person refers to the fan fault external display panel 8 to recognize the fault of the fan unit (2), and prepares one new fan unit (5) for the addition.

[0061]

At this time, by a function of the controlling unit of each fan unit 10 explained above, addresses that correspond to the connection position of each fan unit 10, for example, 3, 2, 1, and 0 are assigned to the four fan units (1) to (4), as the I2C slave addresses that identify each fan unit 10. Accordingly, the fan unit (2) in which fault has occurred is identified by the address "2".

[0062]

Subsequently, as shown in FIG. 10, the maintenance person additionally connects the new fan unit (5) on the right-most side of the four fan units (1) to (4) in server 1 according to the procedure explained above while referring to FIG. 6. The maintenance person causes all serially-connected five fan units (1) to (5) to slide in the left direction shown in FIG. 11, as shown in FIG. 11. Accordingly, the new fan unit (5) is pushed inside server 1, and the fan unit (1) is pushed outside from server 1.

[0063]

At this step, four fan units (2) to (5) are mounted inside server 1. Subsequently, by a function of the controlling unit of each fan unit 10 explained above, addresses that correspond to the connection position of each fan unit 10, for example, 3, 2, 1, and 0 are assigned to these four fan units (2) to (5), as the I2C slave addresses that identify each fan unit 10. Accordingly, the fan unit (2) in which fault has occurred is identified by the address "3".

[0064]

Consequently, when management unit 7 detects a fault of the fan unit (2) that is identified with address "3", and transmits the external fault display signal (refer to FIG. 12) related to the fan unit (2) to the fan fault external display panel 8. As shown in FIG. 11, the LED 8a on the fan fault external display panel 8 that corresponds to the fan unit (2) switches from the green color state to the yellow color state according to the external fault display signal, and the LEDs 8b to 8d that correspond to the fan units (3) to (5) are set to the green color state.

[0065]

Subsequently, the maintenance person recognizes the fault of the fan unit (2) by referring to the fan fault external display panel 8, and then adds and connects the pushed-out fan unit (1) on the right-most side of the four fan units (2) to (5) in server 1. Subsequently, the maintenance person causes all serially-connected five fan units (2) to (5) and (1) to slide in the left direction shown in FIG. 11. Accordingly, the fan unit (1) is pushed inside server 1, and the faulty fan unit (2) is pushed outside from server 1.

[0066]

Accordingly, hot swapping of the faulty fan unit (2) is completed. At this step, the four fan units (3) to (5) and (1) are assigned the addresses, for example, 3, 2, 1, and 0, respectively. Moreover, because all fan units 10 are in the normal state, all the LEDs 8a to 8d of the fan fault external display panel 8 are caused to retain the green color state by the management unit 7, as shown in FIG. 8.

[0067]

4. Hardware configuration of server according to the present embodiment

Next, hardware configuration of the server according to the present embodiment will be explained while referring to FIGS. 12 and 13. FIG. 12 is a block diagram showing a hardware configuration of server 1 used in the technology according to the present embodiment. FIG. 13 is a diagram showing an I2C connection between the management unit 7 (I2C master) and various fan units 10 (I2C slaves) in server 1 used in the technology according to the present embodiment.

[0068]

As explained above, server 1 is an example of an electronic device that includes an electronic apparatus that is cooled by fan unit 10. As shown in FIG. 12, server 1 according to the present embodiment includes, for example, the power source unit 2, CPU 3, MEM 4, HDD 5, an electric voltage regulator 6, the management and monitoring unit 7, the fan fault external display panel 8, and four fan units 10. The CPU is an abbreviation of Central Processing Unit, MEM is an abbreviation of the memory, and HDD is an abbreviation of Hard Disk Drive.

[0069]

The power source unit 2 is an internal power source mounted inside server 1, and as explained above, supplies power to the plurality of fan units 10 via the cable A, the cable B, and the connectors CNA to CND. Moreover, in addition to supplying power to electronic apparatus such as the CPU 3, the MEM 4, and the HDD 5, the power source unit 2 supplies power to other various not-shown electronic apparatus and the like via the electric voltage regulator 6.

[0070]

The CPU 3 is an example of a processor that performs various kinds of controls and calculations. The CPU 3 is connected to the MEM 4, the HDD 5, the management and monitoring unit 7, other various types of electronic apparatus and the like via a bus so as to be mutually communicable. Furthermore, instead of an arithmetic processing device such as the CPU 3, electronic circuit, for example, integrated circuits (IC) such as Micro Processing Unit (MPU), Application Specific Integrated Circuit (ASIC), and Field Programmable Gate Array (FPGA) can be used as a processor.

[0071]

The MEM 4 is an example of hardware of a volatile storage unit that stores information such as various data and computer programs. Memories such as Random Access Memory (RAM) and the like can be cited as an example of the MEM 4.

[0072]

The HDD 5 is an example of hardware of a non-volatile storage unit that stores information such as various data and computer programs. In addition to magnetic disk devices such as HDDs, various kinds of storage devices, for example, semiconductor drive devices such as Solid State Drives (SSD), flash memories, and nonvolatile memories such as Read Only Memory (ROM) and the like can be cited as examples of the non-volatile storage unit. The HDD 5 can store various kinds of computer programs that implement all or a part of various functions of server 1.

[0073]

The CPU 3 can realize various functions of server 1 by, for example, loading various computer programs stored in the HDD 5 onto the MEM 4 and executing thereof.

[0074]

The electric voltage regulator 6 adjusts the power voltage of the power from the power source unit 2, and supplies the voltage-adjusted power to the electronic apparatus, for example, the CPU 3, the MEM 4, and HDD 5 inside server 1.

[0075]

The management and monitoring unit 7 of the entire server casing monitors the hardware configuration of server 1, and can be regarded as, for example, a service processor. The management and monitoring unit 7 according to the present embodiment manages the state of the power source unit 2, the CPU 3, the MEM 4, the HDD 5, and fan unit 10 by exchanging the monitoring signals between the power source unit 2, the CPU 3, the MEM 4, the HDD 5, and fan unit 10. Moreover, the management and monitoring unit 7 controls the state of the power source unit 2 and fan unit 10 by transmitting the control signal to the power source unit 2 and fan unit 10.

[0076]

In the present embodiment, the power line and the control / monitoring signal line of the four fan units 10 inside server 1 are joined in a daisy chain form via the cables A and B, and the connectors CNA, CNB, CNC, and CND. Particularly, as shown in FIG. 13, monitoring unit 7, which is the I2C master, and the fan controller 13, which is the I2C slave in each fan unit 10, are connected by the control / monitoring signal lines SCL and SDL that form the I2C serial interface. SCL is an abbreviation of Serial Clock Line, and SDL is an abbreviation of Serial Data Line.

[0077]

At this step, in each fan unit 10, a countable value AD0-3 (see FIG. 19) obtained by the I2C address counter 60 can be assigned as is to the I2C slave 13 as the I2C slave address. Moreover, as shown in FIG. 13, upon converting the countable value AD0-3 (refer to FIG. 19) to the corresponding address values such as ID, IE, IF, and so on, the converted corresponding address values can be assigned and set to the I2C slave 13 as the I2C slave address.

[0078]

Accordingly, the monitoring unit 7 (I2C master) can identify each fan unit 10 based on the I2C slave addresses that are automatically assigned and set to the fan controller 13 of the respective fan unit 10, and manage / control each fan unit 10 (fan controller 13). Moreover, as explained above while referring to FIGS. 8 to 11, the monitoring unit 7 performs control on the normal / fault display of the four fan units 10 by using the external fault display signal, that is, performs control on the LEDs 8a to 8d on the fan fault external display panel 8.

[0079]

As explained above while referring to FIGS. 8 to 11, the fan fault external display panel 8 is arranged on a lower part of the front surface of server 1, and includes the LEDs 8a to 8d that correspond to the four fan units 10. The LEDs 8a to 8d are controlled by the monitoring unit 7 so as to light in a color based on the state of the four fan units 10 installed inside server 1.

[0080]

The four fan units 10 are serially connected, and cool down the electronic apparatus including the CPU 3, the MEM 4, and the HDD 5. Each fan unit 10 includes a cooling fan 11 that is driven rotationally by a not-shown

motor. Moreover, the four fan units 10 are configured so as to be hot-swappable by performing the sliding operation of a part of fan units 10 as explained above while referring to FIGS. 5 to 11.

[0081]

In addition to the insertable / removable indicator lamp 12 explained above while referring to FIG. 7A, each fan unit 10 includes a controlling unit that includes the fan controller 13. The fan controller 13 monitors the rotation speed and abnormal conditions (performs temperature monitoring) of the cooling fan 11. Moreover, the controlling unit explained above assigns to the fan controller 13 of its own fan unit the I2C slave address that identifies own fan unit among the four fan units 10 by corresponding thereof with the connection position of its own fan unit among the four fan units 10. As explained later while referring to FIG. 14, in addition to the fan controller 13, the controlling unit includes circuits 20, 30, 40, and 50, and the counter 60.

[0082]

5. Configuration of various fan units according to the present embodiment

Next, the configuration of fan unit 10 according to the present embodiment will be explained while referring to FIGS. 14 to 18. Here, configuration for automatically generating, assigning, and setting the I2C slave address with respect to the fan controller 13 of each fan unit 10 is explained below.

[0083]

FIG. 14 is a block diagram showing the configuration of various fan units 10 according to the present embodiment. FIG. 15 is a block diagram showing a detailed configuration of the LED lighting circuit 20 shown in FIG. 14. FIG. 16 is a block diagram showing a detailed configuration of an I2C bus switching circuit 30 shown in FIG. 14. FIG. 17 is a block diagram showing a detailed configuration of an edge generating circuit 40 shown in FIG. 14. FIG. 18 is a block diagram showing a detailed configuration of a pulse generating circuit 50 shown in FIG. 14.

[0084]

As shown in FIG. 14, each fan unit 10 includes the connectors (power source connectors) CNA and CNB for the cables A and B, and the inter-fan connectors CNC and CND explained above.

[0085]

Moreover, each fan unit 10 includes the cooling fan 11, the insertable / removable indicator lamp 12, and the fan controller 13.

[0086]

Furthermore, each fan unit 10 includes the LED lighting circuit 20, the I2C bus switching circuit 30, the edge generating circuit 40, the pulse generating circuit 50, and the I2C address counter 60. Here, the I2C bus switching circuit 30, the edge generating circuit 40, the pulse generating circuit 50, and the I2C address counter 60 function as a controlling unit that automatically generates, assigns, and sets the I2C slave address to the fan controller 13 of each fan unit 10.

[0087]

Functions and operation of the LED lighting circuit 20, the I2C bus switching circuit 30, the edge generating circuit 40, the pulse generating circuit 50, and the I2C address counter 60 are explained below.

[0088]

Furthermore, a part or all functions of the LED lighting circuit 20, the I2C bus switching circuit 30, the edge generating circuit 40, the pulse generating circuit 50, and the I2C address counter 60 can be realized by a processor 10a provided in each fan unit 10 by executing a cooling fan control program.

[0089]

In such a configuration, an arithmetic processing device such as CPU, or integrated circuits such as MPU, ASIC, or FPGA can be used as the processor 10a. Moreover, the computer program executed by processor 10a can be provided in a state in which it is recorded on a non-transitory portable recording medium such as an optical disk, a memory device, or a memory card. Alternatively, the computer program executed by processor 10a can be provided via a network.

[0090]

Furthermore, the optical disk is a portable, non-transitory recording medium on which data is readably recorded by the reflection of light. Blu-ray (trademark), Digital Versatile Disc (DVD), DVD-RAM, Compact Disc Read Only Memory (CD-ROM), CD-R (Recordable) / RW (Rewritable) can be cited as an example of the optical disk. The memory device is a non-transitory recording medium that includes a communication function with a device connection interface, such as a Universal Serial Bus (USB) memory. The memory card is a card-type non-transitory recording medium that serves as a data writing/reading target when connected to a processing unit 22 via a memory reader / writer.

[0091]

In FIG. 14, the connectors CNA and CNB are connected to the cables A and B that are connected to a main body unit of server 1, respectively, as explained above. However, the cables A and B can only be connected to the connectors CNA and CNB of the first fan unit 10. The connectors CNC and CND connect the adjacent fan units 10 as explained above.

[0092]

The connector CNA of the first fan unit 10 is connected to the main body unit of server 1 via the cable A, and is connected to a power source and a signal (a power supply VCCA, an I2C control / monitoring signal line (SCL, SDL) I2CA, an alarm signal AlmA, a ground GND) of a first system A. Similarly, the connector CNB of the first fan unit 10 is connected to the main body unit of server 1 via the cable B, and is connected to a power source and a signal (a power supply VCCB, an I2C control / monitoring signal line I2CB, an alarm signal AlmB, the ground GND) of a second system B.

[0093]

Moreover, in FIG. 14, VCC indicates the power source, and GND indicates ground. Moreover, a character "o" assigned to signals *ALo, I2Co, S0o, S1o, S2o indicates this signal is output from the respective fan unit 10. Similarly, a character "i" assigned to signals *ALi, I2Ci, S0i, S1i, S2i indicates this signal is input to the respective fan unit 10.

[0094]

*AL is an alarm signal that indicates a fan abnormality detected in the fan controller 13 of each fan unit 10 in negative logic. The alarm signal *AL is input from a *ALo terminal of the connector CNC of the previous fan unit 10 to a *ALi terminal of the connector CND of its own fan unit 10. Then, the alarm signal *AL is transmitted in real time from the *ALi terminal of the connector CND of its own fan unit 10 to the terminal *ALo of the connector CNC. Moreover, in the first fan unit 10, the monitoring unit 7 is notified of the alarm signal *AL via an AlmA terminal of the connector CNA and the cable A, and via an AlmB terminal of the connector CNB and the cable B.

[0095]

The alarm signal *AL is a signal that notifies of an abnormality when the fan controller 13 detects a rotation speed abnormality of the cooling fan 11, or a temperature abnormality from a temperature sensor in the cooling fan 11. Detailed information related to the abnormality (such as rotation speed, temperature) is collected by the

monitoring unit 7, which is the I2C master, by accessing the fan controller 13, which is the I2C slave, via an I2C line.

[0096]

As shown in FIG. 15, the LED lighting circuit 20 is configured so as to control the lighting color (luminescent color) of the insertable / removable indicator lamp 12 when hot-swapping fan unit 10, as explained above while referring to FIG. 7A. LED lighting circuit 20 includes an AND gate 21. In FIG. 15, VCC A indicates a power source of the first system A supplied from the connector CNA, and VCCB indicates a power source of the second system B supplied from the connector CNB.

[0097]

While the cable A or cable B is temporarily connected only to the connector CNA or the connector CNB when hot-swapping fan unit 10, a state of the lighting signal from the AND gate 21 becomes "0" and the state of the insertable / removable indicator lamp 12 changes from the green color lighting state to the yellow color lighting state. Moreover, upon connecting the cable A and the cable B to the connectors CNA and CNB of the new fan unit 10, the state of the lighting signal from the AND gate 21 becomes "1" and the state of the insertable / removable indicator lamp 12 changes from the green color lighting state to the yellow color lighting state.

[0098]

Accordingly, when the cables A and B are respectively connected to the connectors CNA and CNB, that is, the cables A and B is in the insertable / removable state (the state in which the power supply is not interrupted even when one of the cables is removed), the insertable / removable indicator lamp 12 is controlled to be in the green color state. On the other hand, when only one of the cables A and B is connected to the connector CNA and CNB (hereinafter, a state in which the power supply is interrupted when the cable is removed), the insertable / removable indicator lamp 12 is controlled to be in the yellow color state.

[0099]

The I2C bus switching circuit 30 is configured to switch a connection destination of an I2C bus within each fan unit 10 to an appropriate connection destination depending on whether fan unit 10 is arranged as the first fan unit 10 or as the second or subsequent fan unit 10, as shown in FIG. 16. The I2C bus switching circuit 30 includes an OR gate 31 and an analog multiplexer 32. The I2C (SCL, SDL) is a signal in conformance with the I2C interface standards, and is connected to the I2C master in monitoring unit 7 and the I2C slave (fan controller 13) of each fan unit 10.

[0100]

Because the I2Ci is set in an open state in the first fan unit 10, the I2Co needs to be switched so as to connect to the I2CA and I2CB signals from the connectors CNA and CNB, instead of I2Ci. Moreover, in the second and subsequent fan units 10, because the I2C buses of the connectors CNA and CNB are set in an open state, and the I2Ci is connected to the I2Co of the previous fan unit 10, it is necessary to connect the I2Co to the I2Ci.

[0101]

In FIG. 16, when a plug of the cable A or the cable B is inserted and connected to the connectors CNA or CNB, a selection signal from the OR gate 31 becomes "1". In other words, in the first fan unit 10, because the cables A and B are connected to the connectors CNA and CNB, the selection signal becomes "1", and the analog multiplexer 32 switches in accordance with the selection signal so as to connect a port A and a port X. Accordingly, the I2Co is connected to I2C A / I2CB connected to the port A.

[0102]

On the other hand, in the second and the subsequent fan units 10, because the cables A and B are not connected to the connectors CNA and CNB, the selection signal becomes "0", and the analog multiplexer 32 switches in accordance with the selection signal so as to connect the port B and the port X. Accordingly, the I2Co is connected to the I2Ci connected to the port B.

[0103]

By using such I2C bus switching circuit 30 shown in FIG. 16, the monitoring unit 7, which is the I2C master, is connected to the I2C slaves (fan controller 13) inside the all serially-connected fan units 10 via the I2Co terminal of the connector CND of each fan unit 10. Accordingly, the I2C master (monitoring unit 7) can identify the I2C slave by using the I2C slave address automatically assigned to the I2C slave, and communicate with the I2C slave.

[0104]

As shown in FIG. 17, in the first fan unit 10, the edge generating circuit 40 is configured to generate an edge which is a starting point of reset when turning on the power of the main unit and inserting / removing fan unit 10. The edge generating circuit 40 includes the AND gate, a Schmidt trigger component element, and an open collector.

[0105]

When the power of the system is turned on while a fault has not occurred in the cooling fan 11, the cables A and B are connected to the connectors CNA and CNB of the first fan unit 10. At this time, an edge from High (H) to Low (L) is generated in S0o signal by the Schmidt trigger component having a delay with respect to rise of the power source VCC.

[0106]

At the time of swapping fan unit 10 after a fault has occurred in the cooling fan 11, upon inserting the cable A to the connector CNA of the new fan unit (first fan unit) 10, output of the Schmidt trigger component (S0o) becomes an H state. Subsequently, upon inserting the cable B in the connector CNB of the new fan unit (first fan unit) 10, the cables A and B are connected to the connectors CNA and CNB, respectively. Consequently, an edge from H to L is generated in the S0o signal by the Schmidt trigger component.

[0107]

This change (edge) is only generated in the edge generating circuit 40 of the first fan unit 10 to which respective cables A and B of the connectors CNA and CNB are connected. The edge generated in the edge generating circuit 40 of the first fan unit 10 is transmitted to the second fan unit 10 and the subsequent fan units 10 via the S0o terminal of the connector CND (refer to area C1 in FIG. 19).

[0108]

As shown in FIG. 18, the pulse generating circuit 50 is configured to generate a pulse signal that is used to generate (calculate) the I2C slave address in each fan unit 10. The pulse generating circuit 50 includes circuit 51 and a D-FF (flip flop) 52 explained later in the document.

[0109]

By using the pulse generating circuit 50 shown in FIG. 18, a pulse signal is generated in accordance with a delay time DL4 in each fan unit 10 that is used as a count UP signal of the I2C address counter 60, and then transmitted to the next (subsequent) fan unit 10. In each fan unit 10, countable value AD0-3 counted by the I2C address counter 60, or the address value obtained by converting the countable value is automatically assigned and set to the fan controller 13 as a unique I2C slave address.

[0110]

In circuit 51 of pulse generating circuit 50, a logical sum (OR) of an input signal S0i and an inverted signal of the input signal S0i according to a delay time DL1 is output as a S0x (Reset) signal. Accordingly, regardless of the state of the S0i signal, the S0x signal, which is an output of the OR gate, is in the H state. Only when the S0i signal changes from the H state to a L state, a pulse signal of a time width DL1 is generated in the S0x (Reset) signal, which is the output of the OR gate (refer to FIG. 19). Functions and operation of the pulse generating circuit 50 is more specifically explained later while referring to FIG. 19.

[0111]

6. Operation of various fan units according to the present embodiment

Next, the operation of fan unit 10 according to the present embodiment will be explained while referring to FIG. 19. Here, operation performed when four fan units 10 shown in FIGS. 14 to 18 are serially connected (function of each fan module 10 as the controlling unit explained above) is explained in accordance with the time chart shown in FIG. 19. Particularly, an operation in which the I2C slave address is automatically generated, assigned, and set to the fan controller 13 of each fan unit 10 is explained. Furthermore, in FIG. 19, t1 to t11 indicate timing of a fixed time interval (for example, the time width DL1 in the present embodiment). For example, t1 indicates connection timing of cable A, and t3 indicates connection timing of the cable B.

[0112]

In the first fan unit 10, power and the control signal is respectively supplied from the power source unit 2 and the monitoring unit 7 via at least one of the two cables A and B. Cable A or cable B is removed from the connector CNA or the connector CNB one by one, and is connected to the connector CNA or the connector CNB of the new fan unit 10. Starting from the time when both cables A and B are connected to the connectors CNA and CNB of the new fan unit 10 (refer to t3 in FIG. 19), as shown in FIG. 19, an internal reset signal S0x (Reset) with the time width DL1 is generated for all fan units 10 (see t3 to t4 in FIG. 19).

[0113]

At this time, as shown in area C1 of FIG. 19, the internal reset signal S0x (Reset) changes to the L state for the time width DL1 at the same time in all fan units 10, and the reset processing is performed. As the reset processing, for example, a processing in which the countable value AD0-3 of the counter 60 is reset to zero, or a processing in which the D-FF 52 of the pulse generating circuit 50 is reset, is performed. In each fan unit 10, because the input S0i and the output S0o are directly connected, the internal reset signal S0x (Reset) is immediately transmitted to all fan units 10.

[0114]

After the reset is released by the internal reset signal S0x (Reset), a pulse signal for counting inside each fan unit 10 is generated with respect to the next fan unit 10 in sequence. Each fan unit 10 transmits to the subsequent fan unit 10 the pulse signal received from the previous fan unit 10 by delaying only for a predetermined delay time DL4 (refer to t3 to t5 and Arrow B1; t5 to t7 and Arrow B2; and t7 to t9 and Arrow B3 in FIG. 19). In each fan unit 10, the internal counter 60 counts the pulse signal received from the previous fan unit, and recognizes the countable value as the address AD0-3 of each fan unit 10.

[0115]

Particularly, in the edge generating circuit 40 shown in FIG. 17, a pulse signal with a delay time (time width, pulse width) DL1 is generated on the internal signal S0x in accordance with the edge notified from the first fan unit 10 (refer to t3 in FIG. 19). Accordingly, the I2C address counter 60 and the D-FF 52 of the pulse generating circuit 50 are reset. The S0i terminal of the connector CNC and the S0o terminal of the connector

CND are electrically serially-connected, and the D-FF 52 and the I2C address counter 60 inside all fan units 10 are reset. [0116]

Moreover, in the pulse generating circuit 50 shown in FIG. 18, an input pulse signal (pulse signal for counting) to be transmitted to the counter 60 that determines the I2C slave address is generated from the input signal Six. At this time, an FFCLK (clock) signal is generated by passing the input signal S1i through an RC integral circuit that prevents erroneous operation due to noise and the Schmidt trigger component. After the FF CLK signal is latched by the D-FF 52, a negative Low pulse signal is generated and output from the *Q terminal of the D-FF 52. Furthermore, because the negative Low pulse signal is delayed only for the predetermined delay time DL4 (> time width DL1 explained above), the negative Low pulse signal is transmitted from the S1o terminal of the connector CND to the subsequent fan unit 10 as the output signal S1o.

[0117]

The FF CLK signal explained above is also input to a CLK terminal of the I2C address counter 60 at the same time, and the I2C address counter 60 also counts the pulse signals generated by its own fan unit 10. Furthermore, because the S1i terminal is the open state in the first fan unit 10, by using a signal synchronized with the signal S0o from the edge generating circuit 40, a signal change (change from H to L; edge) that includes a predetermined delay time DL4 is generated in the signal S1o (refer to t5 in FIG. 19).

[0118]

The pulse signal generated in fan units 10 arranged up to the previous fan unit 10 are input from the S2i terminal of each fan unit 10. The input pulse signal is input to the I2C address counter 60 by passing through the RC integrated circuit that prevents erroneous operation due to noise, and the Schmidt trigger component. Subsequently, in addition to the pulse signals up to the previous fan unit 10, by inputting the pulse signal generated in its own fan unit 10 to the I2C address counter 60, the countable value counted by the counter 60 becomes larger by 1 from that calculated by the counter 60 of the previous fan unit 10. By using such a countable value as the I2C slave address for its own fan unit 10, an I2C slave address that is unique to each fan unit 10 can be assigned and set for each fan unit 10.

[0119]

A 4-bit counter, for example, can be used as the I2C address counter 60 that counts the countable value AD0-3. In server 1 shown in FIG. 12, the countable value counted by the counter 60 of the first fan unit 10 becomes "0", and the countable value counted by the counter 60 of the second fan unit 10 becomes "1". Moreover, the countable value counted by the counter 60 of the third fan unit 10 becomes "2", and the countable value counted by the counter 60 of the fourth fan unit 10 becomes "3". Such countable values are, for example, respectively converted to I2C slave addresses "ID", "IE", "IF", and "20", and are assigned to the fan controllers 13 of each fan unit 10.

[0120]

Here, as explained above, the time width (pulse width) DL1 is a time width of a pulse signal generated by the pulse generating circuit 50. Moreover, the predetermined delay time DL4 is set larger than that of the time width DL1 (for example, $DL4 = 2 \times DL1$ shown in FIG. 19). Accordingly, a transmission delay of the pulse signal is intentionally generated between the four fan units 10, and a count-up pulse signal (S2o) generated in each fan unit 10 is transmitted to the next fan unit 10 by delaying for the delay time DL4.

[0121]

In such a way, the pulse signal generated in each fan unit 10 is sent to the next fan unit 10 with a delay of the predetermined delay time DL4. Therefore, first to N-1st pulse signals are transmitted to an Nth fan unit 10 (N

is an integer equal to or greater than 1) without overlapping. By delaying the pulse transmission to the subsequent fan unit 10 in each fan unit 10, the pulse signal generated in the previous fan unit 10 and the pulse signal generated in its own fan unit 10 can be reliably sent to the subsequent fan unit 10.

[0122]

Furthermore, as shown in area C2 in FIG. 19, a pulse signal is generated by using the signal S1i transmitted from the previous fan unit 10 with the delay time DL4. Accordingly, a pulse signal generated in the previous fan unit 10 and the pulse signal generated in its own fan unit 10 are generated without overlapping and transmitted to the subsequent fan unit 10.

[0123]

As shown in area C3 in FIG. 19, because of the signal S2i, the pulse signals generated up to the previous fan unit 10 are not generated by overlapping and are transmitted with a fixed delay interval DL4. In such a manner, the pulse signal transmitted to fan unit 10 is counted up by the counter 60 of each fan unit 10, and a unique I2C slave address is assigned to the fan controller 13.

[0124]

Each fan controller 13 according to the present embodiment is monitored by the monitoring unit 7 via the I2C interface, and can control the rotation speed of the cooling fan 11 (driving motor) by a pulse width modulation (PWM) signal. At this step, the rotation speed of the cooling fan 11 is read as the number of pulses of a Taco signal. The temperature of the environment cooled by the cooling fan 11 is detected by reading the electric voltage of the temperature sensor. Moreover, abnormalities in the rotation speed, temperature, and the like of the cooling fan 11 are monitored by the monitoring unit 7 via the fan controller 13 and the I2C interface. Upon detecting an abnormality, an alarm signal *AL that indicates such abnormality is output in the negative logic.

[0125]

7. Hot-swapping procedure of fan unit in server according to the present embodiment

Next, hot-swapping procedure of fan unit 10 in server 1 to which the technology according to the present embodiment is applied is explained in accordance with a time chart shown in FIG. 20 (Steps S10 to S18 and Steps S20 to S24).

[0126]

As shown in FIG. 20, when a user such as an operator and a maintenance person inputs a power on instruction by pressing a power on button to start server 1 (Step S10), the system performs processes of Steps S11 to S18.

[0127]

Upon receiving the power on instruction from the outside, the management unit (management and monitoring unit) 7 instructs the power source unit 2 to turn on the power (Step S11).

[0128]

In accordance with the power on instruction to the power source unit 2, power supply and power on is performed in each fan unit 10. Subsequently, the I2C slave address is automatically assigned to the fan controller 13 of each fan unit 10 by executing the procedure explained above in accordance with the time chart shown in FIG. 19. Accordingly, communication becomes possible between the management unit 7 and the fan controller 13 (Step S12).

[0129]

The management unit 7 monitors the temperature of each fan unit 10 (environment cooled by the cooling

fan 11) and controls the rotation speed of the cooling fan 11 according to that temperature via the I2C interface. Moreover, the management unit 7 displays the state of each fan unit 10 (normal / faulty) on the fan fault external display panel 8 (Step SI 3). For example, each of the LEDs 8a to 8d of the fan fault external display panel 8 are controlled to be in the green color state when the corresponding fan unit 10 are in the normal state. On the other hand, each of the LEDs 8a to 8d is controlled to be in the yellow color state when the corresponding fan unit 10 is in the faulty state.

[0130]

Subsequently, the management unit 7 monitors whether the alarm signal (faulty state) of the cooling fan 11 is detected by the fan controller 13 via the I2C interface (Step SI4). When the alarm signal is not detected (NO route at Step S14), the management unit 7 returns to the processing performed at Step S13.

[0131]

On the other hand, when the alarm signal is detected (YES route at Step SI4), the management unit 7 identifies the target fan unit (faulty fan unit) 10 and reads the temperature of the target fan unit 10 via the I2C interface. Moreover, the management unit 7 controls the PWM signal transmitted from each fan controller 13 to the cooling fan 11 so as to forcefully cause the cooling fans 11 of all fan units 10 to rotate at 100% high speed. Furthermore, the management unit 7 causes the LED among the LEDs 8a to 8d corresponding to the target fan unit 10 on the fan fault external display panel 8 to be lit in the yellow color (Step SI5).

[0132]

Furthermore, in the present embodiment, each fan controller 13 is configured to switch the rotation state of the cooling fan 11 between a 100% high speed rotation and a normal rotation. When a fault in the cooling fan 11 is detected, or when a cable is connected to connector CNA or the connector CNB, that is, when it is recognized that it is time for hot-swapping of fan unit 10, the management unit 7 can forcefully switch the rotation state of the cooling fan 11 to the high speed rotation.

[0133]

Subsequently, maintenance work (Steps S21 to 24) in which the user hot-swaps the target fan unit 10 is performed (Step S20).

[0134]

At this step, first, the connector CND of the additional fan unit 10 is joined to the connector CNC of the existing fan unit (Step S21; refer to Arrow (1) in FIG. 6).

[0135]

Subsequently, cable A or cable B connected to the connector CNA or the connector CNB of the existing fan unit 10 is removed from the connector CNA or the connector CNB (Step S22; refer to Arrow (2) or (3) in FIG. 6). Consequently, after this operation, the insertable / removable indicator lamp 12 provided on the side surface of fan unit 10 is set to the yellow color lighting state (Step SI 6).

[0136]

Subsequently, the removed cable A or cable B is connected to the connector CNA or the connector CNB of the additional fan unit 10 (Step S23; refer to Arrow (2) or (3) in FIG. 6). Consequently, after this operation, the insertable / removable indicator lamp 12 provided on the side surface of fan unit 10 is set to the green color lighting state (Step SI7).

[0137]

In the present embodiment, the processes of Steps S22 and S23 and Steps S16 and S17 are performed once for each of the cable A and the cable B, respectively.

[0138]

After connecting the cables A and B to the connectors CNA and CNB of the additional fan unit 10, the additional fan unit 10 is pushed into server 1, and the existing fan unit 10 that is arranged on an opposite side of the additional fan unit 10 is pushed out from server 1 (Step S24; refer to Arrow (4) in FIG. 6).

[0139]

When fan unit 10 pushed out at Step 24 is the target fan unit, the pushed out fan unit 10 is removed and the operation is completed. When the pushed out fan unit 10 is not the target fan unit, the pushed out fan unit 10 is added and connected as the new additional fan unit 10, and the operations performed at Steps 21 to 24 are repeated till the target fan unit is pushed out.

[0140]

Subsequently, upon connecting the cables to the connectors CNA and CNB of the additional fan unit 10 at Step S23, in each fan unit 10, the I2C slave address is automatically assigned to each fan controller 13 of each fan unit 10 in accordance with the time chart shown in FIG. 19 by using the procedure explained above. Accordingly, based on the I2C slave address, management unit 7 recognizes the installation position of each fan unit 10 changed by hot-swapping and manages each fan unit 10 (Step SI 8). Subsequently, management unit 7 returns to the processing performed at Step S13.

[0141]

In such a manner, according to the present embodiment, even when fan unit 10 is swapped, installation position and the I2C slave address thereof are automatically synchronized. Therefore, even after the hot-swapping, it is possible to monitor and control the state of each fan unit 10 from the management monitoring unit 7 without manually setting the I2C slave address.

[0142]

In other words, according to server 1 explained above, a part of the fan units among the plurality of fan units 10 can be hot-swapped by the slide operation without using the exposed power rail configuration. In such a case, immediately after the hot swapping, an I2C slave address is automatically assigned by the controlling unit in each fan unit 10. Accordingly, an address associated with the position of each fan unit 10 can be assigned to each fan unit 10 even after fan unit 10 is hot-swapped.

[0143]

Accordingly, a link between the installation position of each fan unit 10 inside the casing of server 1 and the I2C slave address thereof can be established without performing any special operation, and the management unit 7 can correctly recognize each fan unit 10 and appropriately perform the rotation speed control or abnormality condition monitoring of each fan unit 10. Moreover, according to server 1 of the present embodiment, problems and issues of the related technology explained above by referring to FIGS. 1 to 4, too, can be resolved.

[0144]

8. Other

Preferred embodiments of the present invention are explained above; however, the present invention is not limited to such specific embodiments, and can be implemented with a variety of modifications and changes within the scope of the present invention.

[0145]

For example, in the embodiments explained above, four fan units 10 are arranged; however, the present invention is not limited thereto. Even when the number of fan units 10 is two, three, five or more, the present invention can be applied in the same manner as that in the embodiments explained above and the same effects

and advantages as that in the embodiments explained above can be obtained.

[0146]

9. Supplementary Notes

Regarding the embodiments explained above, the following supplementary notes are further disclosed.

[0147]

(Supplementary Note 1)

An electronic device comprising:

- an electronic apparatus, and

- a plurality of fan units that cools the serially-connected electronic apparatus;

wherein each fan unit among the plurality of the fan units includes a controlling unit that assigns an address that identifies its own fan unit among the plurality of the fan units to its own fan unit by associating the same with a connection position of its own fan unit among the plurality of the fan units.

[0148]

(Supplementary Note 2)

The electronic device as explained in the supplementary Note 1 includes a management unit that identifies each fan unit among the plurality of the fan units based on the assigned address, and manages each fan unit.

[0149]

(Supplementary Note 3)

The electronic device as explained in Supplementary Note 1 or 2, wherein the plurality of the fan units is configured so as to enable hot swapping of one fan unit among the plurality of the fan units by adding and connecting an additional fan unit to one end side of the plurality of the fan units and pushing out a fan unit arranged on the other side of the plurality of the fan units from the other side, and the controlling unit assigns to its own fan unit an address in accordance with the added connection of the additional fan unit.

[0150]

(Supplementary Note 4)

The electronic device as explained in supplementary Note 3, wherein the controlling unit includes

- a counter that counts a pulse signal received from a previous fan unit that is arranged before its own fan unit, and

- delays the pulse signal received from the previous fan unit by a predetermined delay time and outputs thereof to the subsequent fan unit arranged after its own fan unit, and

- assigns to its own fan unit a value in accordance with a countable value counted by the counter as the address.

[0151]

(Supplementary Note 5)

The electronic device as explained in supplementary Note 4, wherein two adjacent fan units among the plurality of the fan units transmit the pulse signal from one side to the other side, and are connected via an inter-fan unit connector that supplies power from one end to the other end.

[0152]

(Supplementary Note 6)

The electronic device as explained in supplementary Note 5, wherein each fan unit among the plurality of the fan units includes a power connector to which two or more power cables that can supply power to its own fan unit are connected when its own fan unit is arranged on one end side of the plurality of the fan units.

[0153]

(Supplementary Note 7)

A cooling fan controller that controls a plurality of fan units that cools a serially-connected electronic apparatus, comprising:

a controlling unit that assigns an address that identifies its fan unit among the plurality of the fan units to its own fan unit by associating the same with a connection position of its own fan unit among the plurality of the fan units.

[0154]

(Supplementary Note 8)

The cooling fan controller as explained in the supplementary Note 7 includes a management unit that identifies each fan unit among the plurality of the fan units based on the assigned address, and manages each fan unit.

[0155]

(Supplementary Note 9)

The cooling fan controller as explained in Supplementary Note 7 or 8, wherein the plurality of the fan units is configured so as to enable hot swapping of one fan unit among the plurality of the fan units by adding and connecting an additional fan unit to one end side of the plurality of the fan units and pushing out a fan unit arranged on the other side of the plurality of the fan units from the other side, and

the controlling unit assigns to its own fan unit an address in accordance with the added connection of the additional fan unit.

[0156]

(Supplementary Note 10)

The cooling fan controller as explained in supplementary Note 9, wherein the controlling unit includes a counter that counts a pulse signal received from a previous fan unit that is arranged before its own fan unit, and

delays the pulse signal received from the previous fan unit by a predetermined delay time and outputs thereof to the subsequent fan unit arranged after its own fan unit, and

assigns to its own fan unit a value in accordance with a countable value counted by the counter as the address.

[0157]

(Supplementary Note 11)

The cooling fan controller as explained in supplementary Note 10, wherein two adjacent fan units among the plurality of the fan units transmit the pulse signal from one side to the other side, and are connected via an inter-fan unit connector that supplies power from one end to the other end.

[0158]

(Supplementary Note 12)

The cooling fan controller as explained in supplementary Note 11, wherein each fan unit among the plurality of the fan units includes a power connector to which two or more power cables that can supply power to its own fan unit are connected when its own fan unit is arranged on one end side of the plurality of the fan units.

[0159]

(Supplementary Note 13)

A cooling fan control program that causes a processor that controls the plurality of the fan units that cools the serially-connected electronic apparatus to execute a processing in which an address that identifies its own fan unit among the plurality of the fan units to its own fan unit is assigned by associating the same with a connection

position of its own fan unit among the plurality of the fan units with a connection position of its own fan unit among the plurality of the fan units.

[0160]

(Supplementary Note 14)

The cooling fan control program as explained in supplementary Note 13, causes the processor to execute processing in which each fan unit among the plurality of the fan units is identified based on the assigned address to manage each fan unit.

[0161]

(Supplementary Note 15)

The cooling fan control program as explained in Supplementary Note 13 or 14, wherein the plurality of the fan units is configured so as to enable hot swapping of one fan unit among the plurality of the fan units by adding and connecting an additional fan unit to one end side of the plurality of the fan units and pushing out a fan unit arranged on the other side of the plurality of the fan units from the other side, and

the processor is caused to execute the processing in which an address is assigned to its own fan unit in accordance with the addition and connection of the additional fan unit.

[0162]

(Supplementary Note 16)

The cooling fan control program as explained in supplementary Note 15, wherein the processor is caused to execute the processing in which a pulse signal received from a previous fan unit that is arranged before its own fan unit is counted by a counter;

the pulse signal received from the previous fan unit is delayed by a predetermined delay time and is output to the subsequent fan unit arranged after its own fan unit, and;

a value in accordance with a countable value counted by the counter as the address is assigned to its own fan unit.

[0163]

(Supplementary Note 17)

A cooling fan controlling method by using which a plurality of fan units that cools serially-connected electronic apparatus is controlled by a processor, comprising:

assigning an address that identifies its own fan unit among the plurality of the fan units to its own fan unit by associating the same with a connection position of its own fan unit among the plurality of the fan units.

[0164]

(Supplementary Note 18)

The cooling fan controlling method as explained in the supplementary Note 17 includes identifying each fan unit among the plurality of the fan units based on the assigned address, and manages each fan unit, respectively.

[0165]

(Supplementary Note 19)

The cooling fan controlling method as explained in Supplementary Note 17 or 18, wherein the plurality of the fan units is configured so as to enable hot swapping of one fan unit among the plurality of the fan units by adding and connecting an additional fan unit to one end side of the plurality of the fan units and pushing out a fan unit arranged on the other side of the plurality of the fan units from the other side, and assigns to its own fan unit an address in accordance with the added connection of the additional fan unit.

[0166]

(Supplementary Note 20)

The cooling fan controlling method as explained in supplementary Note 19, wherein a pulse signal received from a previous fan unit that is arranged before its own fan unit is counted by a counter;

the pulse signal received from the previous fan unit is delayed by a predetermined delay time and is output to the subsequent fan unit arranged after its own fan unit, and

a value is assigned to its own fan unit in accordance with a countable value counted by the counter as the address.

FIGURE 1

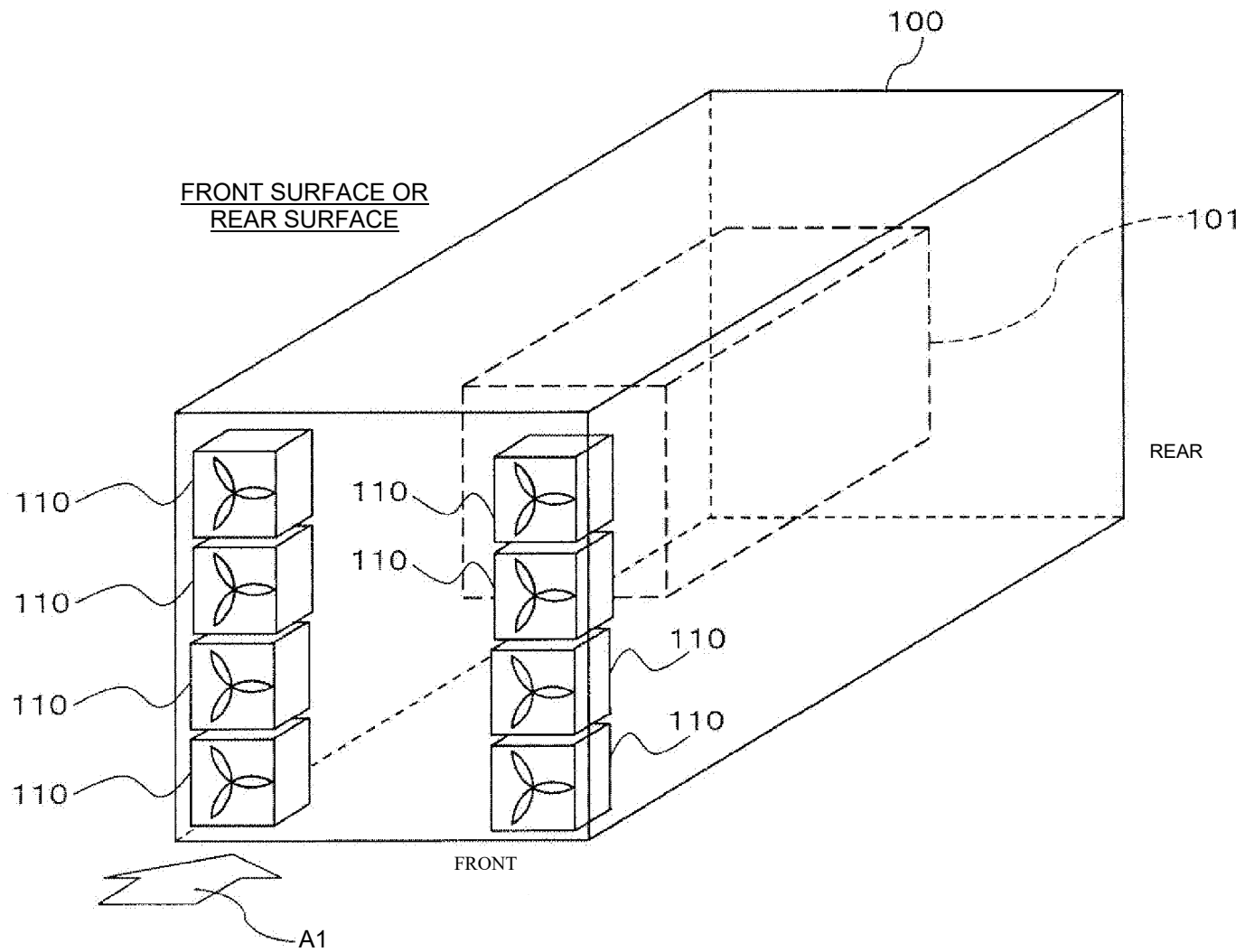


FIGURE 2

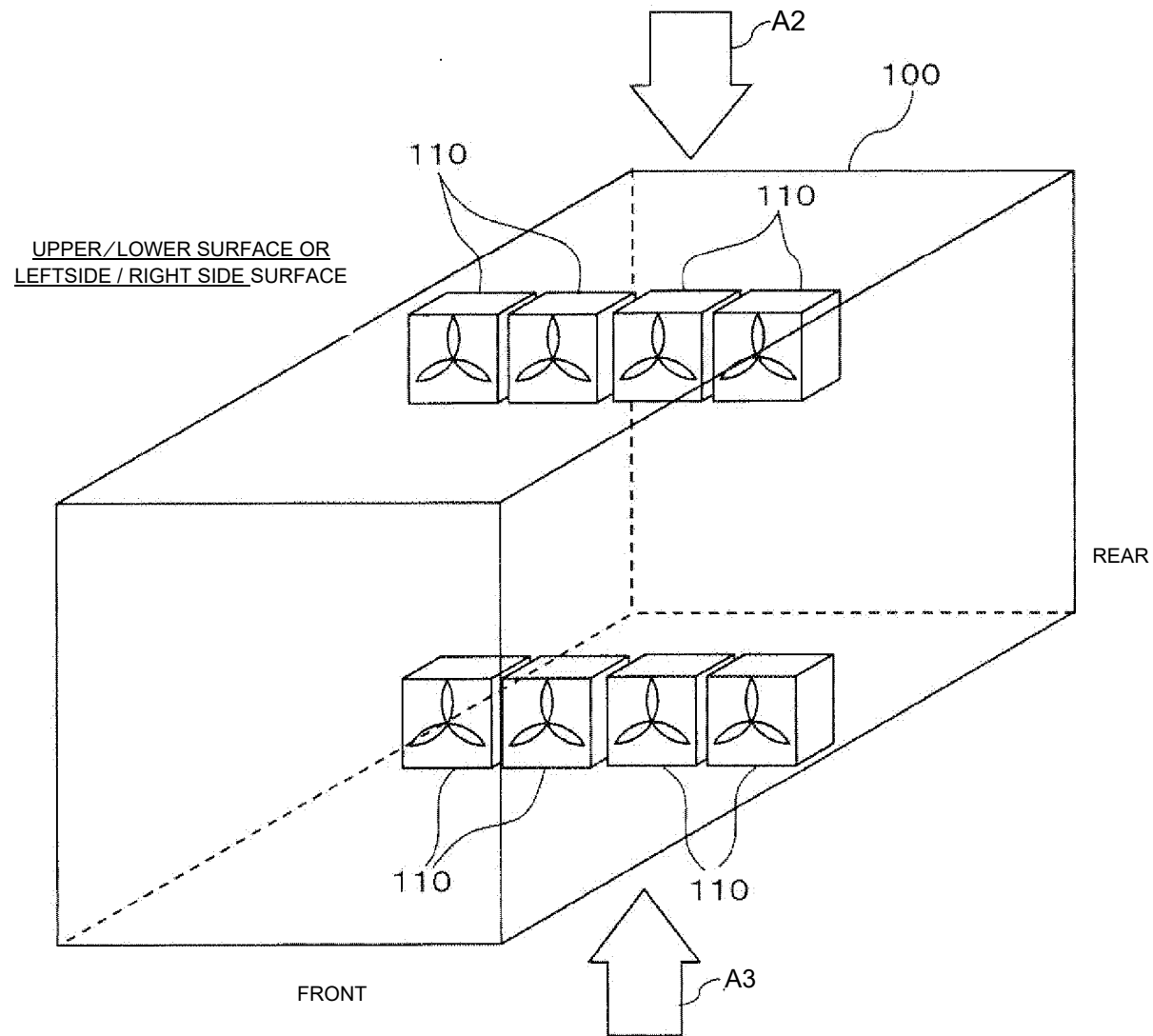


FIGURE 3

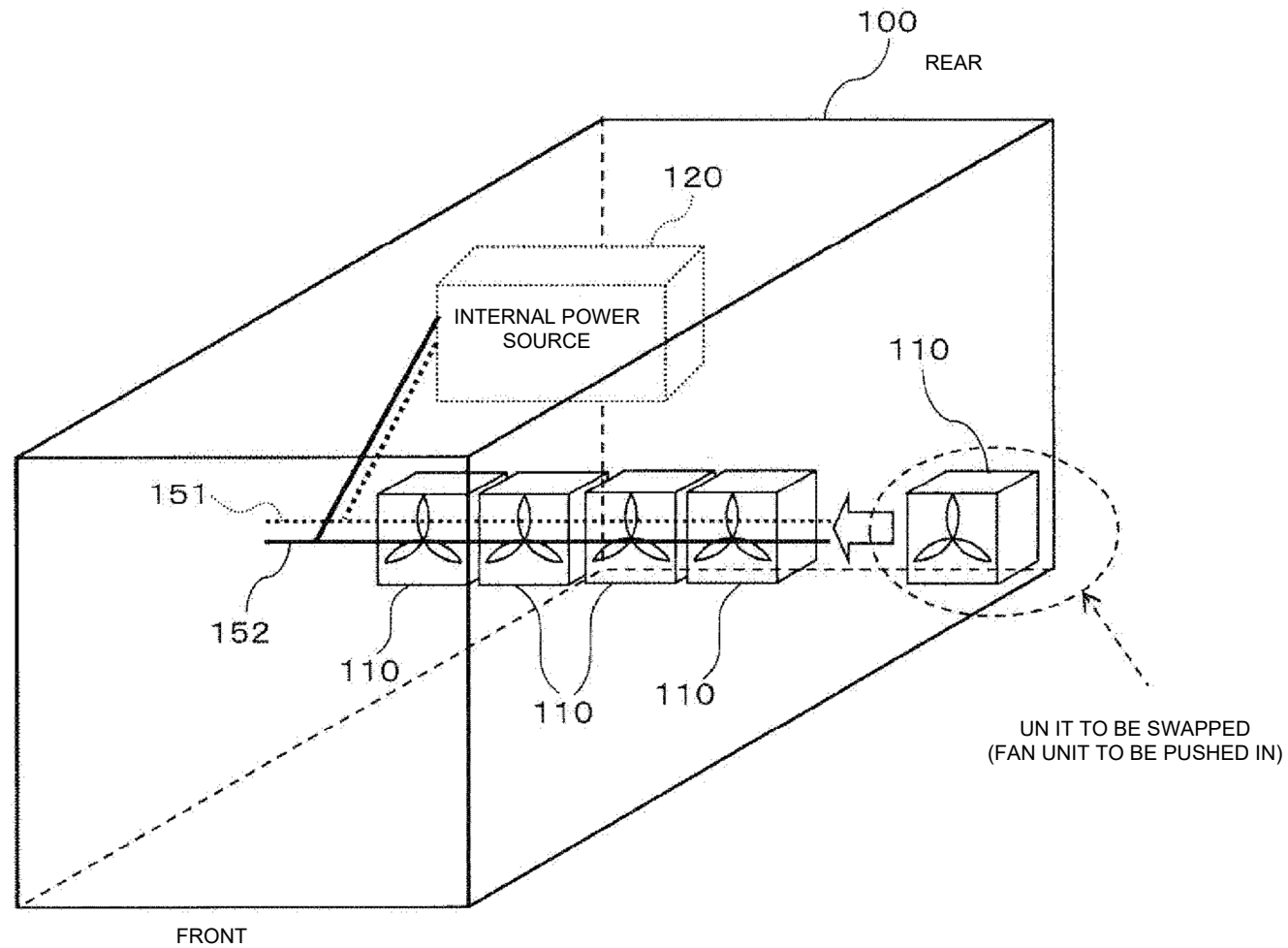


FIGURE 4

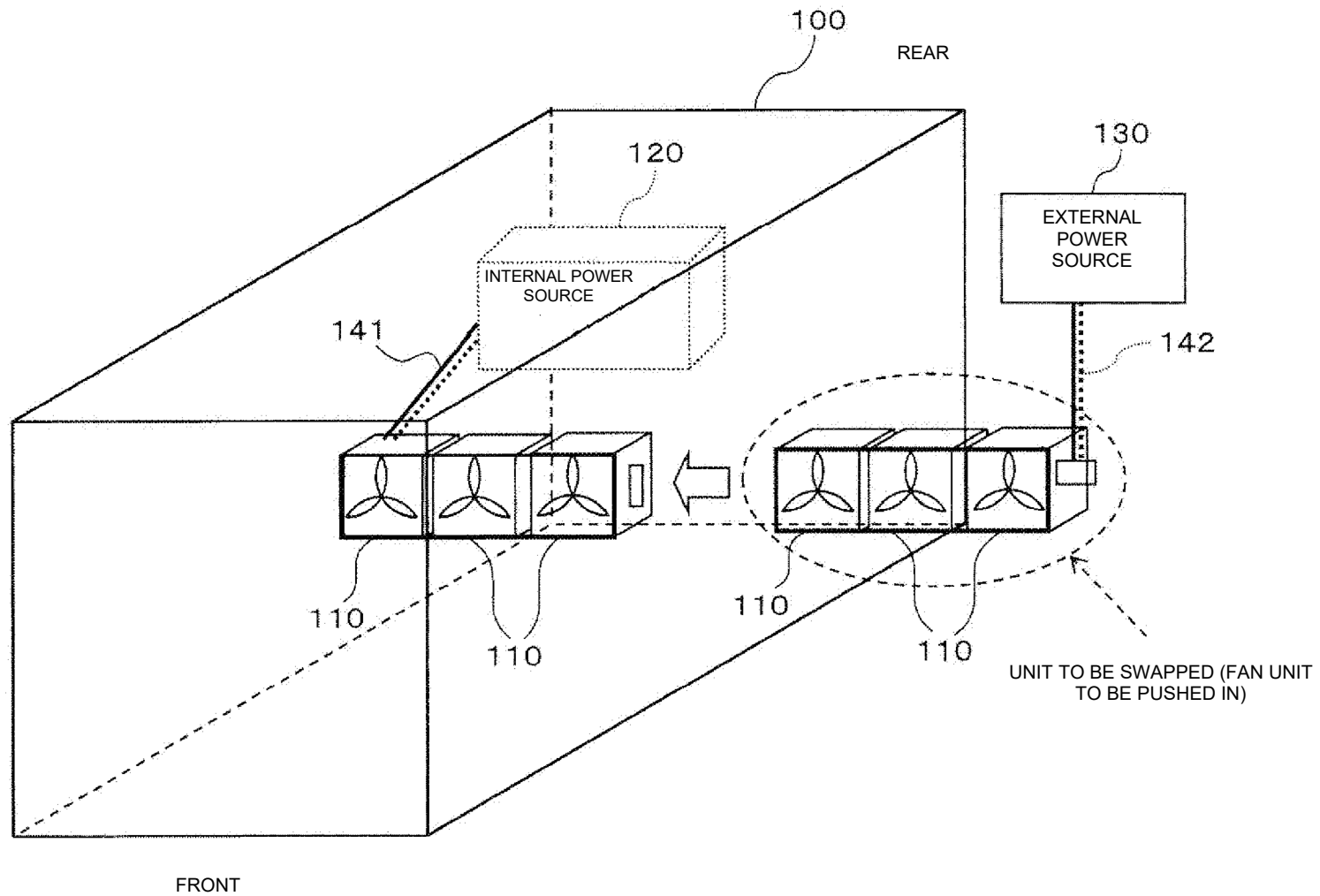


FIGURE 5

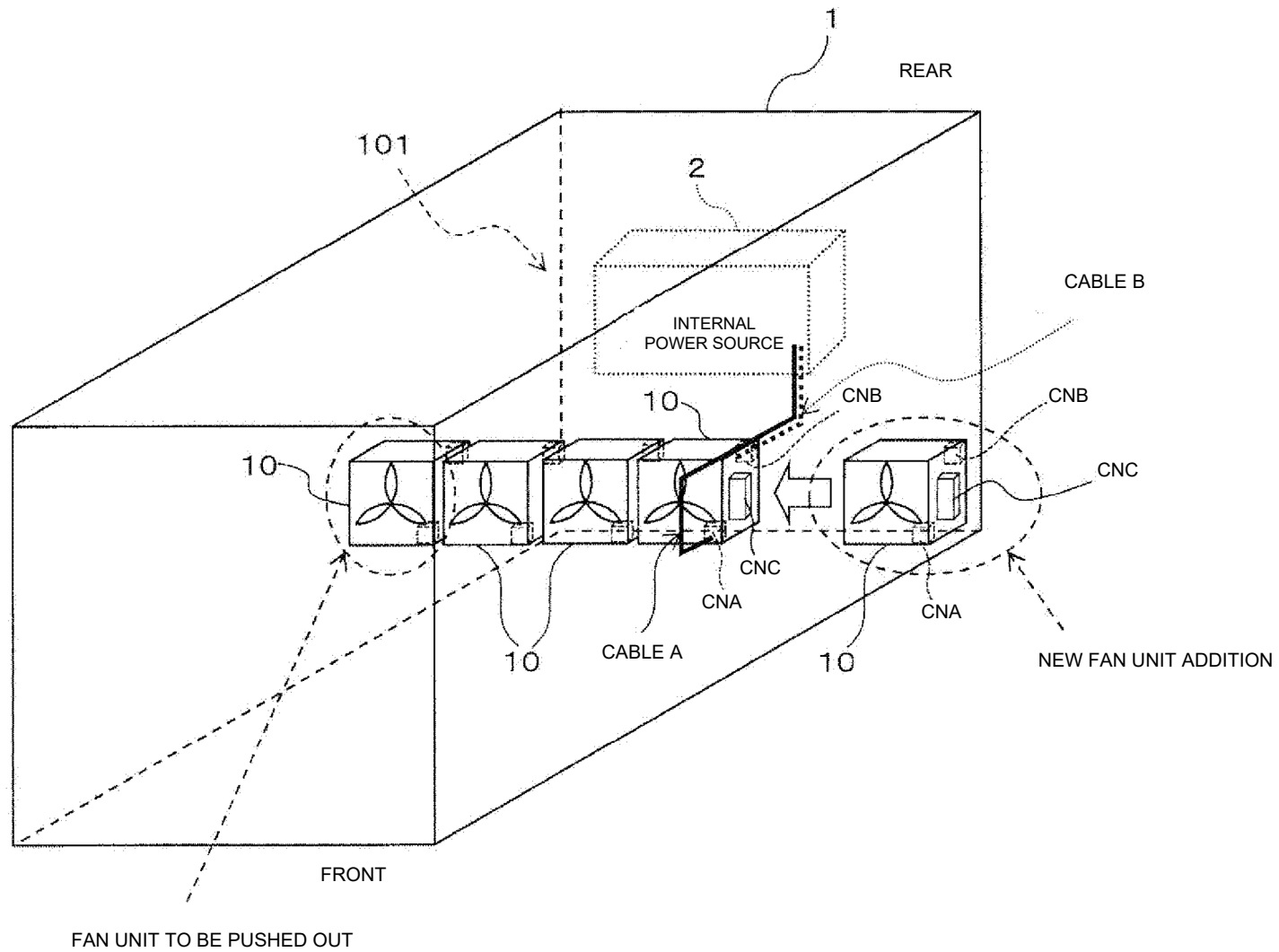


FIGURE 6

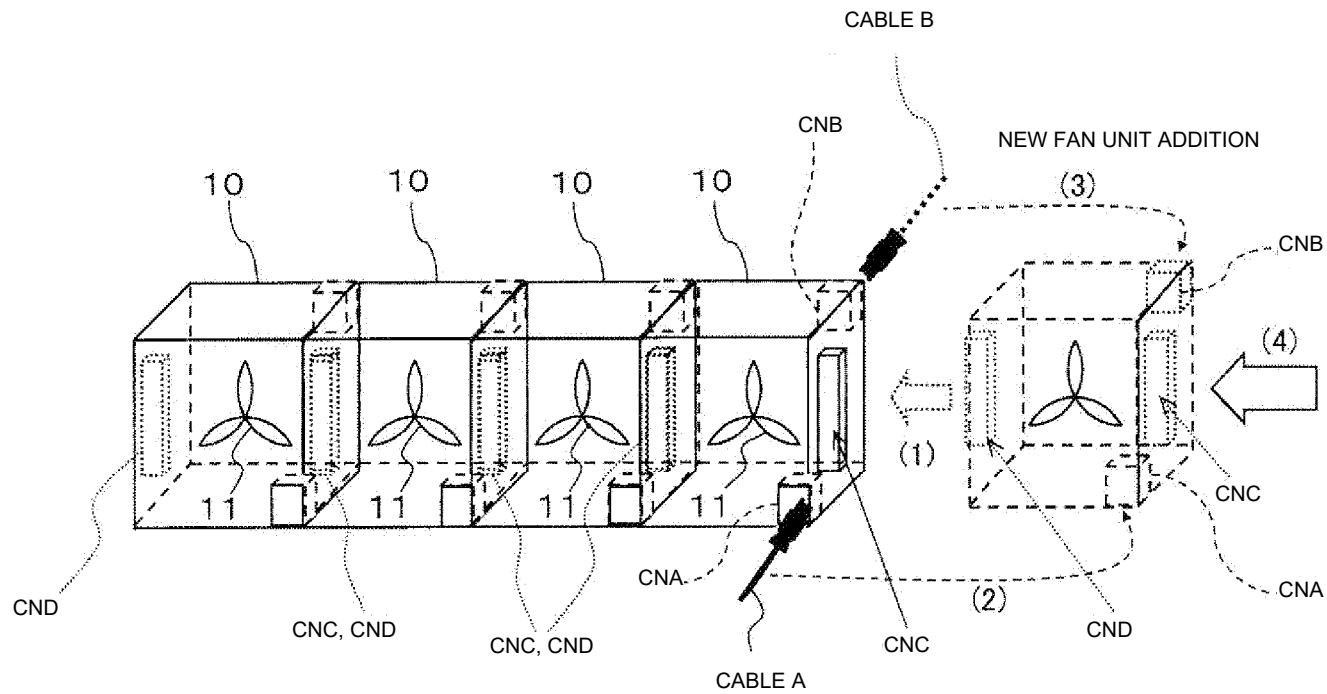


FIGURE 7

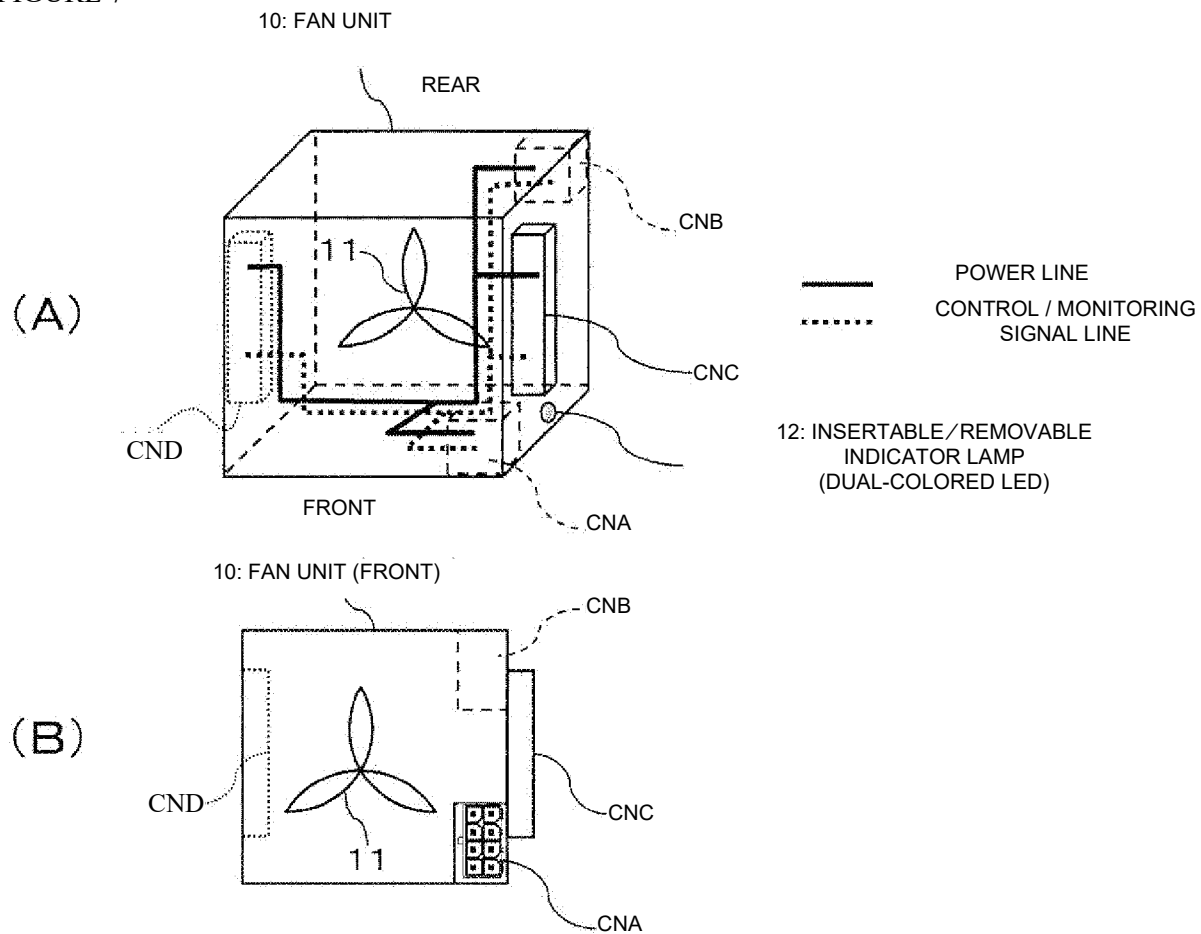
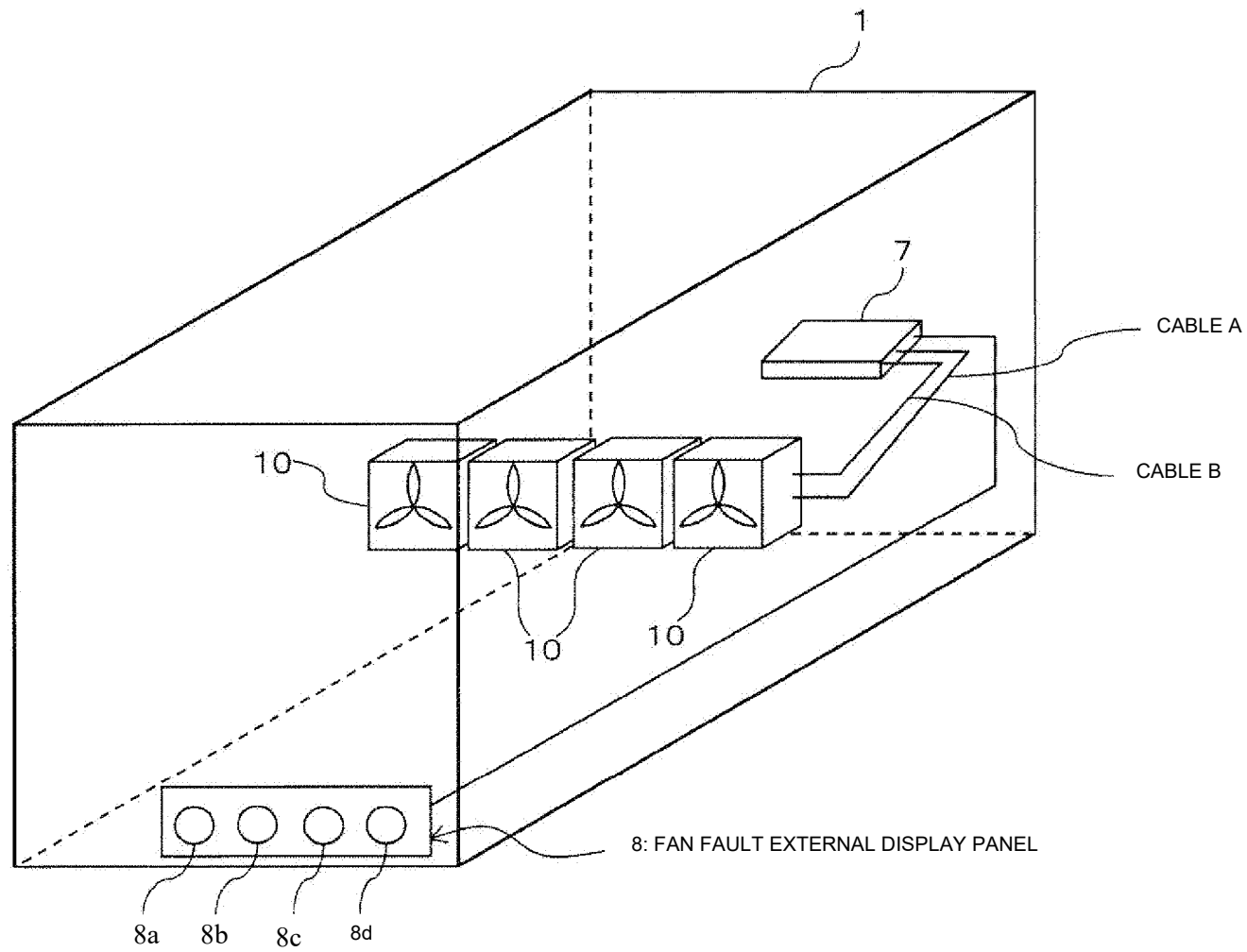


FIGURE 8



ALL FAN UNITS IN NORMAL STATE

FIGURE 9

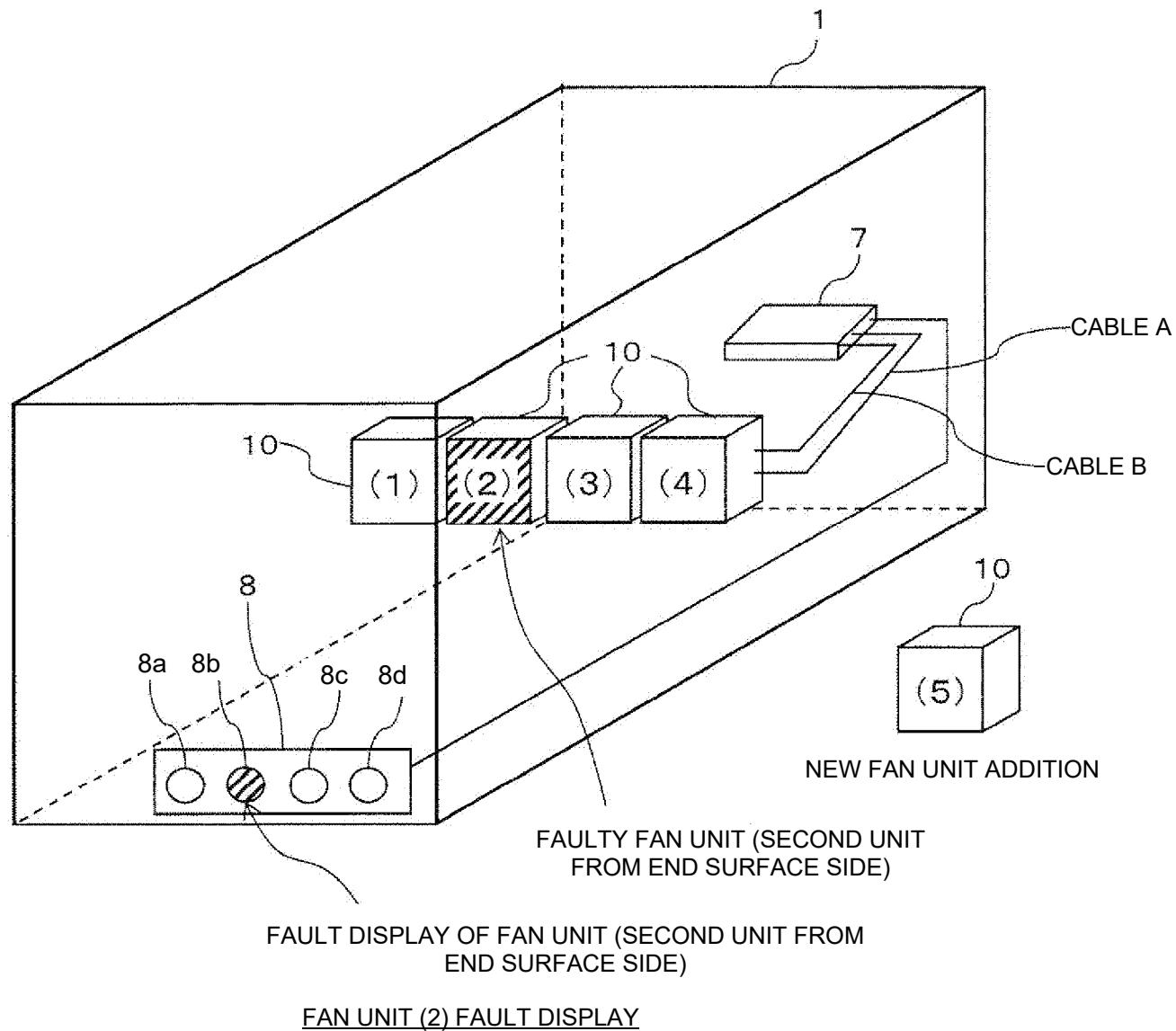
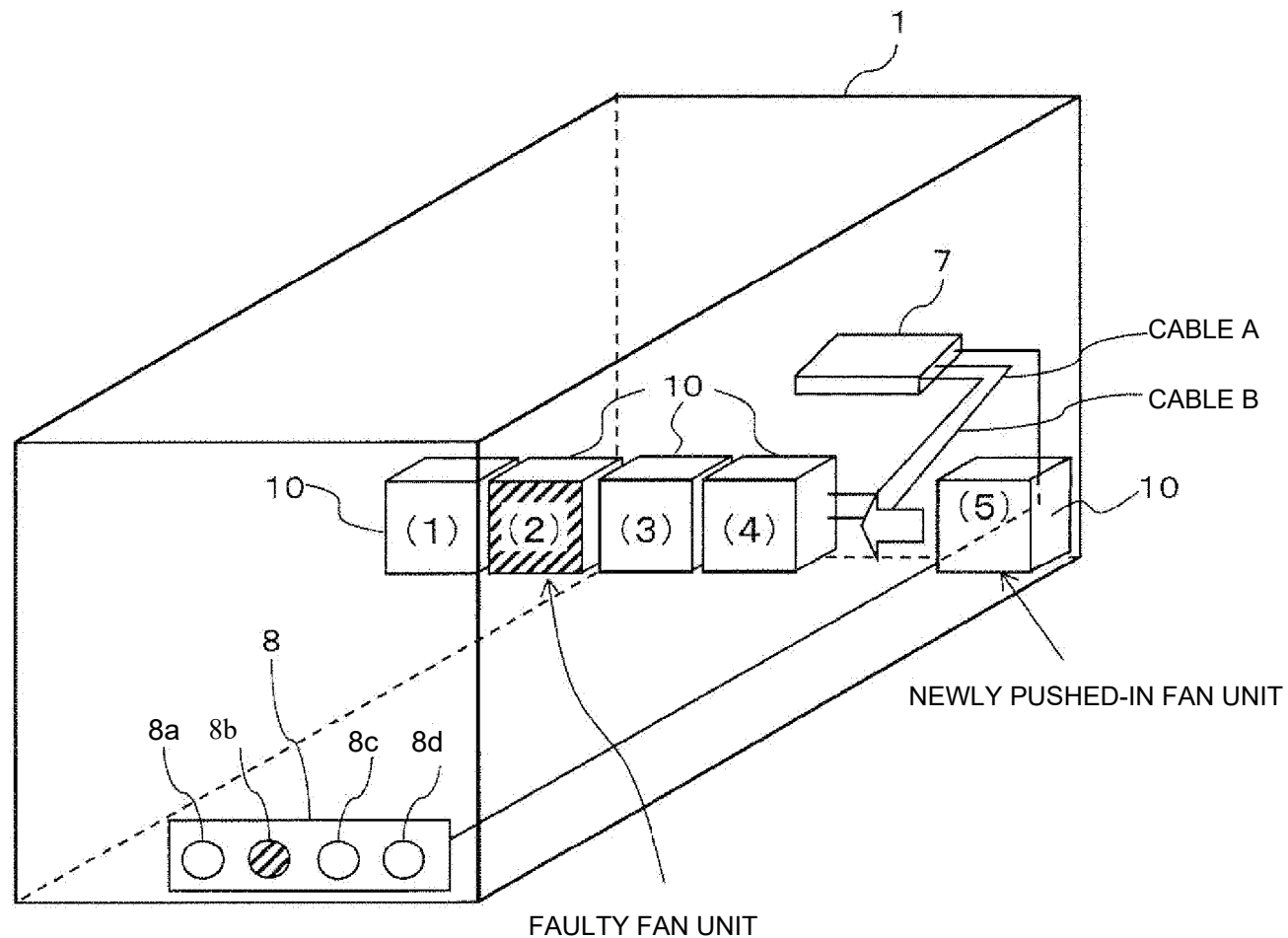
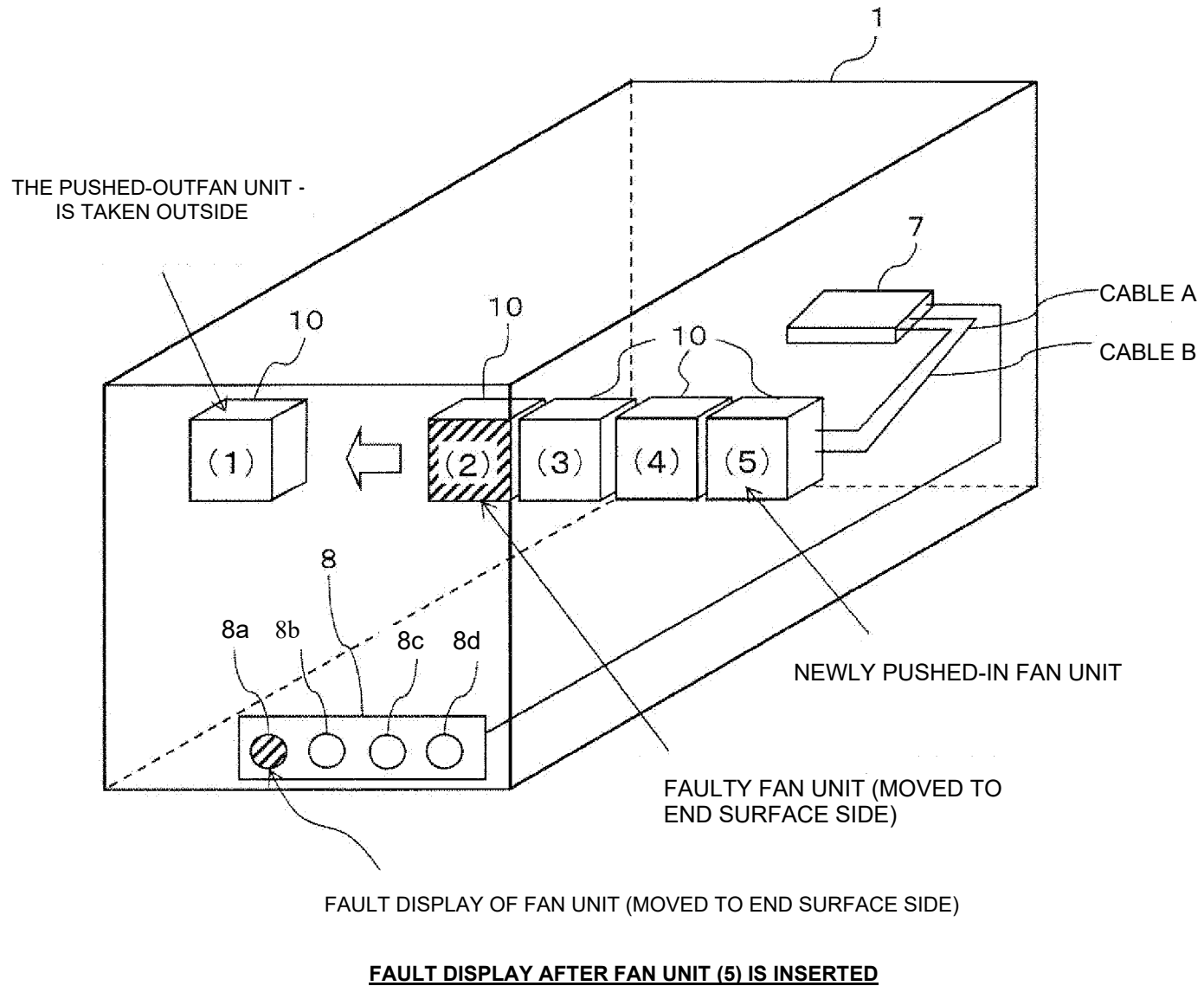


FIGURE 10



FAULT DISPLAY BEFORE FAN UNIT (5) IS INSERTED

FIGURE 11



[illegible]

FIGURE 13

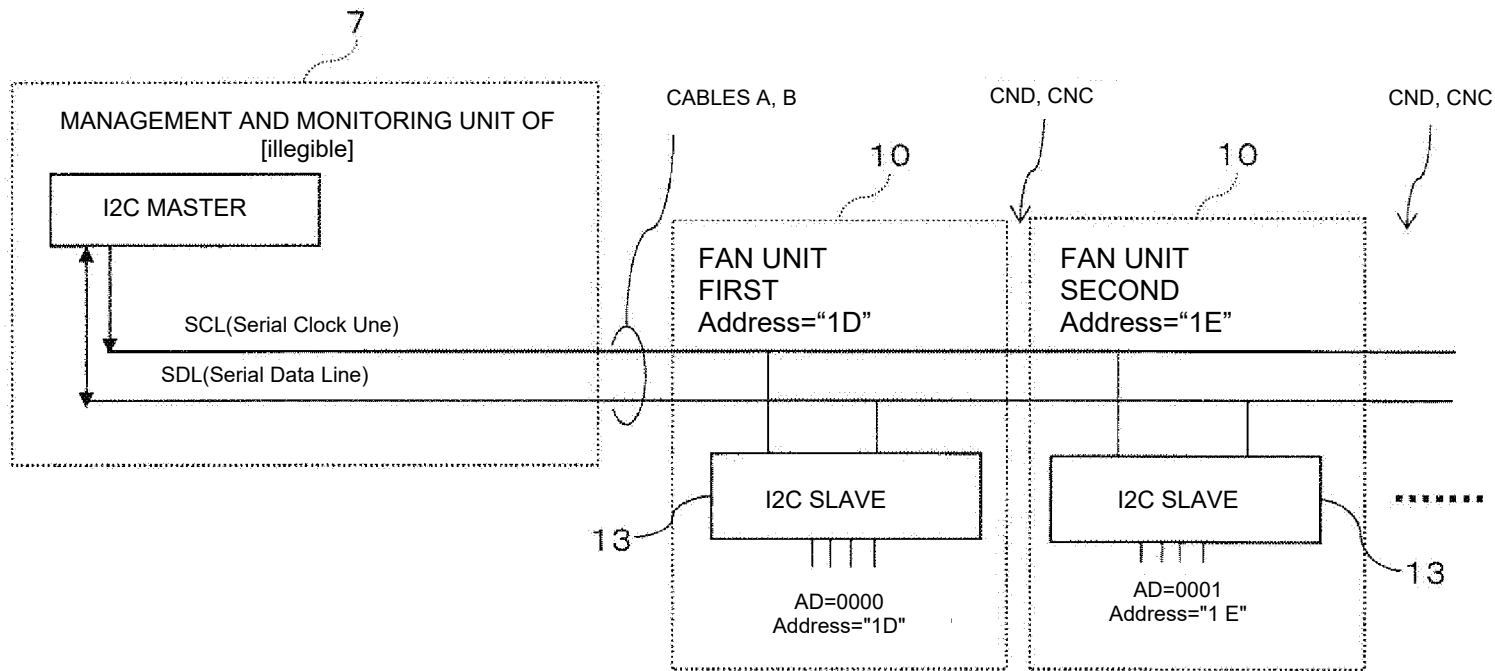


FIGURE 14

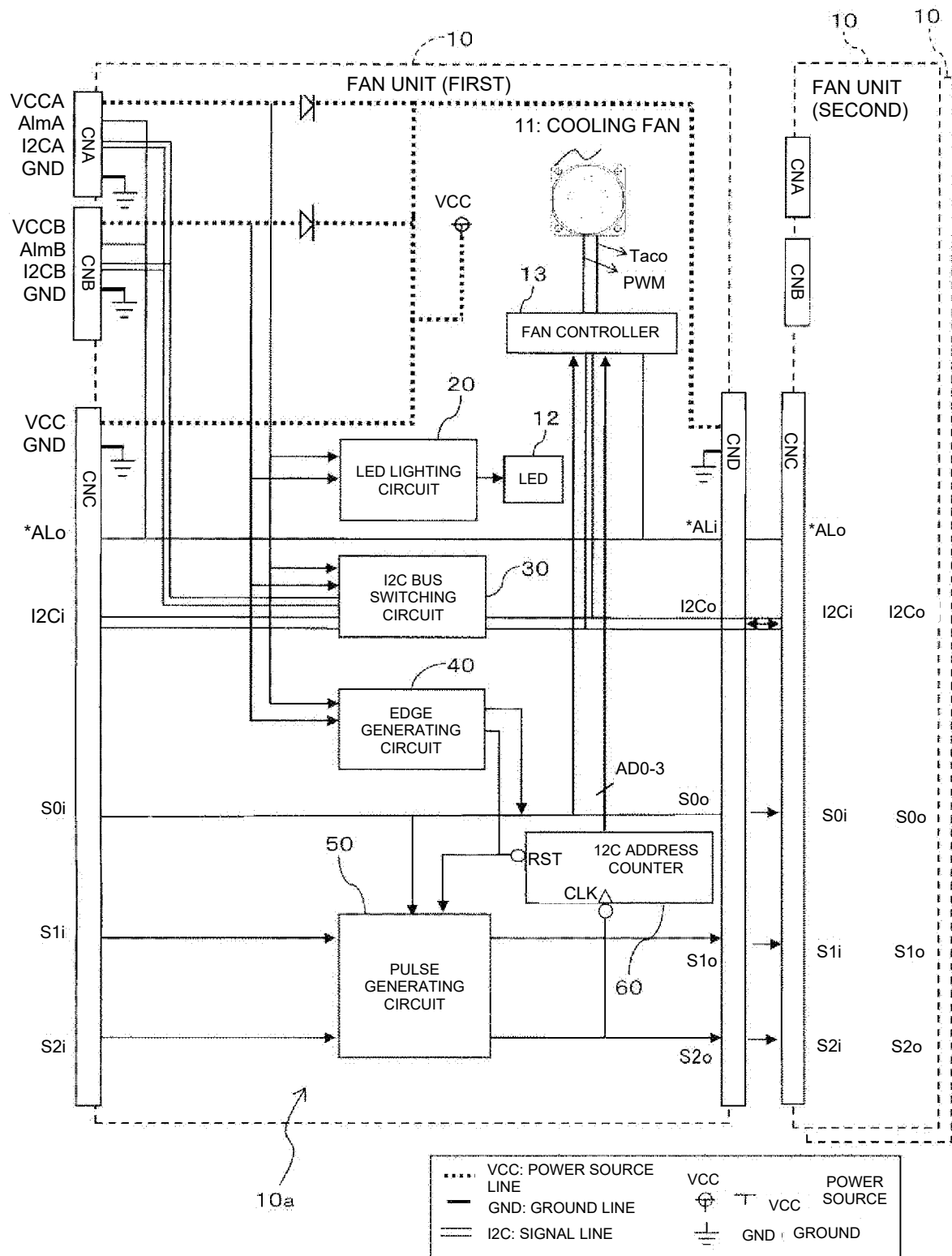


FIGURE 15

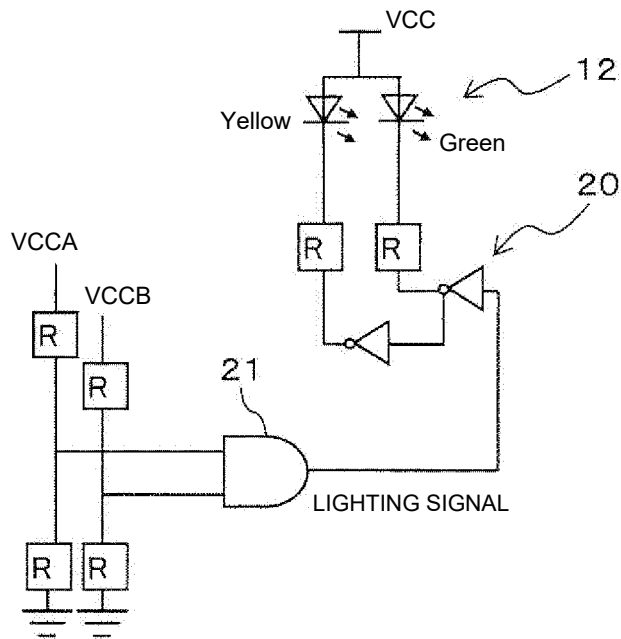


FIGURE 16

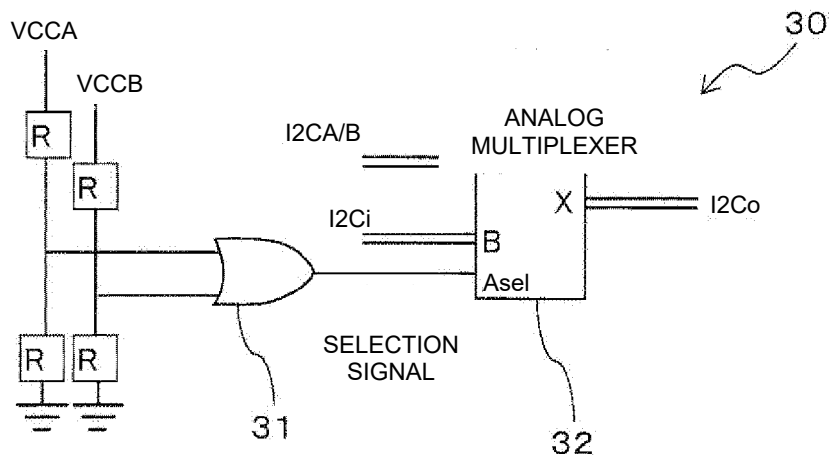


FIGURE 17

FIGURE 18

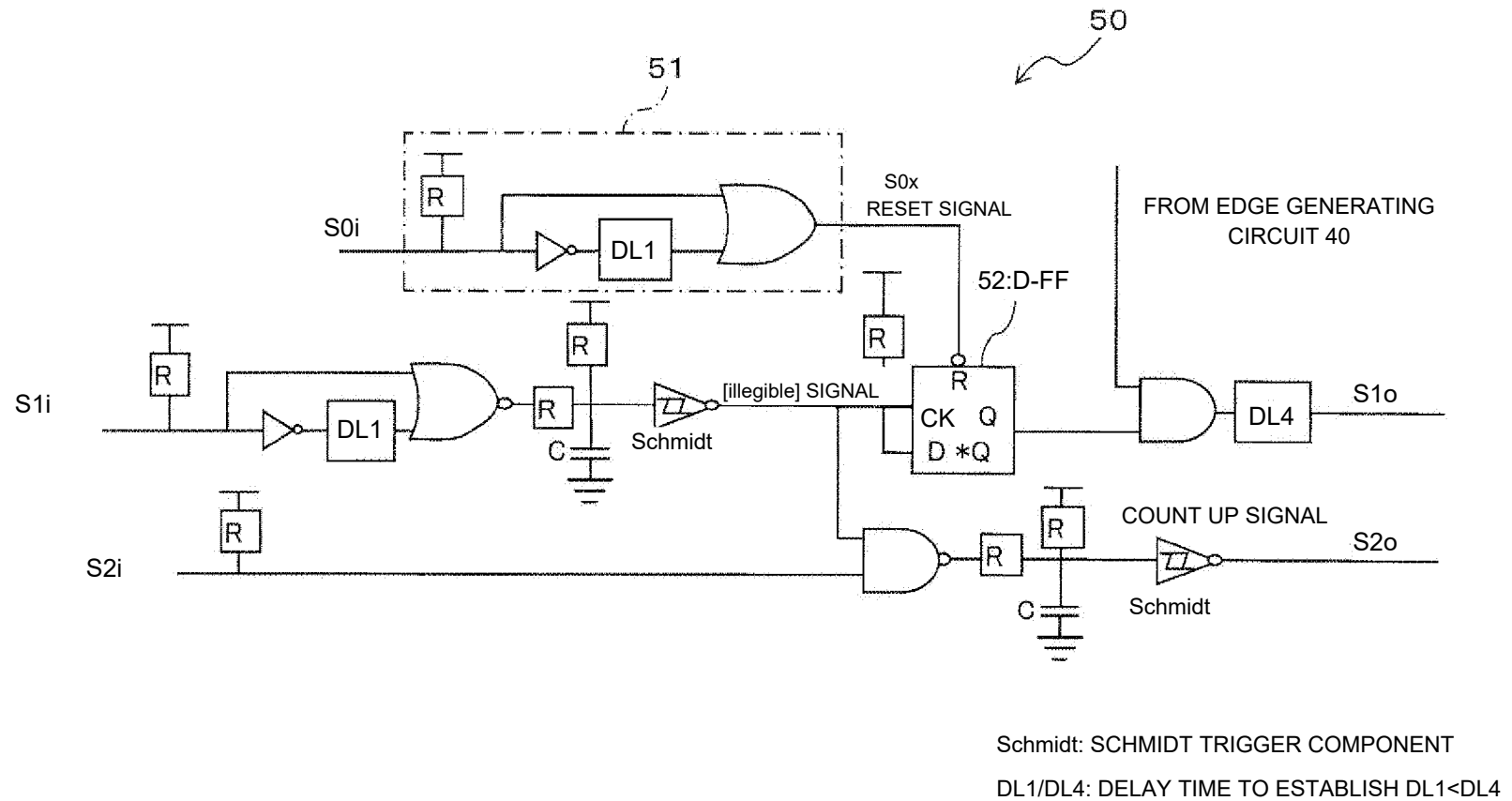


FIGURE 19

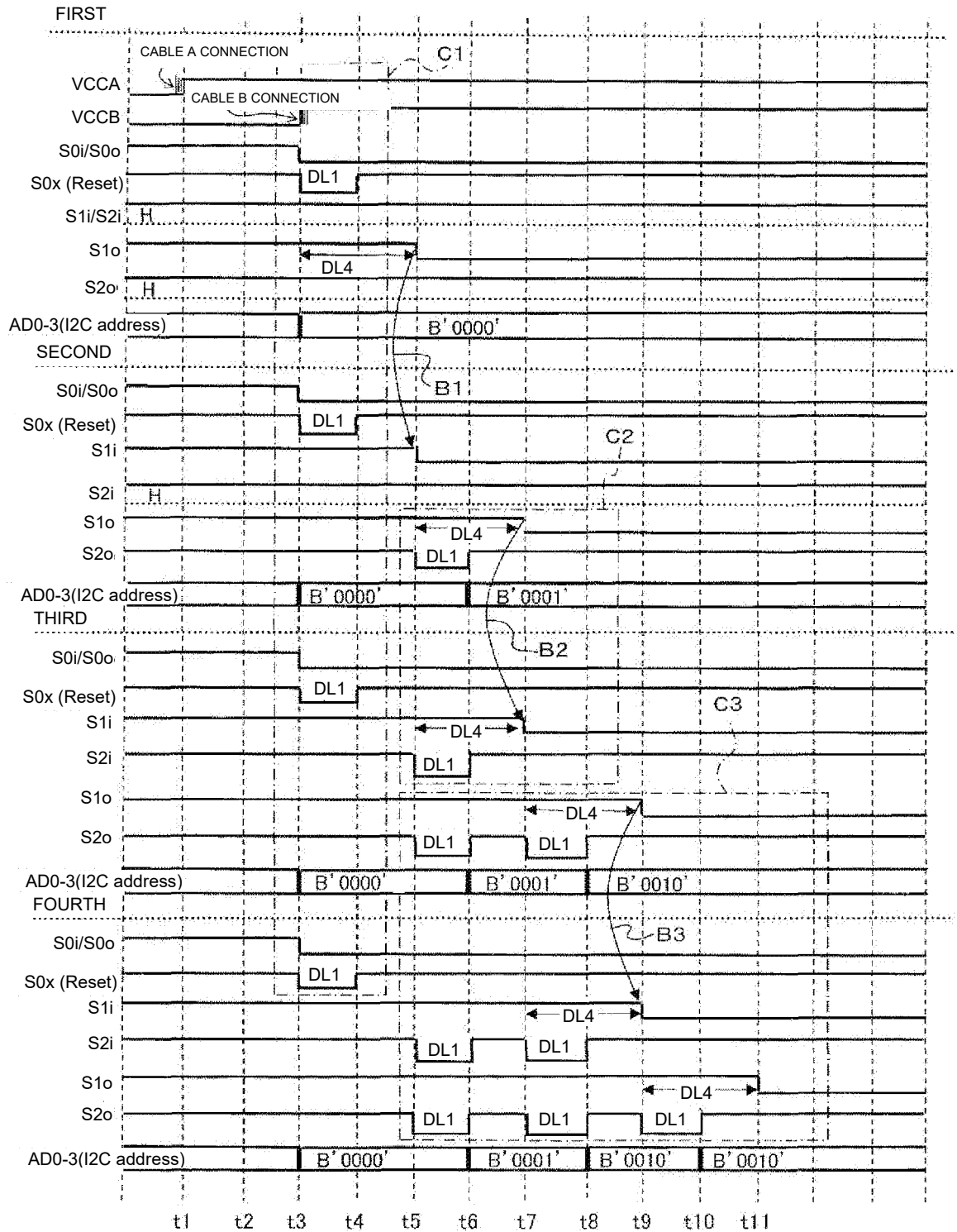


FIGURE 20

