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United States Patent Application Publication	20250260259
Kind Code	A1
Publication Date	August 14, 2025
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UNINTERRUPTIBLE POWER SUPPLY DEVICE

Abstract

First and second bases are arranged to face each other. An inverter is mounted on either of the first and second bases. A converter is mounted on the first base. A chopper is mounted on the second base. At least some of fins thermally connected to the converter via the first base are thermally connected to the chopper via the second base.

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Appl. No.:	**18/857659**
Filed (or PCT Filed):	**November 08, 2022**
PCT No.:	**PCT/JP2022/041558**

Publication Classification

Int. Cl.: **H02J9/06** (20060101); **H02M1/00** (20070101); **H02M1/10** (20060101); **H02M1/32** (20070101); **H02M3/00** (20060101); **H02M7/00** (20060101)

U.S. Cl.:

CPC **H02J9/062** (20130101); **H02M1/007** (20210501); **H02M1/10** (20130101); **H02M1/327** (20210501); **H02M3/003** (20210501); **H02M7/003** (20130101);

Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates to an uninterruptible power supply device.

BACKGROUND ART

[0002] For a power conversion device provided in an uninterruptible power supply device, a configuration including a converter that converts AC power supplied from an AC power supply into DC power, and stops when the AC power supply fails, a chopper that regulates a voltage of DC power supplied from a power storage device while the AC power supply is in failure, and an inverter that converts the DC power output from the converter or the DC power output from the power storage device into AC power and supplies the power to a load has been widely employed.

[0003] In such a power conversion device, the converter and the inverter are active under normal conditions where the AC power is normally supplied from the AC power supply. When a power failure occurs, that is, the supply of the AC power from the AC power supply is interrupted, the chopper and the inverter become active to continue power supply.

[0004] Then, a configuration where a converter, an inverter, and a chopper are mounted on one surface of one heat sink, fins are provided on the other surface of the heat sink, and air from a cooling fan is applied to the fins to release heat of the converter, the inverter, and the chopper is known. In such a configuration, some fins are not used to release heat in both a case where power supply is performed under normal conditions and a case where power supply is performed under a power failure, which results in a cooling structure that is low in fin utilization rate.

[0005] For example, a heat sink that increases the fin utilization rate is disclosed in Japanese Patent Laying-Open No. 2012-182159 (PTL 1). The heat sink disclosed in PTL 1 is provided with a heat pipe. This allows heat to diffuse throughout the fins, and thus allows the heat sink to efficiently release heat.

CITATION LIST

Patent Literature

[0006] PTL 1: Japanese Patent Laying-Open No. 2012-182159

SUMMARY OF INVENTION

Technical Problem

[0007] The use of the heat sink provided with the heat pipe as described above or a heat sink using a thermal diffusion material allows heat to diffuse throughout the fins. The use of the heat pipe or the thermal diffusion material, however, increases the cost of the device.

[0008] The present disclosure has been made to solve the above-described problems, and it is therefore an object of the present disclosure to provide an uninterruptible power supply device that allows not only a reduction in cost and size of the device, but also an increase in cooling efficiency.

Solution to Problem

[0009] An uninterruptible power supply device of the present disclosure is connected between an AC power supply and a load. The uninterruptible power supply device includes a heat sink and a power conversion device. The heat sink includes first and second bases, and fins. The first and second bases are arranged to face each other. The fins are arranged between the first and second bases and coupled to both the first and second bases. The power conversion device is mounted on a surface of each of the first and second bases opposite to a surface to which the fins are coupled. The power conversion device includes a converter, a chopper, and an inverter. The converter converts AC power supplied from the AC power supply into DC power, and stops when the AC power supply fails. The chopper regulates a voltage of DC power supplied from a power storage device while the AC power supply is in failure. The inverter converts the DC power output from the converter or the DC power output from the power storage device into AC power to supply power to the load. The inverter is mounted on either of the first and second bases. The converter is mounted on the first base. The chopper is mounted on the second base. At least some of the fins thermally connected to the converter via the first base are thermally connected to the chopper via

the second base.
Advantageous Effects of Invention
[0010] According to the present disclosure, it is possible to provide the uninterruptible power supply device that allows not only a reduction in cost and size of the device, but also an increase in cooling efficiency.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0011] FIG. **1** is a diagram for describing a circuit configuration of an uninterruptible power supply device.
[0012] FIG. **2** is a diagram for describing the circuit configuration of the uninterruptible power supply device.
[0013] FIG. **3** is a plan view of a heat sink and a power conversion device in the related art.
[0014] FIG. **4** is a front view of the heat sink and the power conversion device illustrated in FIG. **3**.
[0015] FIG. **5** is a front view of the heat sink and the power conversion device illustrated in FIG. **3**.
[0016] FIG. **6** is a plan view of a heat sink and a power conversion device according to the present embodiment.
[0017] FIG. **7** is a bottom view of the heat sink and the power conversion device illustrated in FIG. **6**.
[0018] FIG. **8** is a front view of the heat sink and the power conversion device illustrated in FIG. **6**.
[0019] FIG. **9** is a front view of the heat sink and the power conversion device illustrated in FIG. **6**.
[0020] FIG. **10** is a front view of a heat sink and a power conversion device according to a first modification.
[0021] FIG. **11** is a front view of a heat sink and a power conversion device according to a second modification.
DESCRIPTION OF EMBODIMENTS
[0022] Hereinafter, an embodiment of the present disclosure will be described in detail with reference to the drawings. Note that, in the following description, the same or corresponding parts in the drawings are denoted by the same reference numerals, and no redundant description will be given of such parts in principle.
[0023] FIGS. **1** and **2** are diagrams for describing a circuit configuration of an uninterruptible power supply device **1**. Uninterruptible power supply device **1** is connected between a commercial AC power supply **31** and a load **32**. Uninterruptible power supply device **1** first converts three-phase AC power from commercial AC power supply **31** into DC power, then converts the DC power into three-phase AC power, and finally supplies the three-phase AC power to load **32**.
[0024] Uninterruptible power supply device **1** includes a power conversion device **20**, a bypass circuit (semiconductor switch) **35**, and a control device **30**. Power conversion device **20** includes a converter **24**, a chopper **25**, and an inverter **23**.
[0025] Converter **24** converts AC power supplied from commercial AC power supply **31** into DC power. Converter **24** stops when commercial AC power supply **31** fails. Chopper **25** regulates a voltage of DC power supplied from a power storage device (hereinafter, also referred to as “battery”) **33** while commercial AC power supply **31** is in failure. Inverter **23** converts DC power output from converter **24** or DC power output from battery **33** into AC power and supplies the AC power to load **32**.
[0026] Converter **24**, chopper **25**, and inverter **23** each include an insulated gate bipolar transistor (IGBT) and a diode. The IGBT acts as a “switching element”.
[0027] In the present embodiment, uninterruptible power supply device **1** performs inverter power supply, battery power supply, or bypass power supply. During the inverter power supply, converter

24 converts AC power supplied from commercial AC power supply **31** into DC power, and inverter **23** converts the DC power into AC power and supplies the AC power to load **32**.
[0028] During the bypass power supply, AC power supplied from commercial AC power supply **31** is supplied to load **32** via semiconductor switch **35**, that is, without passing through either converter **24** or inverter **23**. During the battery power supply, chopper **25** regulates the voltage of DC power supplied from battery **33**, and inverter **23** converts the DC power into AC power and supplies the AC power to load **32**.
[0029] Uninterruptible power supply device **1** further includes an AC input terminal T**1**, an AC output terminal T**2**, a battery terminal T**3**, and electromagnetic contactors **36** to **38**. AC input terminal T**1** receives AC power of a commercial frequency from commercial AC power supply **31**. AC output terminal T**2** is connected to load **32**. Load **32** is driven by AC power. Battery terminal T**3** is connected to battery **33**. Battery **33** stores DC power.
[0030] Electromagnetic contactor **36** is connected between AC input terminal T**1** and an input node of converter **24**. Electromagnetic contactor **36** is on while uninterruptible power supply device **1** is in use, and is off, for example, while uninterruptible power supply device **1** is under maintenance.
[0031] Under normal conditions where AC power is supplied from commercial AC power supply **31** (during the inverter power supply), converter **24** is controlled by control device **30** to convert (rectify) three-phase AC power into DC power and outputs the DC power to a DC line L**1**. When a power failure occurs, that is, the supply of AC power from commercial AC power supply **31** is interrupted, converter **24** is brought to a stop. It is possible to regulate the output voltage of converter **24** to a desired value.
[0032] DC line L**1** is connected to a high-voltage side node of chopper (bidirectional chopper) **25**, and a low-voltage side node of chopper **25** is connected to battery terminal T**3** via electromagnetic contactor **38**. Electromagnetic contactor **38** is on while uninterruptible power supply device **1** is in use, and is off, for example, while uninterruptible power supply device **1** and battery **33** are under maintenance.
[0033] Chopper **25** is controlled by control device **30** to store DC power generated by converter **24** into battery **33** under normal conditions where AC power is supplied from commercial AC power supply **31** (during the inverter power supply) and to supply DC power of battery **33** to inverter **23** through DC line L**1** when an instantaneous voltage drop or a power failure occurs (during the battery power supply).
[0034] In a case where DC power is stored into battery **33**, chopper **25** steps down a DC voltage of DC line L**1** and feeds the stepped-down DC voltage to battery **33**. Further, in a case where the DC power of battery **33** is supplied to inverter **23**, chopper **25** boosts the voltage across the terminals of battery **33** and outputs the voltage to DC line L**1**. DC line L**1** is connected to an input node of inverter **23**.
[0035] Inverter **23** is controlled by control device **30** to convert (invert) DC power supplied from converter **24** or chopper **25** through DC line L**1** into three-phase AC power of a commercial frequency and outputs the three-phase AC power. That is, inverter **23** converts the DC power supplied from converter **24** through DC line L**1** into three-phase AC power under normal conditions (during the inverter power supply), and converts the DC power supplied from battery **33** via chopper **25** into three-phase AC power when an instantaneous voltage drop or a power failure occurs, that is, during the battery power supply. It is possible to regulate the output voltage of inverter **23** to a desired value.
[0036] Inverter **23** is connected to AC output terminal T**2** via electromagnetic contactor **37**. Electromagnetic contactor **37** is controlled by control device **30**, and is on during the inverter power supply or the battery power supply, and is off during the bypass power supply.
[0037] Semiconductor switch **35** includes a thyristor switch having a pair of thyristors connected in antiparallel, and is connected between AC input terminal T**1** and AC output terminal T**2**. Semiconductor switch **35** is controlled by control device **30**, and is off during the inverter power

supply or the battery power supply, and is on during the bypass power supply. For example, when inverter **23** suffers a breakdown during the inverter power supply, semiconductor switch **35** is quickly turned on to supply three-phase AC power from commercial AC power supply **31** to load **32**.

[0038] Control device **30** controls entire uninterruptible power supply device **1**. Control device **30** can be implemented by, for example, a microcomputer or the like. As an example, control device **30** includes a memory and a central processing unit (CPU) (not illustrated), and can perform a control operation by software processing performed in accordance with a program prestored in the memory and executed by the CPU. Alternatively, part or all of the control operation can be implemented by hardware processing using a built-in dedicated electronic circuit or the like, rather than the software processing.

[0039] AC input terminal T**1** receives a three-phase AC voltage (U-phase AC voltage, V-phase AC voltage, and W-phase AC voltage) from commercial AC power supply **31**. A three-phase AC voltage synchronized with the three-phase AC voltage from commercial AC power supply **31** is output to AC output terminal T**2**. Load **32** is driven by the three-phase AC voltage from AC output terminal T**2**.

[0040] As illustrated in FIG. **1**, since converter **24** and inverter **23** are active during the inverter power supply, the amount of heat released from converter **24** and inverter **23** becomes large. Further, chopper **25** is also active to charge battery **33**, but the amount of heat released from chopper **25** is considerably smaller than the amount of heat released from converter **24**.

[0041] As illustrated in FIG. **2**, since chopper **25** and inverter **23** are active during the battery power supply, the amount of heat released from chopper **25** and inverter **23** becomes large. In this case, since power is not supplied from commercial AC power supply **31**, converter **24** is inactive.

[0042] In the present embodiment, power conversion device **20** is mounted on a heat sink. With reference to FIGS. **3** to **5**, a heat sink **19** and a power conversion device **10** in the related art will be described first. FIG. **3** is a plan view of heat sink **19** and power conversion device **10** in the related art.

[0043] As illustrated in FIG. **3**, heat sink **19** includes a base **11**. Power conversion device **10** includes an inverter **13**, a converter **14**, and a chopper **15**.

[0044] Inverter **13**, converter **14**, and chopper **15** of power conversion device **10** each include a plurality of semiconductor elements (IGBT). In this example, inverter **13** includes four semiconductor elements, converter **14** includes four semiconductor elements, and chopper **15** includes two semiconductor elements, but this is merely an example, and inverter **13**, converter **14**, and chopper **15** may each include any number of semiconductor elements.

[0045] Inverter **13**, converter **14**, and chopper **15** of power conversion device **10** are mounted on base **11**. Note that power conversion device **10** also has the same circuit configuration as illustrated in FIG. **1**, and commercial AC power supply **31**, load **32**, and battery **33** are connected to power conversion device **10**.

[0046] FIGS. **4** and **5** are front views of heat sink **19** and power conversion device **10** illustrated in FIG. **3**. As illustrated in FIG. **4**, heat sink **19** further includes fins **12**. Fins **12** are coupled to a surface of base **11** of heat sink **19** opposite to a surface on which power conversion device **10** (inverter **13**, converter **14**, chopper **15**) is mounted.

[0047] Fins **12** include fins **12***a* to **12***c*. Fins **12***a* are thermally connected to inverter **13** via base **11**. Fins **12***b* are thermally connected to converter **14** via base **11**. Fins **12***c* are thermally connected to chopper **15** via base **11**. That is, the heat of inverter **13** is released from fins **12***a*, the heat of converter **14** is released from fins **12***b*, and the heat of chopper **15** is released from fins **12***c*.

[0048] Heat sink **19** has comb-shaped gaps provided by fins **12** so as to allow its front side to receive cooling air (see FIG. **3**) from a cooling fan (not illustrated) and let the cooling air out toward the other side. Heat sink **19** causes base **11** to receive the heat of the semiconductor elements and transfer the heat to fins **12** by means of heat conduction of the individual. A mechanism for transporting heat from the surfaces of fins **12** to air by means of heat transfer is provided. Air from the cooling fan is applied to fins **12** to release the heat of the semiconductor elements.

[0049] As illustrated in FIG. **4**, in a case where power is supplied from commercial AC power supply **31** (during the inverter power supply), since inverter **13** and converter **14** are active, the amount of heat released from fins **12***a* and **12***b* becomes large.

[0050] On the other hand, as illustrated in FIG. **5**, in a case where power is supplied from battery **33** (during the battery power supply), since inverter **13** and chopper **15** are active, the amount of heat released from fins **12***a* and **12***c* becomes large.

[0051] As described above, during the inverter power supply (FIG. **4**), fins **12***a* and **12***b* are effectively used to release heat, but fins **12***c* are not effectively used. On the other hand, during the battery power supply (FIG. **5**), fins **12***a* and **12***c* are effectively used to release heat, but fins **12***b* are not effectively used.

[0052] In heat sink **19** and power conversion device **10** in the related art, inverter **13**, converter **14**, and chopper **15** are mounted on one base **11** in a row. It can be said that, in this device, some fins are not used to release heat during both the inverter power supply and the battery power supply, which makes the fin utilization rate low.

[0053] On the other hand, in the present embodiment, two bases on which inverter **23**, converter **24**, and chopper **25** are mounted are provided. Then, converter **24** is mounted on one base, and chopper **25** is mounted on the other base so as to face converter **24**.

[0054] With reference to FIGS. **6** to **9**, a heat sink **29** and power conversion device **20** according to the present embodiment will be described below. FIG. **6** is a plan view of heat sink **29** and power conversion device **20** according to the present embodiment. FIG. **7** is a bottom view of heat sink **29** and power conversion device **20** illustrated in FIG. **6**. FIGS. **8** and **9** are front views of heat sink **29** and power conversion device **20** illustrated in FIG. **6**.

[0055] Heat sink **29** includes a base **21** (base **21***a* and base **21***b*) and fins **22**. Inverter **23**, converter **24**, and chopper **25** are mounted on base **21** (base **21***a* and base **21***b*).

[0056] As illustrated in FIG. **6** (plan view), converter **24** is mounted on base **21***a*. As illustrated in FIG. **7** (bottom view), chopper **25** is mounted on base **21***b*. Inverter **23** may be mounted on either base **21***a* or base **21***b*. In the present embodiment, inverter **23** is mounted on base **21***a*.

[0057] As in FIG. **3**, inverter **23**, converter **24**, and chopper **25** each include a plurality of semiconductor elements (IGBT). Further, cooling is made by cooling air sent from a cooling fan in directions illustrated in FIGS. **6** and **7** in the same manner as in FIG. **3**.

[0058] As illustrated in FIG. **8** (front view), base **21***a* and base **21***b* are arranged to face each other. Fins **22** are arranged between base **21***a* and base **21***b*, and are coupled to both base **21***a* and base **21***b*. Power conversion device **20** (inverter **23**, converter **24**, and chopper **25**) is mounted on a surface of each of bases **21***a* and **21***b* opposite to a surface to which fins **22** are coupled.

[0059] In the present embodiment, at least some of fins **22** thermally connected to converter **24** via base **21***a* are thermally connected to chopper **25** via base **21***b*.

[0060] That is, at least some of fins **22** serve to release heat from both converter **24** and chopper **25** (there are fins used in common to release heat).

[0061] In the present embodiment, fins **22** includes fins **22***a* and fins **22***b*. Fins **22***b* are thermally connected to converter **24** via base **21***a* and are thermally connected to chopper **25** via base **21***b*. Fins **22***a* are thermally connected to inverter **23** via base **21** (base **21***a* or base **21***b*) on which inverter **23** is mounted.

[0062] In this example, converter **24** is identical in size (mounting area on the base) to chopper **25**, so that the fins that release heat from converter **24** and the fins that release heat from chopper **25** coincide with each other.

[0063] During the inverter power supply, as illustrated in FIG. **8**, since inverter **23** is active, the amount of heat released from fins **22***a* becomes large, and since converter **24** is active, the amount of heat released from fins **22***b* becomes large. In this case, the heat released from chopper **25** is considerably small, so that fins **22***b* are mainly used to release the heat from converter **24**.

[0064] On the other hand, a case during the battery power supply is as illustrated in FIG. **9**. Since inverter **23** is active, the amount of heat released from fins **22***a* becomes large, and since chopper **25** is active, the amount of heat released from fins **22***b* becomes large. In this case, converter **24** is not used, so that fins **22***b* are used to release the heat from chopper **25**.

[0065] As described above, in uninterruptible power supply device **1** of the embodiment of the present invention, base **21***a* and base **21***b* are arranged to face each other. Fins **22** are arranged between base **21***a* and base **21***b*, and are coupled to both base **21***a* and base **21***b*. Power conversion device **20** is mounted on a surface of each of bases **21***a* and **21***b* opposite to a surface to which fins **22** are coupled. Inverter **23** is mounted on either base **21***a* or base **21***b*. Converter **24** is mounted on base **21***a*. Chopper **25** is mounted on base **21***b*. At least some of fins **22** thermally connected to converter **24** via base **21***a* are thermally connected to chopper **25** via base **21***b*.

[0066] Since either of converter **24** and chopper **25** is selectively used between the inverter power supply and the battery power supply, it is possible to increase both the fin utilization rate and the efficiency of cooling the device by using the fins in common between converter **24** and chopper **25**. As a result, as compared with a case where a heat pipe or a thermal diffusion material is used to cause heat to diffuse throughout the fins (to increase the fin utilization rate), it is possible to reduce the cost of the device by making cooling only by air cooling. Further, two bases are provided on both sides of the fins, and inverter **23**, converter **24**, and chopper **25** are mounted on the two bases (elements are mounted on both the sides of the fins), so that the device can be downsized as compared with a device in which such components are mounted on one base. It is therefore possible to increase the cooling efficiency while reducing the cost and size of the device.

[0067] Further, fins **22** includes fins **22***a* and fins **22***b*. Fins **22***b* are thermally connected to converter **24** via base **21***a* and are thermally connected to chopper **25** via base **21***b*. Fins **22***a* are thermally connected to inverter **23** via base **21** (base **21***a* or base **21***b*) on which inverter **23** is mounted. As described above, since the fins (fins **22***a*) used by converter **24** and chopper **25** are different from the fins (fins **22***b*) used by inverter **23**, the heat of converter **24** or chopper **25** causes no reduction in the efficiency of cooling inverter **23**.

[0068] FIG. **10** is a front view of heat sink **29** and power conversion device **20** according to a first modification. In the first modification, a chopper **25***a* smaller in size (mounting area on the base) than converter **24** is mounted on base **21***b*. The other conditions are the same as those in the example described with reference to FIGS. **6** to **9**.

[0069] Also in this case, it is only required that chopper **25***a* be mounted such that at least some of fins **22** thermally connected to converter **24** via base **21***a* are thermally connected to chopper **25***a* via base **21***b*. In the first modification, of fins **22***b*, fins used by chopper **25***a* are also used by converter **24**.

[0070] Further, in a case where chopper **25***a* is larger in size than converter **24**, the size (mountable area) of bases **21***a* and **21***b* may be increased so as to avoid the fins used by chopper **25***a* and the fins used by inverter **23** from overlapping each other. Alternatively, if space saving is important, the fins used by chopper **25***a* and the fins used by inverter **23** may overlap each other. In the latter case, mounting inverter **23** on base **21***a* allows a reduction in space as compared with a case where inverter **23** is mounted on base **21***b*.

[0071] FIG. **11** is a front view of heat sink **29** and power conversion device **20** according to a second modification. In the second modification, inverter **23** is mounted on base **21***b*. The other conditions are the same as those in the example described with reference to FIGS. **6** to **9**.

[0072] In this case, in a case where converter **24** is larger in size than chopper **25**, the size (mountable area) of bases **21***a* and **21***b* may be increased so as to avoid the fins used by converter **24** and the fins used by inverter **23** from overlapping each other. Alternatively, if space saving is important, the fin used by converter **24** and the fins used by inverter **23** may overlap each other. In

the latter case, mounting inverter **23** on base **21***b* allows a reduction in space as compared with a case where inverter **23** is mounted on base **21***a*.
[0073] It should be understood that the embodiment disclosed herein is illustrative in all respects and not restrictive. The scope of the present invention is defined by the claims rather than the above description, and the present invention is intended to include the claims, equivalents of the claims, and all modifications within the scope of claims.
REFERENCE SIGNS LIST
[0074] **1**: uninterruptible power supply device, [0075] **10**, **20**: power conversion device, **11**, **21**: base, **12**, **12***a* to **12***c*, **22**, **22***a*, **22***b*: fin, **13**, **23**: inverter, **14**, **24**: converter, **15**, **25**: chopper, **19**, **29**: heat sink, **13***a* to **13***d*, **14***a* to **14***d*, **15***a*, **15***b*: power module, **30**: control device, **31**: commercial AC power supply, **32**: load, **33**: battery (power storage device), **35**: bypass circuit (semiconductor switch), **36** to **38**: electromagnetic contactor, T**1**: AC input terminal, T**2**: AC output terminal, T**3**: battery terminal.

Claims

1. An uninterruptible power supply device connected between an AC power supply and a load, the uninterruptible power supply device comprising: a heat sink including first and second bases, and fins, the first and second bases being arranged to face each other, the fins being arranged between the first and second bases and coupled to both the first and second bases; and a power conversion device mounted on a surface of each of the first and second bases opposite to a surface to which the fins are coupled, wherein the power conversion device includes: a converter to convert AC power supplied from the AC power supply into DC power, and stop when the AC power supply fails; a chopper to regulate a voltage of DC power supplied from a power storage device while the AC power supply is in failure; and an inverter to convert the DC power output from the converter or the DC power output from the power storage device into AC power and supply power to the load, the inverter is mounted on either of the first and second bases, the converter is mounted on the first base, the chopper is mounted on the second base, and at least some of the fins thermally connected to the converter via the first base are thermally connected to the chopper via the second base.
2. The uninterruptible power supply device according to claim 1, wherein the fins includes first fins and second fins, the first fins are thermally connected to the converter via the first base and are thermally connected to the chopper via the second base, and the second fins are thermally connected to the inverter via a base on which the inverter is mounted.
3. The uninterruptible power supply device according to claim 1, wherein the inverter is mounted on the first base.
4. The uninterruptible power supply device according to claim 1, wherein the inverter is mounted on the second base.
5. The uninterruptible power supply device according to claim 2, wherein the inverter is mounted on the first base.
6. The uninterruptible power supply device according to claim 2, wherein the inverter is mounted on the second base.