(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 February 2013 (28.02.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/027392 A2

(51) International Patent Classification:
H02M 7/539 (2006.01)

(21) International Application Number:
PCT/JP2012/005235

(22) International Filing Date:
21 August 2012 (21.08.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2011-182062 23 August 2011 (23.08.2011) JP
2011-181836 23 August 2011 (23.08.2011) JP

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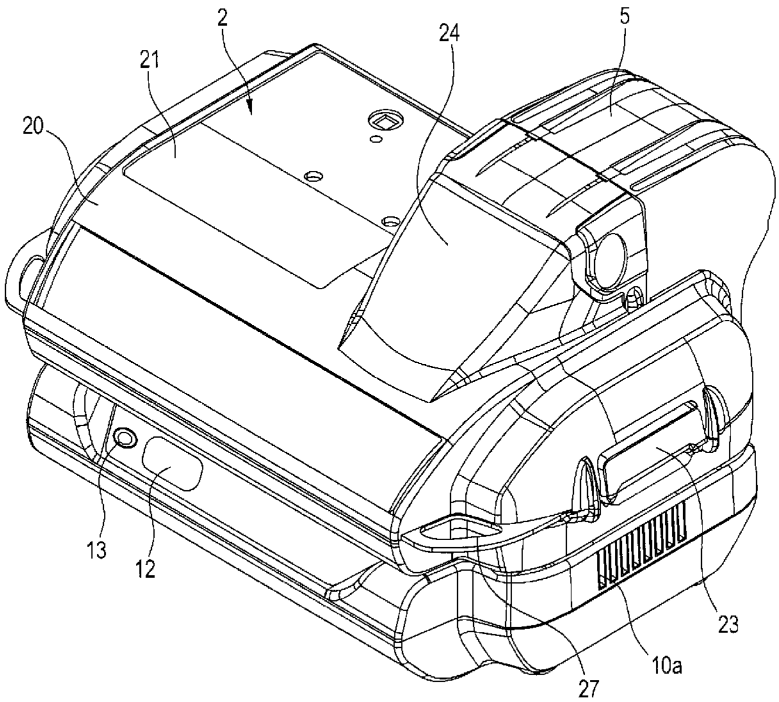
[Continued on next page]

(54) Title: WAVEFORM CONVERTER AND POWER SUPPLY DEVICE HAVING THE SAME

[Fig. 6]

FIG.6



(57) Abstract: A waveform converter includes: an input section configured to receive an input voltage; an inverter circuit configured to convert the input voltage into a sine wave AC voltage; and an output section configured to output the sine wave AC voltage.

WO 2013/027392 A2

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

Description

Title of Invention: WAVEFORM CONVERTER AND POWER SUPPLY DEVICE HAVING THE SAME

Technical Field

[0001] The present invention relates to a waveform converter and a power supply device having the waveform converter.

Background Art

[0002] Japanese Patent Application Laid-Open Publication No. 2009-278832 discloses an inverter device that converts DC voltage into AC voltage.

Disclosure of Invention

Solution to Problem

[0003] The inverter device mentioned above can be used as a power supply for a precision machine. However, in a case where an output of the inverter device is rectangular wave voltage, the precision machine may fail to operate normally. In order to cope with this problem, a waveform converter (sine wave adopter) may be connected between the inverter device and precision machine so as to convert the rectangular wave voltage to sine wave voltage.

[0004] However, the sine wave adapter and inverter device are separately provided, which makes users feel troublesome at the time of use and transportation.

[0005] An object of the present invention is to provide a waveform converter capable of reducing a burden imposed at the time of use and transportation and a power supply device having the waveform converter.

[0006] Further, the waveform converter need not be provided when the inverter device is a type that outputs the sine wave voltage. If the waveform converter is made to operate even in such a case, power of a storage battery serving as a power supply is wasted.

[0007] Another object of the present invention is to provide a waveform converter capable of reducing waste of storage battery power and a power supply device having the waveform converter.

[0008] In order to attain the above and other objects, the invention provides a waveform converter including: an input section configured to receive an input voltage; an inverter circuit configured to convert the input voltage into a sine wave AC voltage; and an output section configured to output the sine wave AC voltage.

[0009] Another aspect of the present invention provides a waveform converter including: an input section configured to receive an input voltage; a booster circuit configured to boost the input voltage;

an inverter circuit configured to convert the boosted input voltage into a sine wave voltage; a controller configured to control the booster circuit and the inverter circuit; an output section configured to output the sine wave voltage; and a voltage detection section configured to detect the input voltage. The controller prohibits the booster circuit from boosting the input voltage if the input voltage detected by the voltage detection section falls within a boosting prohibition range.

Advantageous Effects of Invention

[0010] According to the battery pack, there can be provided a sine wave adapter capable of reducing a burden imposed at the time of use and transportation.

Brief Description of Drawings

[001 1] [fig. 1]FIG. 1 is a front perspective view of a sine wave adapter according to a first embodiment of the present invention.

[fig.2]FIG. 2 is a side view of the sine wave adapter according to the first embodiment of the present invention.

[fig.3]FIG. 3 is a partial cross-sectional view of the sine wave adapter according to the first embodiment of the present invention taken along III-III line of FIG. 2.

[fig.4]FIG. 4 is an exploded plan view of the sine wave adapter according to the first embodiment of the present invention.

[fig.5]FIG. 5 is a front perspective view of an inverter device according to the first embodiment of the present invention.

[fig.6]FIG. 6 is a front perspective view illustrating a state where the sine wave adapter, inverter device, and a battery pack according to the first embodiment of the present invention are attached to each other.

[fig.7]FIG. 7 is a rear perspective view illustrating a state where the sine wave adapter, inverter device, and battery pack according to the first embodiment of the present invention are attached to each other.

[fig.8]FIG. 8 is an exploded perspective view of the sine wave adapter, inverter device, and battery pack according to the first embodiment of the present invention.

[fig.9]FIG. 9 is a side view illustrating a state where the sine wave adapter, inverter device, and battery pack according to the first embodiment of the present invention are attached to each other.

[fig. 10]FIG. 10 is an exploded side view of the sine wave adapter, inverter device, and battery pack according to the first embodiment of the present invention.

[fig. 11]FIG. 11 is an exploded front view of the sine wave adapter, inverter device, and battery pack according to the first embodiment of the present invention.

[fig.l2]FIG. 12 is a cross-sectional side view of a power supply device according to a modification of the first embodiment of the present invention.

[fig.l3]FIG. 13 is a front perspective view illustrating a state where the sine wave adapter, inverter device, and an adapter according to the modification of the first embodiment of the present invention are attached to each other.

[fig. 14]FIG. 14 is a rear perspective view illustrating a state where the sine wave adapter, inverter device, and adapter according to the modification of the first embodiment of the present invention are attached to each other.

[fig.l5]FIG. 15 is a view illustrating a manner of use of the sine wave adapter serving as a waveform converter according to the first embodiment of the present invention.

[fig. 16]FIG. 16 is a view explaining a change in a voltage waveform in each device illustrated in FIG. 15.

[fig.l7]FIG. 17 is a block diagram of the sine wave adapter according to the first embodiment of the present invention.

[fig. 18A]FIG. 18A is a circuit diagram of the sine wave adapter according to the first embodiment of the present invention.

[fig.l8B]FIG. 18B is a view for explaining inrush current in the absence of an inrush current preventing circuit.

[fig.l8C]FIG. 18C is a view for explaining inrush current in the presence of an inrush current preventing circuit.

[fig. 19]FIG. 19 is a table illustrating an example of display content displayed by a display section according to the first embodiment of the present invention.

[fig.20]FIG. 20 is a flowchart of input voltage monitoring, determination on whether to perform boosting, and soft start according to the first embodiment of the present invention.

[fig.21]FIG. 21 is an explanatory view of the soft start according to the first embodiment of the present invention.

[fig.22A]FIG. 22A is a circuit diagram of a sine wave adapter serving as a waveform converter according to a second embodiment of the present invention.

[fig.22B]FIG. 22B is a flowchart of control processing for a bypass circuit according to the second embodiment of the present invention.

[fig.23]FIGS. 23 is a view explaining a waveform detected by a waveform determination circuit according to the second embodiment of the present invention.

[fig.24]FIG. 24 is a circuit diagram of a sine wave adapter serving as a waveform converter according to a third embodiment of the present invention.

[fig.25]FIG. 25 is a flowchart of overcurrent control according to a fourth embodiment of the present invention.

[fig.26]FIG. 26 is a circuit diagram of a sine wave adapter according to a modification.

[fig.27]FIG. 27 is a partial cross-sectional view of a sine wave adapter according to a fifth embodiment of the present invention taken along III-III line of FIG. 2.

[fig.28]FIG. 28 is a flowchart of the input voltage monitoring, determination on whether to perform boosting, and soft start according to the modification.

Reference Signs List

[0012] 1 Sine Waveform Converter
2 Inverter Device

Best Mode for Carrying out the Invention

[0013] A configuration of a sine wave adapter 1 which is a waveform converter according to an embodiment of the present invention will be described with reference to the accompanying drawings.

[0014] The sine wave adapter 1 is a device that outputs voltage (e.g., 100-V AC voltage of a rectangular wave) input from an inverter device 2 to be described later as 100-V AC voltage of a sine wave.

[0015] As illustrated in FIGS. 1 to 4, the sine wave adapter 1 has a casing 10 constituting an outer shell of the sine wave adapter 1, an engaging portion 11 protruding from the casing 10, a display section 12 configured to display a setting status of the sine wave adapter 1, a setting section 13 for use in setting an output frequency of the sine wave adapter 1, an output cable 14, an input section 15 configured to receive an input from an external device, a cooling fan 16, and a circuit board 17.

[0016] In the following description, a side at which the display section 12 is provided is defined as "front" and the opposite side thereof is as "rear". A side at which an air outlet 10b is provided is defined as "right" and the opposite side thereof is as "left".

[0017] The casing 10 has an air inlet 10a for introducing outside air and an air outlet 10b for exhausting the introduced outside air. As illustrated in FIGS. 1 and 2, the air inlet 10a and air outlet 10b each formed into a vertically elongated substantially rectangular shape and arranged in plural in front-rear direction. The air inlet 10a and air outlet 10b have substantially the same opening area.

[0018] As illustrated in FIG. 3, a partition wall 10A for preventing water that has entered through the air inlet 10a from entering further inside extends vertically upward from a bottom surface of the casing 10 so as to be spaced apart from a side surface of the casing 10 by a predetermined interval. The partition wall 10A is vertically arranged on each of the air inlet 10a side and air outlet 10b side. As illustrated in FIG. 4, the partition wall 10A is formed so as to surround the circuit board 17 and also plays a role of positioning the circuit board 17.

[0019] As illustrated in FIG. 3, a drain outlet 10c for discharging water that has entered through the air inlet 10a is formed in a bottom surface of the sine wave adapter 1 at a position between the side surface of the casing 10 and partition wall 10A. A drain space lOd for temporarily storing water that has entered through the air inlet 10a is defined between the casing 10 and partition wall 10A. A structure on the air outlet 10b side is the same as that illustrated in FIG. 3.

[0020] The casing 10 corresponds to a first housing of the present invention, the air inlet 10a and air outlet 10b correspond to a through hole of the present invention, the drain outlet 10c corresponds to a drain through hole, and the partition wall 10A corresponds to a shield wall.

[0021] The engaging portion 11 can be engaged with an engaged portion formed at an end portion of an attachment/detachment button 23 of the inverter device 2 illustrated in FIG. 5. The engaging portion 11 is formed at left-right direction both ends of an upper surface of the casing 10. Thus, the sine wave adapter 1 is fixed to the inverter device 2 at two points, thereby achieving secure connection between the sine wave adapter 1 and inverter device 2. Further, formation of the engaging portion 11 at the end portion of the upper surface prevents the relative position between the sine wave adapter 1 and inverter device 2 from being displaced even if a large force is applied to one of the sine wave adapter 1 and inverter device 2.

[0022] The engaging portion 11 corresponds to a first fixing portion of the present invention.

[0023] The display section 12 is inclined obliquely downward in the front direction so as to be easily viewed from the front even in a state where the inverter device 2 is fixed to the sine wave adapter 1. The display section 12 has two LED lamps. When the output frequency of the sine wave adapter 1 set by the setting section 13 is 50 Hz, one of the two LED lamps is ON; when the output frequency of the sine wave adapter 1 set by the setting section 13 is 60 Hz, the other one of the two LED lamps is ON.

[0024] Like the display section 12, the setting section 13 is inclined obliquely downward in the front direction so as to be easily viewed from the front even in a state where the inverter device 2 is fixed to the sine wave adapter 1. The setting section 13 is a push-button switch. Pressing the setting section 13 allows switching of the output frequency of the sine wave adapter 1.

[0025] The output cable 14 extends outward from a rear surface of the casing 10. A plug 14A is provided at one end of the output cable 14. 100-V AC voltage of a sine wave is output from the plug 14A.

[0026] The input section 15 is provided at the rear surface of the casing 10 so as to be positioned adjacent to the output cable 14. The input section 15 receives an output from the inverter device 2.

[0027] The output cable 14 and input section 15 correspond to a first input/output terminal of the present invention.

[0028] As illustrated in FIG. 4, the cooling fan 16 is fixed to a portion near the air outlet 10b formed in the right side surface of the sine wave adapter 1 and is configured to suck in outside air from the air inlet 10a and exhaust the outside air through the air outlet 10b to thereby cool the inside of the sine wave adapter 1. The cooling fan 16 is always on while the sine wave adapter 1 is running. The cooling fan 16 may be activated in accordance with temperature of the circuit board 17.

[0029] The circuit board 17 is provided with a plurality of electronic components such as capacitors. An outer periphery of the circuit board 17 is covered by urethane 17A. More specifically, the circuit board 17 is disposed in an area surrounded by the partition wall 10A and side surfaces of the casing 10, and the urethane 17A is poured into the area and cured, whereby the circuit board 17 and electronic components on the circuit board 17 are covered by the urethane 17A. A meshed portion in FIG. 4 denotes the region filled with the urethane 17A. This configuration allows the circuit board 17 to be fixed to the casing 10 and assures waterproof, vibration-proof, and dustproof structures of the circuit board 17.

[0030] The above described sine wave adapter 1 can be attached/detached to/from the inverter device 2. The inverter device 2 can receive a battery pack 5 (e.g., lithium battery of 14.4 V, 3.0 A) for electric tool serving as a storage battery.

[0031] As illustrated in FIG. 5, the inverter device 2 has a housing 20 constituting an outer shell of the inverter device 2, a display panel 21 configured to display a status of the inverter device 2, an output cable 22, an attachment/detachment button 23, an accommodating portion 24 for accommodating the battery pack 5, an electric power input section 25 configured to receive an input from an external device, a power supply cable 26 detachably connected to the electric power input section 25, and a band anchoring portion 27.

[0032] The inverter device 2 converts 14.4-V DC voltage from the battery pack 5 into 100-V AC voltage of a rectangular wave and outputs the 100-V AC voltage through the output cable 22. When the inverter device 2 is connected to a commercial power supply through the power supply cable 26, the battery pack 5 can be charged with an input from the commercial power supply. Further, the inverter device 2 can obtain a DC output of the battery pack 5 through the output cable 22. Further, the inverter device 2 can output AC voltage of the commercial power supply directly to the output cable 22.

[0033] The display panel 21 has an LED lamp. An operator can determine, depending on a status (lighting, blinking, etc.) of the LED lamp, whether the battery pack 5 is being charged, whether output is being fed through the output cable 22, or whether an abnormality has occurred in the inverter device 2. The output cable 22 extends outward from a rear surface of the housing 20.

[0034] The attachment/detachment button 23 is provided at left-right direction both ends of the inverter device 2. Simultaneously pressing the left and right attachment/detachment buttons 23 allows the inverter device 2 to be attached/detached to/from the sine wave adapter 1. An engaged portion that can be engaged with the engaging portion 11 of the sine wave adapter 1 is formed on a bottom surface of the housing 20 at an end portion of the attachment/detachment button 23.

[0035] The engaged portion corresponds to a second fixing portion of the present invention.

[0036] The accommodating portion 24 can accommodate not only the battery pack 5 but also an adapter 4 (FIGS. 12 to 14) which has the same shape as the battery pack 5. The adapter 4 is connected to a lead storage battery 3 to be described later through a cable 4A. The use of the lead storage battery 3 having a large capacity (12 V, 38 Ah) achieves longer operating time than the use of the battery pack 5. A detailed configuration of the adapter 4 will be described later.

[0037] The electric power input section 25 and power supply cable 26 each extend outward from a rear surface of the inverter device 2.

[0038] The output cable 22 and electric power input section 25 correspond to a second input/output terminal of the present invention.

[0039] The band anchoring portion 27 is provided at left-right direction both ends of a front part of the inverter device 2, by which a not-illustrated shoulder band can be anchored. Further, the band anchoring portion 27 is provided on a side of the inverter device 2 opposite to a side where the output cable 22 and electric power input section 25 are provided. In a state where an operator puts a not-illustrated band over his or her shoulder, the output cable 22 extends from a lower side in a vertical direction. Thus, connecting the sine wave adapter 1 and inverter device 2 to each other and using the battery pack 5 for electric tool as a power supply increase portability. Further, the band anchoring portion 27 and input/output sections are provided on different surfaces, mutual interference can be avoided. The band anchoring portion 27 may be provided on the sine wave adaptor 1 side.

[0040] As illustrated in FIGS. 6 to 11, when the engaging portion 11 of the sine wave adapter 1 and the engaged portion of the inverter device 2 are engaged with each other, the sine wave adapter 1 and inverter device 2 are fixed to each other with a bottom surface of the inverter device 2 facing an upper surface of the sine wave adapter 1. The areas of the bottom surface of the inverter device 2 and upper surface of the sine wave adapter 1 are substantially the same, and front-rear and left-right lengths thereof are also substantially the same, so that the sine wave adapter 1 can be integrally fixed to the inverter device 2.

[0041] As illustrated in FIG. 7, inserting the output cable 22 into the input section 15 in a state where the battery pack 5 is attached to the accommodating portion 24 allows 100-V AC voltage of a sine wave to be obtained through the output cable 14. Further, the output cable 14, input section 15, output cable 22, and electric power input section 25 (hereinafter, referred to as "input/output sections") are disposed so as to concentrate in one location, in a state where the sine wave adapter 1 is fixed to the inverter device

2. In more detail, the input section 15 of the sine wave adapter 1 and output cable 22 of the inverter device 2 are disposed on the same direction plane, the input section 15 is disposed just below the electric power input section 25, and the output cable 14 is disposed just below the output cable 22 (connection portion with the housing 20). This minimizes the length of the cables routed between the sine wave adapter 1 and inverter device 2.

[0042] In a state where the sine wave adapter 1 is fixed to the inverter device 2, the input/output sections are disposed on the opposite side to the side where the band anchoring portion 27 is provided. Further, the cable 4A of the adapter 4 to be described later is also disposed near the input/output sections. That is, in a state where an operator puts a not-illustrated band anchored by the band anchoring portion 27 over his or her shoulder, the cables extend from the lower side in the vertical direction. As a result, the position of the input/output sections does not interfere with the operator.

[0043] With the configuration described above, the sine wave adapter 1 and inverter device 2 can be integrated in a compact fashion to facilitate the use and transportation thereof. Further, the sine wave adapter 1 and inverter device 2 are fixed by the engagement between the engaging portion 11 of the sine wave adapter 1 and the engaged portion of the inverter device 2, one of the sine wave adapter 1 and inverter device 2 can be prevented from being unexpectedly coming off from the other.

[0044] Further, the sine wave adapter 1 is fixed to the engaging portion 11 in a positional relationship where the upper surface of the casing 10 faces the bottom surface of the housing 20 and the four side surfaces of the housing 20 correspond respectively to (are flush with) the four side surfaces of the casing 10, so that the output cable 14, input section 15, output cable 22, and electric power input section 25 can be disposed close to each other, and the length of cables to be connected to the above input/output sections can be reduced. Further, cable routing can be achieved in a compact space.

[0045] Further, as described above, the casing 10 has the air inlet 10a and air outlet 10b, each of which makes the inside of the casing 10 communicate with the outside thereof. The partition wall 10A is provided inside the casing 10 at portions facing the air inlet 10a and air outlet 10b. The drain space lOd is defined between the side surface of the casing 10 in which the air inlet 10a is formed and the partition wall 10A and between the side surface of the casing 10 in which the air outlet 10b is formed and the partition wall 10A. The lower portion of the drain space lOd is defined by the bottom surface of the casing 10. The drain outlet 10c that makes the inside of the casing 10 communicate with the outside thereof is formed in the bottom surface of the casing 10 defining the lower portion of the drain space lOd. With the above configuration, water such as rainwater flowing in through the air inlet 10a and air outlet 10b is prevented from flowing over the partition wall 10A into the casing 10. Further, water flowing in the drain space lOd can be discharged outside from the casing 10.

[0046] Further, the circuit board 17 having a voltage conversion circuit that converts the rectangular wave AC voltage into sine wave AC voltage and outputs the sine wave AC voltage is covered in its entirety by the urethane 17A. Thus, even if water such as rainwater or dust enters the casing 10, the water or dust can be prevented from directly contacting the circuit board 17.

[0047] Next, a modification of the embodiment will be described using FIGS. 12 to 14. In this modification, a lead storage battery for vehicle is used, in place of the battery pack 5 for electric tool, as a DC power supply (drive source).

[0048] The sine wave adapter 1 can be accommodated in a power supply device 101. The power supply device 101 mainly includes a main body 102 constituting an outer frame of the power supply device 101 and an upper lid 103 serving as a lid body for opening and closing an internal space 102a of the main body 102. The internal space 102a of the main body 102 accommodates a lead storage battery 3 (12 V) for vehicle used, in place of the battery pack 5 for electric tool, as a power supply and an inner lid 105 that partitions the internal space 102a into a chamber in which the lead storage battery 3 is accommodated and a chamber in which the sine wave adapter 1 is accommodated.

[0049] The main body 102 has a protruding portion 102A protruding toward the internal space 102a at a portion above the lead storage battery 3 and a wheel 102B rotatably supported by the main body 102. The upper part of the main body 102 is opened, and the opening can be closed by the upper lid 103. The lead storage battery 3 is fixed in the internal space 102a by a battery shaft 3A. The inner lid 105 is placed on the protruding portion 102A of the main body 102. On an upper surface of the inner lid 105, the sine wave adapter 1 is placed.

[0050] The inverter device 2 is placed on the upper lid 103. The upper lid 103 has an engaging portion having the same structure as the engaging portion 11 of the sine wave adapter 1. An engagement between this engaging portion and the attachment/detachment button 23 of the inverter device 2 allows the inverter device 2 to be fixed to the upper lid 103. The inverter device 2 is connected to the lead storage battery 3 through the adapter 4 having a connection portion (terminal or rail portion to be connected to the accommodating portion 24) having the same shape as that of the battery pack 5 for electric tool. The adapter 4 and lead storage battery 3 are connected to each other through the cable 4A extending from the adapter 4.

[0051] The cable 4A of the adapter 4 and cables of the sine wave adapter 1 and inverter device 2 are exposed outside the main body 102 through a not-illustrated groove portions formed in the inner lid 105 and upper lid 103. In a state illustrated in FIG. 12, the inverter device 2 receives DC voltage from the lead storage battery 3 through the adapter 4 and cable 4A. The inverter device 2 then boosts 12-V DC voltage from the lead storage battery 3, applies waveform conversion thereto, and outputs rectangular wave AC voltage through the output cable 22. The sine wave adapter 1 converts the rectangular wave AC voltage input through the input section 15 thereof into sine wave AC voltage and outputs the sine wave AC voltage through the output cable 14.

[0052] Further, as in the case where the battery pack 5 for electric tool is used, the lead storage battery may be used in a state where the sine wave adapter 1 and inverter device 2 are connected to each other. That is, the upper lid 103 is opened, and the inverter device 2 is attached to the sine wave adapter 1, whereby a state illustrated in FIGS. 13 and 14 can be obtained. Further, formation of the same mechanism as the attachment/detachment button 23 of the inverter device 2 in the sine wave adapter 1 allows the structure of FIG. 13 to be fixed to the upper lid 13.

[0053] According to the modification, although portability of the sine wave adapter 1 or inverter device 2 is lower than a case where the battery pack 5 for electric tool is used, longer operating time can be achieved due to use of the lead storage battery 3 having a large capacity. Further, the main body 102 has the wheel 102B, making it easy to move the power supply device 101, which expands applications thereof.

[0054] Further, as illustrated in FIGS. 13 and 14, the input/output sections (input section 15 and the like) are provided on one side in a left-right direction of the rear surface of the casing 10 and housing 20, and the accommodating portion 24 is provided on the other side in the left-right direction thereof, so that the cable 4A of the adapter 4 and input/output sections do not interface with each other. Thus, the input/output sections do not interface with the attachment/detachment operation of the adapter 4.

[0055] Next, an electrical configuration of the sine wave adapter 1 serving as the waveform converter according to the first embodiment of the present invention will be described using FIGS. 15 to 22.

[0056] FIG. 15 illustrates a manner of use of the sine wave adapter 1 according to the first embodiment, and FIGS. 16A to 16G are views explaining a change in a voltage waveform in each device.

[0057] As illustrated in FIG. 15, the sine wave adapter 1 can be connected to the inverter device 2 through an input terminal A. The inverter device 2 receives DC voltage from the lead storage battery 3 through the adapter 4 (FIG. 15A, FIG. 16A). In place of the lead storage battery 3, the above-described battery pack 5 for electric tool may be used. In the case of the lead storage battery 3, a voltage value varies according to a charge/discharge state or lifetime thereof.

[0058] The inverter device 2 uses a booster circuit to boost the DC voltage up to about 141-V DC voltage (FIG. 15B, FIG. 16B) and then uses an inverter circuit to convert the DC voltage into rectangular wave voltage (AC 100 V in effective value) for output (FIG. 15C, FIG. 16C).

[0059] The sine wave adapter 1 uses a rectifier circuit to rectify the rectangular wave voltage input to the input terminal A into DC voltage (FIG. 15D, FIG. 16D) and then uses a booster circuit to boost the DC voltage up to about 141 V (FIG. 15E, FIG. 16E). An output of the rectifier circuit varies depending on an output of the inverter device 2. For example, the higher a load, the smaller the output becomes.

[0060] Subsequently, the sine wave adapter 1 uses an inverter circuit to convert the boosted DC voltage into pulse wave voltage of 50Hz (FIG. 15F, FIG. 16F) and then uses a shaping circuit to convert the pulse wave voltage into sine wave voltage (FIG. 15G, FIG. 16G). The inverter circuit performs switching at a switching frequency of 20 kHz. The sine wave voltage can be output to, e.g., a precision machine through an output terminal B. The lead storage battery 3, inverter device 2, and sine wave adapter 1 constitute the power supply device.

[0061] Next, a circuit configuration of the sine wave adapter 1 will be described. FIG. 17 is a block diagram of the sine wave adapter 1, and FIG. 18A is a circuit diagram of the sine wave adapter 1.

[0062] As illustrated in FIG. 17 and FIG. 18A, the sine wave adapter 1 includes a rectifier circuit 111, a first smoothing capacitor 112, an inrush current preventing circuit 113, a voltage detection circuit (voltage detection section) 114, an auxiliary power supply 115, a booster circuit 116, a second smoothing capacitor 117, an inverter circuit 118, a current detection resistor 119, a driver IC 120, a microcomputer 121, a frequency switching circuit 122, and a fan mechanism 124.

[0063] The microcomputer 121 corresponds to a controller of the present invention.

[0064] The rectifier circuit 111 and first smoothing capacitor 112 rectify and smoothen the rectangular wave voltage input from the inverter device 2, respectively. As a result, as illustrated in FIGS. 16C and 16D, DC voltage having a value corresponding to the maximum value of the voltage input from the inverter device 2 is output.

[0065] The inrush current preventing circuit 113 prevents high inrush current from flowing in the sine wave adapter 1 when the circuit is powered ON. The inrush current preventing circuit 113 includes an FET 131, an inrush current preventing resistor 132, and voltage dividing resistors 133 and 134. The inrush current preventing resistor 132 has a resistance value high enough to keep high current from flowing in the first smoothing capacitor 112.

[0066] Here, assumed is a case where the highest voltage of 141 V of a rectangular wave is input to the sine wave adapter 1 in the absence of the inrush current preventing circuit 113. In this case, a calculation performed with an impedance of a pattern being, e.g., 1 W reveals that inrush current up to as high as 141 A flows in the sine wave adapter 1 due to existence of the first smoothing capacitor 112, as illustrated in FIG. 18B, which may damage an element such as the FET in the sine wave adapter 1.

[0067] However, in the present embodiment, the inrush current preventing resistor 132 is connected in series to the first smoothing capacitor 112 and, further, the FET 131 is connected in parallel to the inrush current preventing resistor 132. After power-on of the inverter device 2 (that is, after operation of the sine wave adapter 1 is started) the FET 131 is kept OFF until a value of voltage obtained by dividing the voltage output from the rectifier circuit 111 and first smoothing capacitor 12 using the voltage dividing resistors 133 and 134 reaches a gate voltage of the FET 131. Thus, while the FET 131 is OFF, current flows from the first smoothing capacitor 112 to the inrush current preventing resistor 132. Therefore, in this case, a calculation performed with a resistance value of the inrush current preventing resistor 132 being, e.g., 100 W reveals that inrush current flowing in the sine wave adapter 1 becomes about 1.4 A, as illustrated in FIG. 18C, preventing an element such as the FET in the sine wave adapter 1 from being damaged.

[0068] On the other hand, making current to continuously flow in the inrush current preventing resistor 132 even after the high inrush current has subsided results in waste of electric power. To prevent this, in the present embodiment, resistance values of the voltage dividing resistors 133 and 134 are set so as to turn ON the FET 131 when the high inrush current has subsided, i.e., voltage input to the sine wave adapter 1 has increased to some extent. Thus, after the FET 131 has turned ON, current flows from the first smoothing capacitor 112 to FET 131 and does not flow in the inrush current preventing resistor 132. An on-resistance of the FET 131 is extremely low relative to a resistance value of the inrush current preventing resistor 132, waste of electric power by the FET 131 hardly occurs.

[0069] The inverter device 2 has an overcurrent preventing function that stops operation when high current flows therein. Accordingly, even when high inrush current occurs in the sine wave adapter 1 side, the inverter device 2 stops the operation thereof. However, in the present embodiment, the sine wave adapter 1 has the inrush current preventing circuit 113, thus preventing the inverter device 2 from stopping the operation thereof due to the inrush current that has occurred in the sine wave adapter 1 side.

[0070] The voltage detection circuit 114 has voltage detection resistors 141 and 142 connected in series to each other and outputs to the microcomputer 121 voltage output from the rectifier circuit 111 and first smoothing capacitor 112, i.e., voltage obtained by dividing charged voltage of the first smoothing capacitor 112 by the voltage detection resistors 141 and 142.

[0071] The auxiliary power supply 115 has a three-terminal regulator 151 and oscillation preventing capacitors 152 and 153. The auxiliary power supply 115 converts voltage output from the rectifier circuit 111 and first smoothing capacitor 112 into DC voltage of a predetermined value (e.g., 5 V) and supplies the DC voltage to the microcomputer 121 as drive voltage.

[0072] The booster circuit 116 has a coil 161, an FET 162, a switching IC 163, a rectifier diode 164, and voltage detection resistors 165 and 166.

[0073] The switching IC 163 turns ON/OFF the FET 162, and voltage stored in the coil 161 is output in a pulse shape. The pulse-shaped voltage is rectified and smoothened by the rectifier diode 164 and second smoothing capacitor 117 and is output as DC voltage. In the present embodiment, 141-V DC voltage is output from the booster circuit 116 and second smoothing capacitor 117 as illustrated in FIG. 16E. The voltage detection resistors 165 and 166 monitor voltage at the second smoothing capacitor 117 and feeds back a result of the monitoring to the switching IC 163. The switching IC 163 turns ON/OFF the FET 162 so as to set the voltage at the second smoothing capacitor 117 to 141 V.

[0074] The inverter circuit 118 has an inverter section 181 and a filter section (shaping circuit) 182.

[0075] The inverter section 181 has four FETs 181a to 181d. A drain of the FET 181a is connected to a cathode of the rectifier diode 164, and a source thereof is connected to a drain of the FET 181b. A drain of the FET 181c is connected to the cathode of the rectifier diode 164, and a source thereof is connected to a drain of the FET 181d. A second PWM signal for turning ON/OFF the FETs 181a to 181d is input to gates of the FETs 181a to 181d by a driver IC 120. Turning ON/OFF the FETs 181a to 181d causes DC voltage output from the booster circuit 116 and second smoothing capacitor 117 to be converted into pulse wave voltage (FIG. 16F).

[0076] The filter section 182 has coils 182a and 182b and a capacitor 182c. The coil 182a is connected with the source of the FET 181a and drain of the FET 181b, and coil 182b is connected with the source of the FET 181c and drain of the FET 181d. The pulse wave voltage output from the inverter section 181 (FETs 181a to 181d) is converted (shaped) into sine wave voltage by the filter section 182 (FIG. 16G).

[0077] The current detection resistor 119 is connected between sources of the FETs 181b and 181d and a GND, and a high voltage side terminal of the current detection resistor 119 is connected to the microcomputer 121. With this configuration, the current detection resistor 119 detects current flowing in the inverter circuit 118 (sine wave adapter 1) and outputs the detected current to the microcomputer 121 in the form of voltage.

[0078] The microcomputer 121 performs ON/OFF control of the switching IC 163 with a first PWM signal generated based on the voltage detected by the voltage detection circuit 114. The switching IC 163 performs PWM control for the FET 162 such that DC voltage of a predetermined value (141 V in the present embodiment) is output from the booster circuit 116 and second smoothing capacitor 117, that is, boosted voltage of the second smoothing capacitor 117 becomes 141 V.

[0079] The microcomputer 121 outputs the second PWM signal to the gates of the FETs 181a to 181d through the driver IC 120, the second PWM signal causing pulse wave voltage of 100 V in effective value to be output from the inverter circuit 118. In the present embodiment, at normal time, the microcomputer 121 outputs the second PWM signal causing a first set (FETs 181a and 181d) and a second set (FETs 181b and 181c) to alternately be turned ON/OFF with a duty ratio of 100%. Note that the second PWM signal causes each FET to be turned ON/OFF at a switching frequency of 20 kHz. At this time, the second PWM signal is output at an output frequency (50 Hz in FIG. 16F) set by the frequency switching circuit 122 to be described later.

[0080] The microcomputer 121 according to the present embodiment further performs, at the operation start time of the sine wave adapter 1, input voltage monitoring, determination on whether to perform boosting, and soft start.

[0081] In the input voltage monitoring, when the maximum value of rectangular wave voltage input from the inverter device 2 falls outside a first range (input allowable range, 99 V or more and 169 V or less in the present embodiment), the microcomputer 121 stops operation of the booster circuit 116 and inverter circuit 118. This prevents an element such as the FET in the sine wave adapter 1 from being damaged.

[0082] In the determination on whether to perform boosting, when the maximum value of the rectangular wave voltage falls within a second range (boosting prohibition range, 127 V or more and 141 V or less in the present embodiment), the microcomputer 121 stops operation of the booster circuit 116. This prevents waste of electric power due to unnecessary operation of the booster circuit 116.

[0083] In the soft start, when a value of current flowing in the invert circuit 118 is higher than a predetermined value (10 A, in the present embodiment) during a predetermined length of time (100 ms, in the present embodiment) immediately after start of operation of the inverter circuit 118, the microcomputer 121 reduces the duty of the second PWM signal to 50% and thereafter spends 2.5 s to set back the duty ratio to 100%. This prevents high current from flowing in the sine wave adapter 1 and inverter device 2.

[0084] The frequency switching circuit 122 has a switch 221 and an EEPROM 222.

[0085] The frequency switching circuit 122 corresponds to a frequency setting section of the present invention.

[0086] An operator can select 50 Hz or 60 Hz as a frequency of the sine wave voltage to be output from the sine wave adapter 1 by pressing the switch 221 provided in the setting section 13 for a predetermined length of time (e.g., 3 seconds). In more detail, when the switch 221 is pressed, a HIGH level frequency switching signal is input to the microcomputer 121 from the frequency switching circuit 122, and then the microcomputer 221 changes a level of the second PWM signal according to the frequency switching signal so as to switch the frequency of the sine wave voltage to be output from the sine wave adapter 1.

[0087] The EEPROM 222 stores a frequency at the operation stop time of the microcomputer 121, that is, at a time when supply of power from the inverter device 2 is stopped. The microcomputer 121 outputs, at the start time of the next operation, the second PWM signal according to the frequency stored in the EEPROM 222.

[0088] The display section 12 has a transistor 231 and an LED 232. A LOW signal output from the microcomputer 121 turns ON the transistor 231, causing the LED 232 to light or blink.

[0089] Although not-illustrated in FIG. 18, the transistor 231 actually has a 50 Hz transistor for green color, a 50 Hz transistor for red color, a 60 Hz transistor for green color, and a 60 Hz transistor for red color, and the LED 232 has a 50 Hz green LED connected to the 50 Hz transistor for green color, a 50 Hz red LED connected to the 50 Hz transistor for red color, a 60 Hz green LED connected to the 60 Hz transistor for green color, and a 60 Hz red LED connected to the 60 Hz transistor for red color. The microcomputer 121 outputs, to the display section 12, a signal causing one of the above LEDs corresponding to a status of the sine wave adapter 1 to light.

[0090] More specifically, as illustrated in FIG. 19, when the frequency set in the frequency switching circuit 122 is 50 Hz, the 50 Hz green LED is made to light; when the set frequency is 60 Hz, the 60 Hz green LED is made to light.

[0091] When the current detected by the current detection resistor 119 is 4 A or higher, the red LED corresponding to a set frequency is made to light; when the current detected by the current detection resistor 119 is 5 A or higher, the red LED corresponding to a set frequency is made to blink.

[0092] Further, although not-illustrated, a temperature detection means (e.g., thermistor) is disposed close to the FET 162. When a temperature detected by the thermistor is 100 Centigrade or higher, the green LED corresponding to a set frequency is made to blink.

[0093] Further, when the frequency is switched in the frequency switching circuit 122, the green and red LEDs corresponding to a set frequency are made to blink at a cycle of 0.5 sec for 3 seconds, followed by at a cycle of 0.2 sec for 2 seconds, and then only the green LED is made to light. Note that when both the green LED and red LED are being lighted, orange is lighted.

[0094] The fan mechanism 124 has a cooling fan 16 and a transistor 242. Upon reception of drive power, the microcomputer 121 outputs an ON signal (HIGH signal) to the transistor 242 to cause the cooling fan 16 to operate.

[0095] Here, using a flowchart of FIG. 20, the input voltage monitoring, determination on whether to perform boosting, and soft start which are performed by the microcomputer 121 will be described.

[0096] A routine of the flowchart of FIG. 20 starts when the inverter device 2 to which the sine wave adapter 1 has been attached is powered on to cause drive power to be supplied from the auxiliary power supply 115 to the microcomputer 121.

[0097] Upon reception of the drive power, the microcomputer 121 determines, based on voltage detected by the voltage detection circuit 114, whether or not voltage having a value higher than 120 V has been input from the inverter device 2 for 0.5 s (SI).

[0098] When the voltage having a value higher than 120 V has not been input for 0.5 s (NO in SI), the microcomputer 121 prevents the booster circuit 116, cooling fan 16, and inverter circuit 118 from operating (S2 to S4) to prevent the sine wave adapter 1 from outputting a sine wave (S5). This causes low voltage to be input to the sine wave adapter 1, preventing an element such as the FET in the sine wave adapter 1 from being damaged.

[0099] On the other hand, when the voltage having a value higher than 120 V has been input for 0.5 s (YES in SI), the microcomputer 121 determines, based on voltage detected by the voltage detection circuit 114, whether or not input voltage falls outside the first range (99 V or more and 169 V or less) (S6 and S7).

[0100] When the input voltage falls outside the first range (YES in S6 or S7), the micro-computer 121 prevents the booster circuit 116, cooling fan 16, and inverter circuit 118 from operating (S2 to S4) to prevent the sine wave adapter 1 from outputting a sine wave (S5).

[0101] On the other hand, when the input voltage falls within the first range (NO in S6 or S7), the microcomputer 121 determines whether the input voltage falls within the second range (127 V or more and 141 V or less) (S8 and S9).

[0102] When the input voltage falls outside the second range (NO in S8 or S9), the micro-computer 121 causes the booster circuit 116 to operate (S10) and then causes the cooling fan 16 to operate (Sll).

[0103] On the other hand, when the input voltage falls within the second range (YES in S8 or S9), the microcomputer 121 causes only the cooling fan 16 to operate (Sll) without causing the booster circuit 116 to operate. In this case, voltage output from the rectifier circuit 111 and first smoothing capacitor 112 is input unchanged to the inverter circuit 118. Note that whether or not the input voltage falls within the second range is de-termined when a time during which the input voltage falls within the second range continues for a predetermined length of time (e.g., 0.5 seconds). This is to make sine wave voltage of 100 V in effective value be reliably output with a case where the input value may rise and fall intermittently taken into consideration.

[0104] Subsequently, the microcomputer 121 causes operation of the inverter circuit 118 to start (S12) and determines, based on voltage detected by the current detection resistor 119, whether current having a value higher than 10 A has flowed in the inverter circuit 118 for 100 ms (S13).

[0105] When the current having a value higher than 10 A has flowed in the inverter circuit 118 for 100 ms (YES in SI3), the microcomputer 121 performs the soft start. That is, the microcomputer 121 reduces once the duty ratio of the second PWM signal to 50% (S14) and then spends 2.5 s to set back the duty ratio to 100% as illustrated in FIG. 2 1 (S 15 and S 16).

[0106] On the other hand, when the current having a value higher than 10 A has not flowed in the inverter circuit 118 for 100 ms (NO in SI3), the microcomputer 121 does not reduce the duty ratio but outputs the sine wave voltage with a duty ratio of 100% (S17).

[0107] As described above, in the sine wave adapter 1 according to the present embodiment, the microcomputer 121 stops operation of the booster circuit 116 when the maximum value of voltage input to the sine wave adapter 1 falls within the second range (127 V or more and 141 V or less in the present embodiment), thereby preventing waste of electric power due to unnecessary operation of the booster circuit 116.

[0108] On the other hand, the microcomputer 121 causes the booster circuit 116 to operate when the maximum value of voltage input to the sine wave adapter 1 falls outside the second range (127 V or more and 141 V or less in the present embodiment). Thus, even if rectangular wave voltage having a maximum value different from 141 V is output from the inverter device 2 due to, e.g., a reduction in the voltage of the lead storage battery 3, sine wave voltage having 100 V in effective value can be output from the since wave adapter 1, thus preventing a precision machine connected to the sine wave adapter 1 from breaking down.

[0109] Further, the microcomputer 121 stops operation of the booster circuit 116 and inverter circuit 118 when the maximum value of the input voltage falls outside the first range (99 V or more and 169 V or less in the present embodiment), thereby preventing an element such as the FET in the sine wave adapter 1 from being damaged.

[0110] Further, the sine wave adapter 1 according to the present embodiment has the frequency switching circuit 122 and can thereby be used in both the Kanto area and Kansai area which are different in frequency of the commercial power supply.

[0111] Next, using FIGS. 22 and 23, a sine wave adapter 200 according to a second embodiment of the present invention will be described.

[0112] The sine wave adapter 200 according to the present embodiment is featured in that when a waveform input thereto is a sine wave, the sine wave adapter 200 outputs without change the input sine wave without causing the booster circuit 116 and inverter circuit 118 to operate. As illustrated in FIG. 22A, the since wave adapter 200 has a waveform determination circuit 125 and a bypass circuit 126.

[0113] The waveform determination circuit 125 corresponds to a waveform determination section of the present invention.

[0114] The waveform determination circuit 125 has a rectifier diode 251, voltage dividing resistors 252 and 253, and a transistor 254.

[0115] Assuming that one of sine wave voltage and rectangular wave voltage illustrated in FIG. 23A is input to the sine wave adapter 200, the input voltage is rectified by the rectifier diode 251, the rectified voltage is then divided by the voltage dividing resistors 252 and 253, and the divided voltage is input to a base of the transistor 254 (FIG. 23B). While the divided voltage input to the base exceeds ON voltage of the transistor 254 (dotted line in FIG. 23C), the transistor 254 is kept ON. As a result, the microcomputer 121 receives as an input a LOW level determination signal while the transistor 254 is kept ON and receives a HIGH level determination signal while the transistor 254 is kept OFF (FIG. 23D). Since T1 (HIGH signal time) and T2 (HIGH signal time + LOW signal time) are different between the sine wave voltage and rectangular wave voltage, the microcomputer 121 can determine whether the voltage input to the sine wave adapter 200 is the sine wave or rectangular wave based on T1 and T2.

[0116] In more detail, the microcomputer 121 determines that the voltage input to the sine wave adapter 200 is the rectangular wave when T1 is about half the T2 and determines that the voltage input to the sine wave adapter 200 is the sine wave when T1 is sufficiently smaller than T2.

[0117] The bypass circuit 126 has a relay circuit 261 and a transistor 262.

[0118] The relay circuit 261 has a relay 261a connected between input terminals A and B of the sine wave adapter 200 and a coil 261b disposed closed to the relay 261a. One end of the coil 261b is connected to a power supply and the other end thereof is connected to a collector of the transistor 262.

[0119] When determining, based on the determination signal from the waveform determination circuit 125, that the sine wave voltage is input, the microcomputer 121 outputs an ON signal (HIGH signal) to a base of the transistor 262. Then, the transistor 262 is tuned ON to cause current to flow in the coil 262b to thereby close the relay 261a. It follows that the sine wave voltage input to the input terminal A is output from the output terminal B without intervention of the booster circuit 116 and inverter circuit 118.

[0120] The operation described above will be described along a flowchart of FIG. 22B. As illustrated in FIG. 22B, supply of drive power causes the waveform determination circuit 125 and microcomputer 121 to determine whether the voltage input to the input terminal A is the sine wave voltage or rectangular wave voltage (S50). When the input voltage is the rectangular wave voltage (YES in S50), the microcomputer 121 determines a frequency set by a not-illustrated frequency switching circuit (frequency switching circuit 122 of FIG. 18A) (S51) and sets an output of the inverter circuit 118 according to the set frequency (S52 and S53). Thereafter, the microcomputer 121 turns OFF the bypass circuit 126 (S54) and, after a predetermined time (e.g., 5 seconds) required for the bypass circuit 126 to be tuned OFF reliably has elapsed (S55), causes the booster circuit 116 and inverter circuit 118 to operate (S56).

[0121] On the other hand, when the input voltage is the sine wave voltage (NO in S50), the microcomputer 121 determines a frequency from time T2 illustrated in FIG. 23D (S57). When the frequency is neither 50 Hz nor 60 Hz (NO in S57), a frequency of the input voltage is calculated by 1/T2 and, assuming that the calculated frequency is, e.g., 55 Hz, the microcomputer 121 redetermines that the input voltage is the rectangular wave voltage and performs step S51 and subsequent steps based on this determination. When the frequency is one of 50 Hz and 60 Hz (YES in S57), the microcomputer 121 stops operation of the booster circuit 116 and inverter circuit 118 (S58) and, after a predetermined time (e.g., 5 seconds) required for the operation of the booster circuit 116 and inverter circuit 118 to be stopped reliably has elapsed (S59), causes the bypass circuit 126 to be turned ON (S60).

[0122] As described above, in the sine wave adapter 200 according to the present embodiment, when the sine wave voltage is input to the sine wave adapter 200, the microcomputer 121 outputs without change the sine wave voltage without causing the booster circuit 116 and inverter circuit 118 to operate, preventing waste of electric power. Although whether the input voltage is the sine wave voltage or rectangular voltage is determined in the present embodiment, determination of DC voltage may be added to the processing routine. When the input voltage is determined to be the DC voltage, the same procedure as in the case where the input voltage is determined to be the rectangular voltage may be taken. That is, no matter what type (rectangular wave voltage, DC voltage, etc.) of voltage is input to the sine wave adapter 200, the sine wave voltage is always output.

[0123] Next, a sine wave adapter 300 according to a third embodiment of the present invention will be described using FIG. 24.

[0124] The sine wave adapter 300 according to the present embodiment is featured in that an output voltage can be switched. As illustrated in FIG. 24, the sine wave adapter 300 has a voltage switching resistor 127, a voltage switching FET 128, and a voltage switching circuit 129.

[0125] The voltage switching resistor 127 and voltage switching FET 128, which are connected in series to each other, are connected in parallel to the voltage detection resistor 166 of the booster circuit 116.

[0126] The voltage switching circuit 129 has a switch 291 and an EEPROM 292. An operator can select 100 V or 230 V as an effective value of the sine wave voltage to be output from the sine wave adapter 300 by pressing the switch 291 for a predetermined length of time (e.g., 3 seconds). Storing the selected voltage in the EEPROM 292 allows the set voltage to be kept even if power supply to the sine wave adapter 300 is stopped.

[0127] The voltage switching circuit 129 corresponds to a voltage setting section of the present invention.

[0128] In more detail, when the switch 291 is pressed, a HIGH level voltage switching signal is input to the microcomputer 121 from the voltage switching circuit 129, and then the microcomputer 121 turns ON the voltage switching FET 128 in response to the voltage switching signal. When the voltage switching FET 128 is tuned ON, divided voltage to be input to the switching IC 163 changes. Upon occurrence of the change in the divided voltage, the switching IC 163 changes the duty of ON/OFF of the FET 162 to thereby switch the effective value of the sine wave voltage to be output from the sine wave adapter 300 so as to allow the operator to select 100 V or 230 V. Note that the effective value of the sine wave voltage may be switched to a voltage value other than 100 V and 230 V. In this case, a set of a voltage switching resistor and a voltage switching FET similar to a set of the voltage switching resistor 127 and voltage switching FET 128 is connected in parallel to the voltage detection resistor 166, and an FET corresponding to desired voltage is turned ON in accordance with pressed time of the switch 291.

[0129] As described above, the sine wave adapter 300 according to the present embodiment can change voltage to be output therefrom and can thus be used in a foreign country where a voltage of a commercial power supply may differ.

[0130] Next, a sine wave adapter 400 according to a fourth embodiment of the present invention will be described.

[0131] The sine wave adapter 400 according to the present embodiment performs overcurrent control.

[0132] More in detail, as illustrated in FIG. 25, when current detected by the current detection resistor 119 is higher than a predetermined value (5 A in the present embodiment) (YES in S21), the microcomputer 121 reduces the duty of the second PWM signal (S22). Then, when current detected by the current detection resistor 119 has not been reduced to equal to or less than a predetermined value (NO in S24)after elapse of a predetermined time (10 s in the predetermined embodiment) (YES in S23), the microcomputer 121 outputs the second PMW signal causing operation of the inverter circuit 118 to be stopped (S25).

[0133] As described above, the sine wave adapter 400 according to the present embodiment prevents high current from flowing in the inverter circuit 118, thereby preventing the FETs 181a to 181d constituting the inverter circuit 118 from being damaged. When operation of the inverter circuit 118 is stopped due to detection of overcurrent, a red LED corresponding to a set frequency is made to blink as illustrated in FIG. 19 so as to allow an operator to grasp that output operation is stopped due to detection of overcurrent.

[0134] A fifth embodiment of the present invention is illustrated in FIG. 27. The fifth embodiment differs from the above-described embodiments in the structure involved in drainage structure formed in the sine wave adapter 1.

[0135] In the fifth embodiment, in addition to the drain outlet 10c, a second drain outlet 110c is formed adjacent to the drain outlet 10c. Further, a second partition wall 110A extends vertically downward from an inner upper surface of the casing 10 so as to be slightly spaced apart from the partition wall 10A in the left-right direction. Furthermore, a third partition wall 110B extends vertically upward from the inner bottom surface of the casing 10 so as to be slightly spaced apart from the second partition wall 110A in the left-right direction. The second drain outlet 110c is formed between the partition wall 10A and third partition wall HOB. With the above configuration, even if outside water that has flowed over the partition wall 10A, the water can be discharged outside through the second drain outlet 110c. Such a labyrinth structure prevents water entering through the air inlet port 10a from entering further inside. The air outlet 10b side also has a configuration as illustrated in FIG. 27.

[0136] As described above embodiments, the sine wave adapter 1 and inverter device 2 are separately provided. There may be a case where some user uses only devices that are driven by rectangular AC voltage. In such a case, setting the output of the inverter device 2 to the rectangular AC voltage satisfies the requirement of the user. In order to set the output of the inverter device 2 to the rectangular AC voltage, a filter circuit section is required after the DC voltage is converted into AC voltage in the inverter section of the inverter device 2. The filter circuit section is a circuit for shaping a rectangular waveform into a sine waveform. This filter circuit requires a plurality of coil and capacitors and thus costs high. This poses a large cost burden on the user who uses only devices driven by the rectangular AC voltage.

[0137] Further, even if the inverter 2 is configured to be able to switch between the sine wave and rectangular wave, a switching section for achieving the switching needs to be provided in addition to the filter circuit section, and the cost burden becomes large.

[0138] In order to cope with this, the present invention provides the sine wave adapter 1 capable of outputting the sine wave by being connected to the inverter device 2 that outputs the rectangular wave. It follows that only a user who requires the function of the sine wave adapter 1 may use the sine wave adopter 1, and the cost burden for the user who does not require the function of the sine wave adapter 1 is reduced. Further, designing the sine wave adapter 1 so as to be fixable to the inverter device 2 prevents the entire size from significantly increasing and allows the sine wave adapter 1 and inverter device 2 to be used in an integrated manner, thereby increasing portability and operability.

[0139] The power supply device according to the present invention is not limited to the above embodiments but may be variously changed and modified within the scope of the appended claims.

[0140] Although the circuit board 17 is filled with the urethane 17A for waterproof, dustproof, and vibration-proof purposes in the first embodiment, a resin to be used is not limited to the urethane. For example, silicone may be used as the resin.

[0141] Further, operation of the inrush current preventing circuit 13 (113) may be controlled by the microcomputer 21 (121). In this case, the microcomputer 21 (121) monitors input voltage by means of the voltage detection circuit 14 (114). Then, as illustrated in FIG. 28, when voltage having a value higher than 120 V is input from the inverter device 2 for 0.5 s (YES in SI), the microcomputer 121 outputs an ON signal to a gate of the FET 131 to cause the inrush current preventing circuit 113 to operate (SIB).

[0142] On the other hand, when voltage having a value lower than 120 V is input from the inverter device 2 for 0.5 s (NO in SI), the microcomputer 121 outputs an OFF signal to the gate of the FET 131 to stop operation of the inrush current preventing circuit 113 (to prevent the inrush current preventing circuit 113 from operating). Adopting this configuration allows the voltage dividing resistors 133 and 134 of the inrush current preventing circuit 113 to be omitted, thereby reducing cost.

[0143] In the third embodiment, a configuration may be adopted in which the voltage switching resistor 127 and voltage switching FET 128 are not provided but boosted voltage is switched by the switching IC 163 detecting a change in feedback voltage of the second smoothing capacitor 117. Further, when a voltage switching signal is input, the microcomputer 121 may directly control the switching IC 163.

[0144] Although the first and second ranges are defined as 99 V or more and 169 V or less and 127 V or more and 141 V or less in the above embodiments, the values of the first and second ranges are not limited to theses values.

[0145] Although the lead storage battery 3 and battery pack 5 (lithium ion battery) are used as a power supply to be connected to the inverter device 2 through the adapter 4 in FIGS. 1 and 2, other types of battery such as a nickel-cadmium battery and a nickel hydride battery may be connected to the inverter device 2. Further, batteries having any voltage value may be connected.

[0146] Although both the first and second PWM signals are used to stop the output of the sine wave adapter 1 in the above embodiments, the output of the sine wave adapter 1 may be stopped only by using the second PWM signal. When the booster circuit 116 is a transformer, the output of the sine wave adapter 1 may be stopped only by using the first PWM signal.

[0147] Further, the sine wave adapter 1 may directly receive DC voltage from, e.g., the battery pack 5. Even in this case, the sine wave adapter 1 can output the sine wave.

[0148] Although one partition wall 10A is used to prevent entering of water in the first embodiment and three partition walls 10A, 110A (second partition wall), and 110B (third partition wall) are used to prevent entering of water in the fifth embodiment, the number of partition walls to be used is not limited to these values.

Claims

[Claim 1] A waveform converter comprising:
an input section configured to receive an input voltage;
an inverter circuit configured to convert the input voltage into a sine wave AC voltage; and
an output section configured to output the sine wave AC voltage.

[Claim 2] The waveform converter according to claim 1, further comprising a first housing having a first fixing portion to which an inverter device configured to output the input voltage to the input section is fixed.

[Claim 3] The waveform converter according to claim 2, wherein the inverter device converts a DC voltage into a rectangular wave AC voltage, and wherein the inverter circuit converts the rectangular wave AC voltage into the sine wave AC voltage.

[Claim 4] The waveform converter according to claim 2, wherein the first housing has a box-like shape having a first upper surface, a first bottom surface, and a first side surface, the first fixing portion being provided on the first upper surface.

[Claim 5] The waveform converter according to claim 2, wherein the inverter device converts the DC voltage supplied from a battery pack for an electric tool into the rectangular wave AC voltage, and
wherein the inverter device is configured to be fixed to the first fixing portion upon connected with the battery pack.

[Claim 6] The waveform converter according to claim 2, wherein the first housing has a box-like shape having a first upper surface, a first bottom surface, and four first side surfaces, a first input/output terminal directed outward of the first housing being provided on the first side surface,
wherein the inverter device has a second housing having a box-like shape having a second upper surface, a second bottom surface, and four second side surfaces, a second input/output terminal directed outward of the second housing being provided on the second side surface, and
wherein the inverter device is fixed to the first fixing portion so that the second surface faces the first upper surface and the four first sides correspond to the four second sides, respectively.

[Claim 7] The waveform converter according to claim 6, wherein the inverter device has a second fixing portion configured to be engaged with the first fixing portion, and
wherein the second fixing portion and the second input/output terminal

are provided on different surfaces of the second housing.

[Claim 8] The waveform converter according to claim 1, further comprising:
a booster circuit configured to boost the input voltage;
a controller configured to control the booster circuit and the inverter circuit; and
a voltage detection section configured to detect the input voltage,
wherein the controller prohibits the booster circuit from boosting the input voltage if the input voltage detected by the voltage detection section falls within a boosting prohibition range.

[Claim 9] The waveform converter according to claim 8, wherein the inverter circuit further comprises:
an inverter section configured to convert a voltage outputted from the booster circuit into a pulse wave voltage; and
a shaping section configured to shape the pulse wave voltage into a sine wave voltage,
wherein the controller operates the inverter circuit without operating the booster circuit if the input voltage detected by the voltage detection section falls within the boosting prohibition range.

[Claim 10] The waveform converter according to claim 8, wherein the controller prohibits the operations of at least one of the booster circuit and inverter circuit if the input voltage detected by the voltage detection section falls outside an input allowable range.

[Claim 11] The waveform converter according to claim 8, further comprising a current detection section configured to detect a current flowing in the inverter circuit,
wherein the controller controls the inverter circuit to reduce a voltage outputted from the inverter circuit if the current detected by the current detection section is equal to or higher than a predetermined value.

[Claim 12] The waveform converter according to claim 8, further comprising a frequency setting section configured to set a frequency of a voltage outputted from the output section,
wherein the controller controls the inverter circuit so that a voltage having a frequency set in the frequency setting section is outputted from the output section.

[Claim 13] The waveform converter according to claim 8, further comprising a voltage setting section configured to set a voltage outputted from the output section,
wherein the controller controls the booster circuit so that a voltage set

in the voltage setting section is outputted from the output section.

[Claim 14] The waveform converter according to claim 8, further comprising:
a waveform determination section configured to determine a waveform of the input voltage; and
a bypass circuit connected between the input section and the output section,
wherein the controller turns the bypass circuit ON if the waveform determined by the waveform determination section is a sine wave.

[Claim 15] The waveform converter according to claim 14, wherein the controller prohibits the operation of at least the inverter circuit if the waveform determined by the waveform determination section is a sine wave.

[Claim 16] A power supply device comprising:
an inverter device connected with a battery pack for an electric tool to convert a DC voltage from the battery pack into a rectangular wave AC voltage; and
the waveform converter according to claim 8 connected with the inverter device.

[Claim 17] The waveform converter according to claim 2, wherein the housing is formed with a through hole; a shield wall provided inside the housing to face the through hole; a drain space defined between the through hole and the shield wall, a lower portion of the drain space being defined by a bottom surface of the housing; and a drain through hole at the bottom surface.

[Claim 18] The waveform converter according to claim 1, further comprising a circuit board having a voltage conversion circuit configured to convert a rectangular wave AC voltage into a since wave AC voltage, the circuit board being covered with a resin material.

[Claim 19] A power supply device comprising:
a box-like main body having an opening;
a lid body provided in the main body to close the opening;
a lead storage battery accommodated in the main body; and
an inverter device configured to receive a DC voltage from the lead storage battery through an adapter,
wherein the main body is configured to accommodate the waveform converter according to claim 1.

[Claim 20] The power supply device according to claim 19, wherein the waveform converter and inverter device are configured to be connected to each other in a state where the inverter device is fixed to the lid body and the waveform converter is accommodated in the main body.

[Claim 21] A waveform converter comprising:
an input section configured to receive an input voltage;
a booster circuit configured to boost the input voltage;
an inverter circuit configured to convert the boosted input voltage into a sine wave voltage;
a controller configured to control the booster circuit and the inverter circuit;
an output section configured to output the sine wave voltage; and
a voltage detection section configured to detect the input voltage,
wherein the controller prohibits the booster circuit from boosting the input voltage if the input voltage detected by the voltage detection section falls within a boosting prohibition range.

[Claim 22] The waveform converter according to claim 21, wherein the inverter circuit further comprises:
an inverter section configured to convert the boosted voltage into a pulse wave voltage; and
a shaping section configured to shape the pulse wave voltage into a sine wave voltage,
wherein the controller operates the inverter circuit without operating the booster circuit if the input voltage detected by the voltage detection section falls within the boosting prohibition range.

[Claim 23] The waveform converter according to claim 21, wherein the controller prohibits the operations of at least one of the booster circuit and inverter circuit if the input voltage detected by the voltage detection section falls outside an input allowable range.

[Claim 24] The waveform converter according to claim 21, further comprising a current detection section configured to detect a current flowing in the inverter circuit,
wherein the controller controls the inverter circuit to reduce a voltage outputted from the inverter circuit if the current detected by the current detection section is equal to or higher than a predetermined value.

[Claim 25] The waveform converter according to claim 21, further comprising a frequency setting section configured to set a frequency of a voltage outputted from the output section,
wherein the controller controls the inverter circuit so that a voltage having a frequency set in the frequency setting section is outputted from the output section.

[Claim 26] The waveform converter according to claim 21, further comprising a voltage setting section configured to set a voltage outputted from the output section,
wherein the controller controls the booster circuit so that a voltage set in the voltage setting section is outputted from the output section.

[Claim 27] The waveform converter according to claim 21, further comprising:
a waveform determination section configured to determine a waveform of the input voltage; and
a bypass circuit connected between the input section and the output section,
wherein the controller turns the bypass circuit ON if the waveform determined by the waveform determination section is a sine wave.

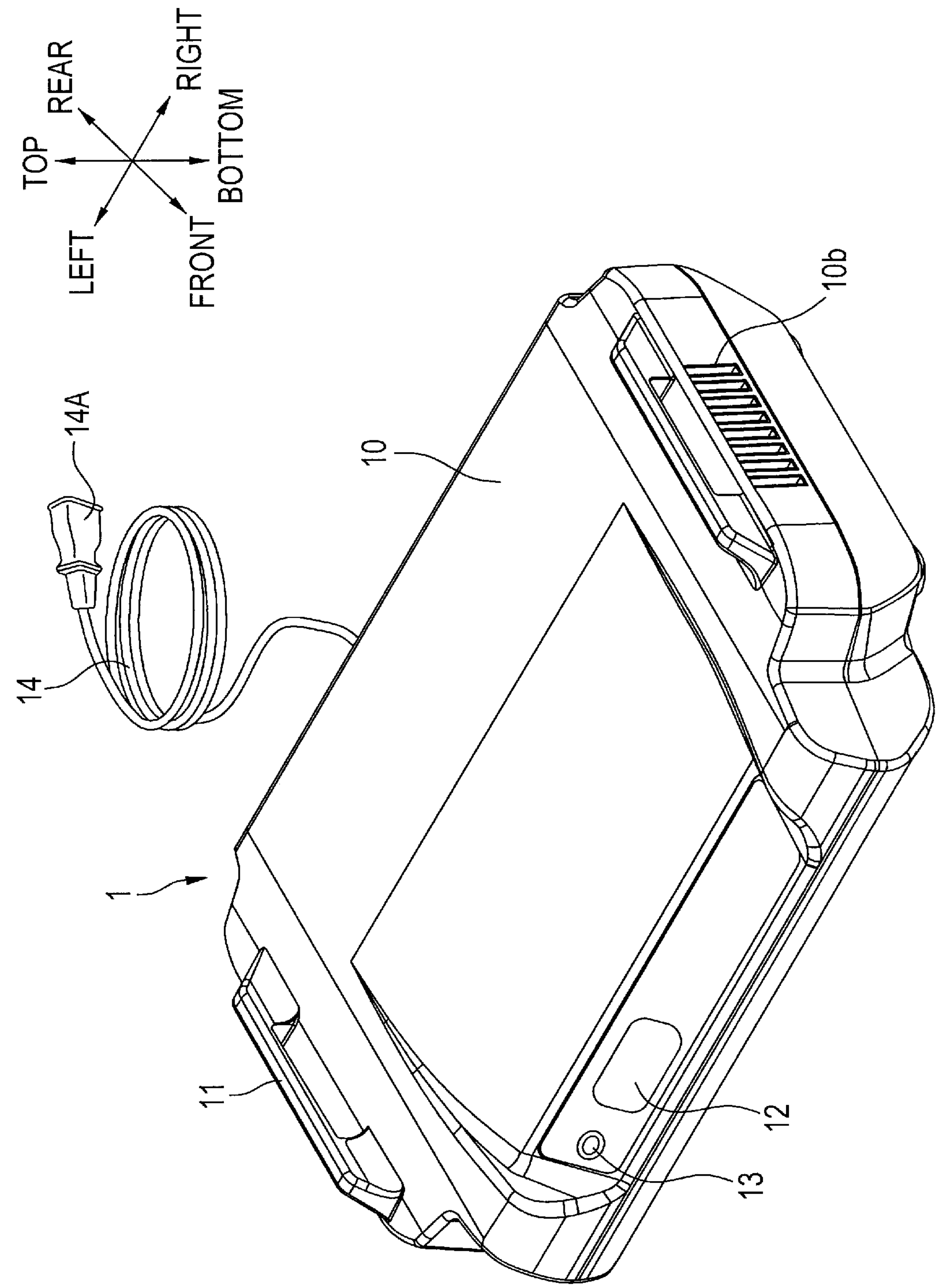
[Claim 28] The waveform converter according to claim 27, wherein the controller prohibits the operation of at least the inverter circuit if the waveform determined by the waveform determination section is a sine wave.

[Claim 29] A power supply device comprising:
an inverter device connected with a battery pack for an electric tool to convert a DC voltage from the battery pack into a rectangular wave voltage; and
the waveform converter according to claim 21 connected with the inverter device.

[Claim 30] The power supply device according to claim 28, wherein then inverter device converts a DC voltage from a lead storage battery into a rectangular wave AC voltage.

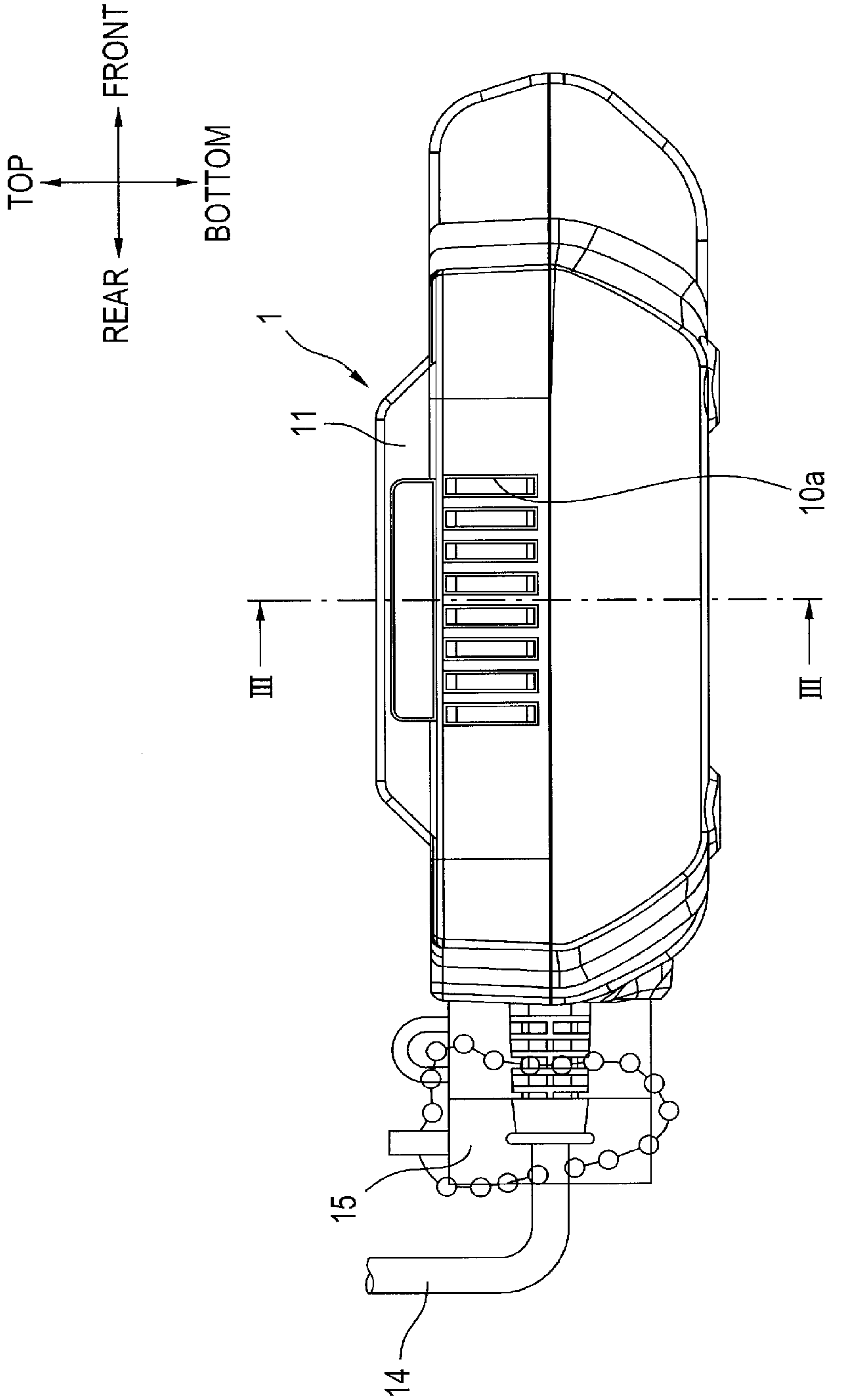
[Fig. 1]

FIG.1



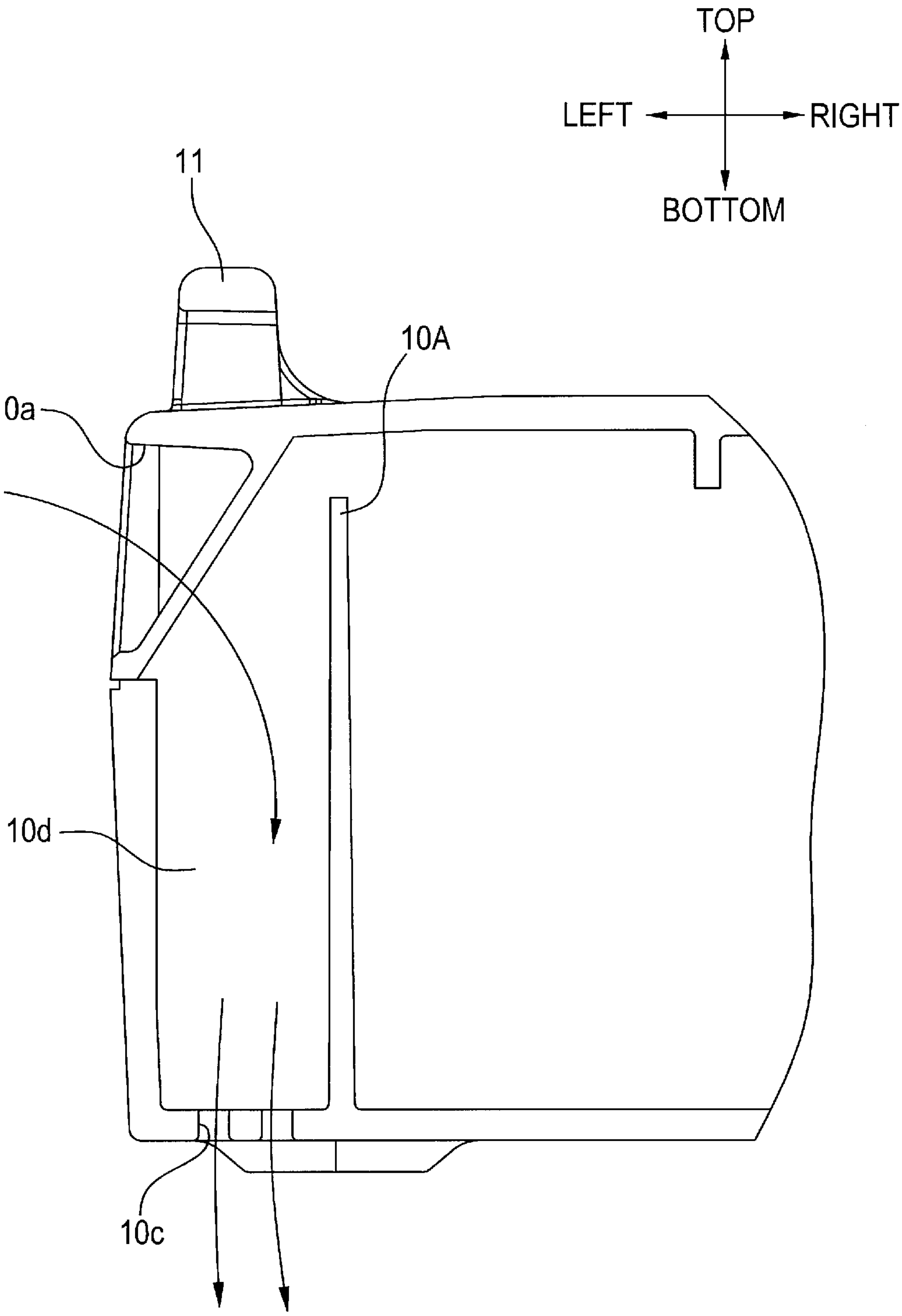
[Fig. 2]

FIG.2



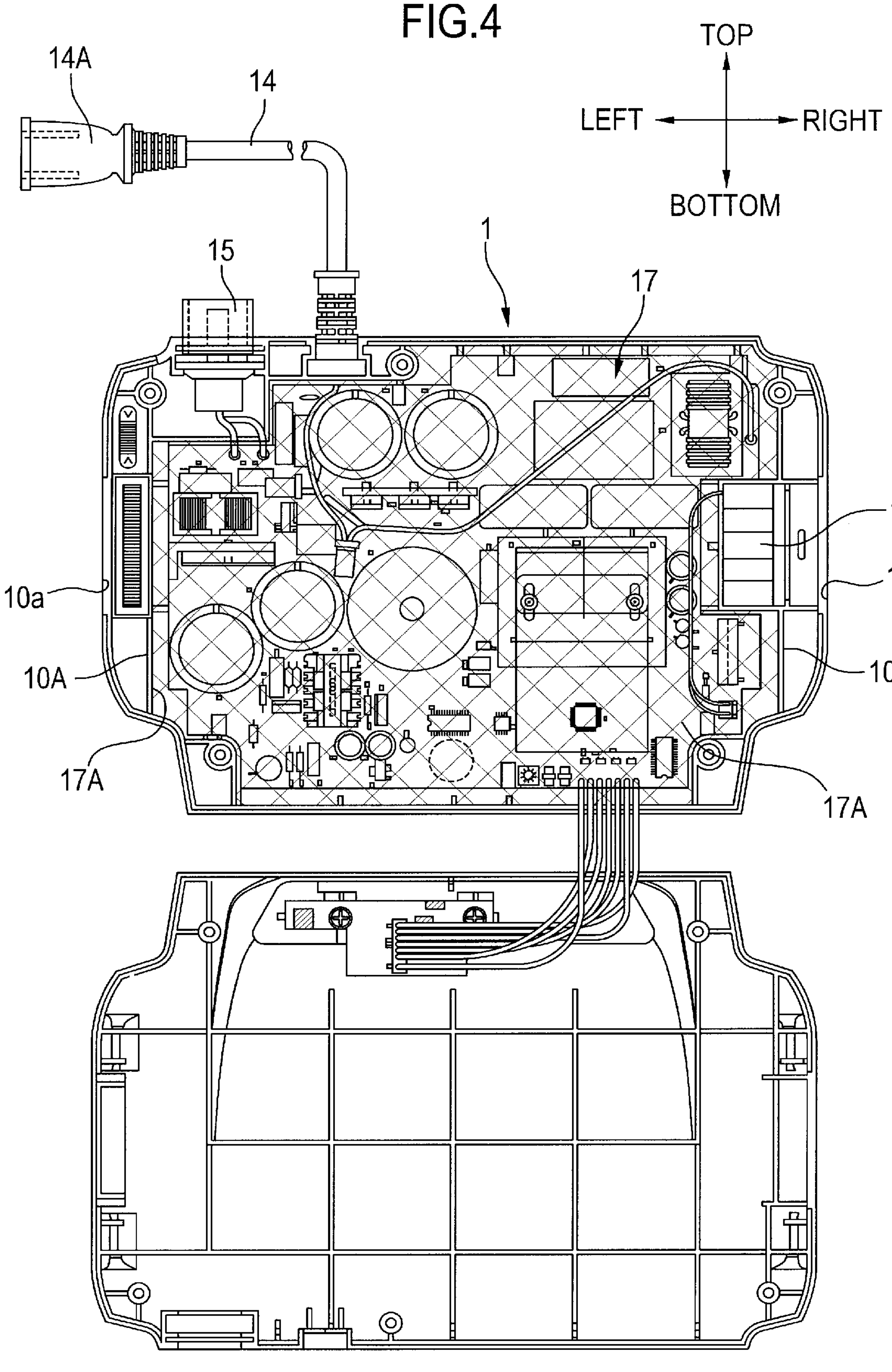
[Fig. 3]

FIG.3



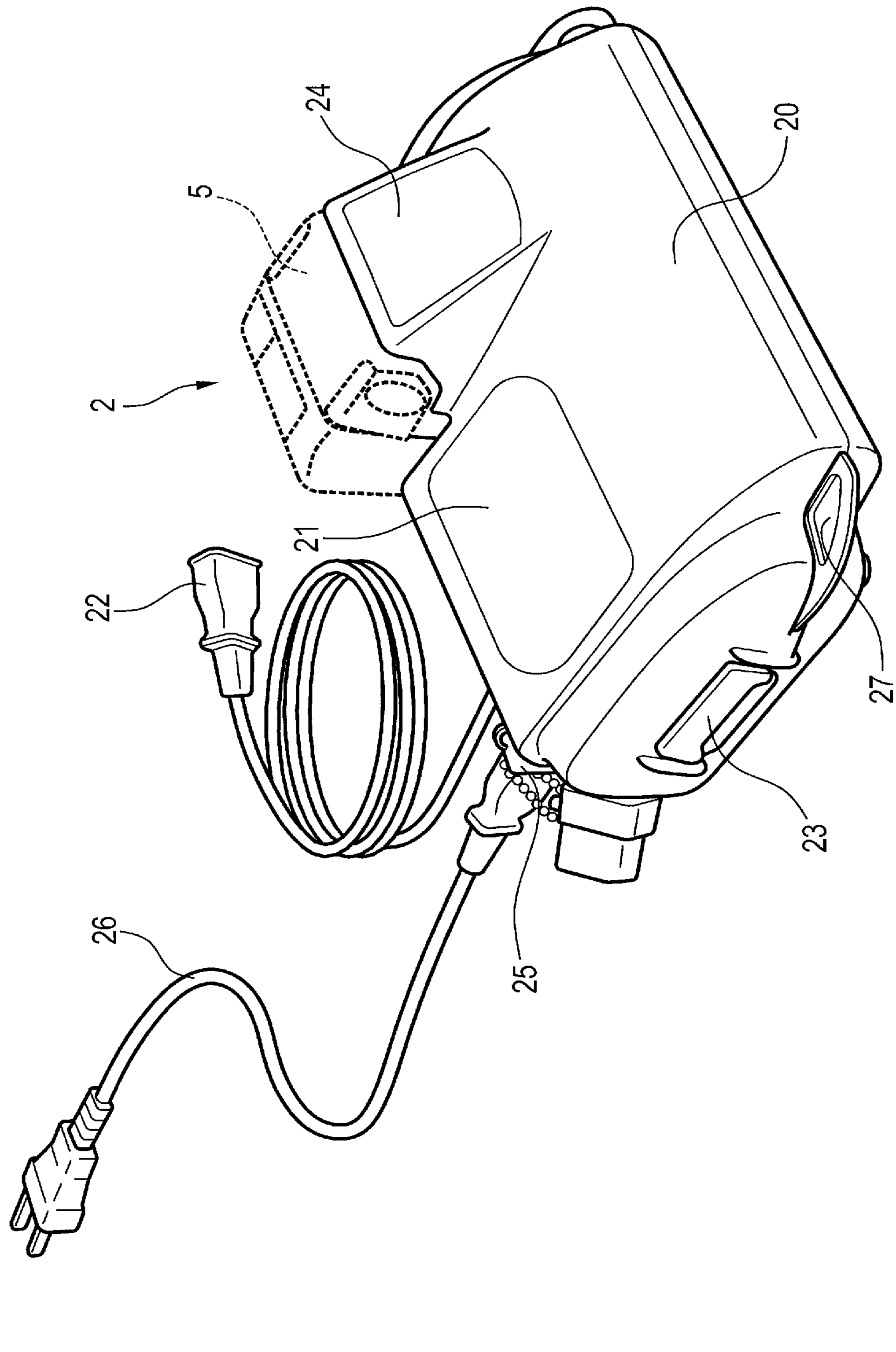
[Fig. 4]

FIG.4



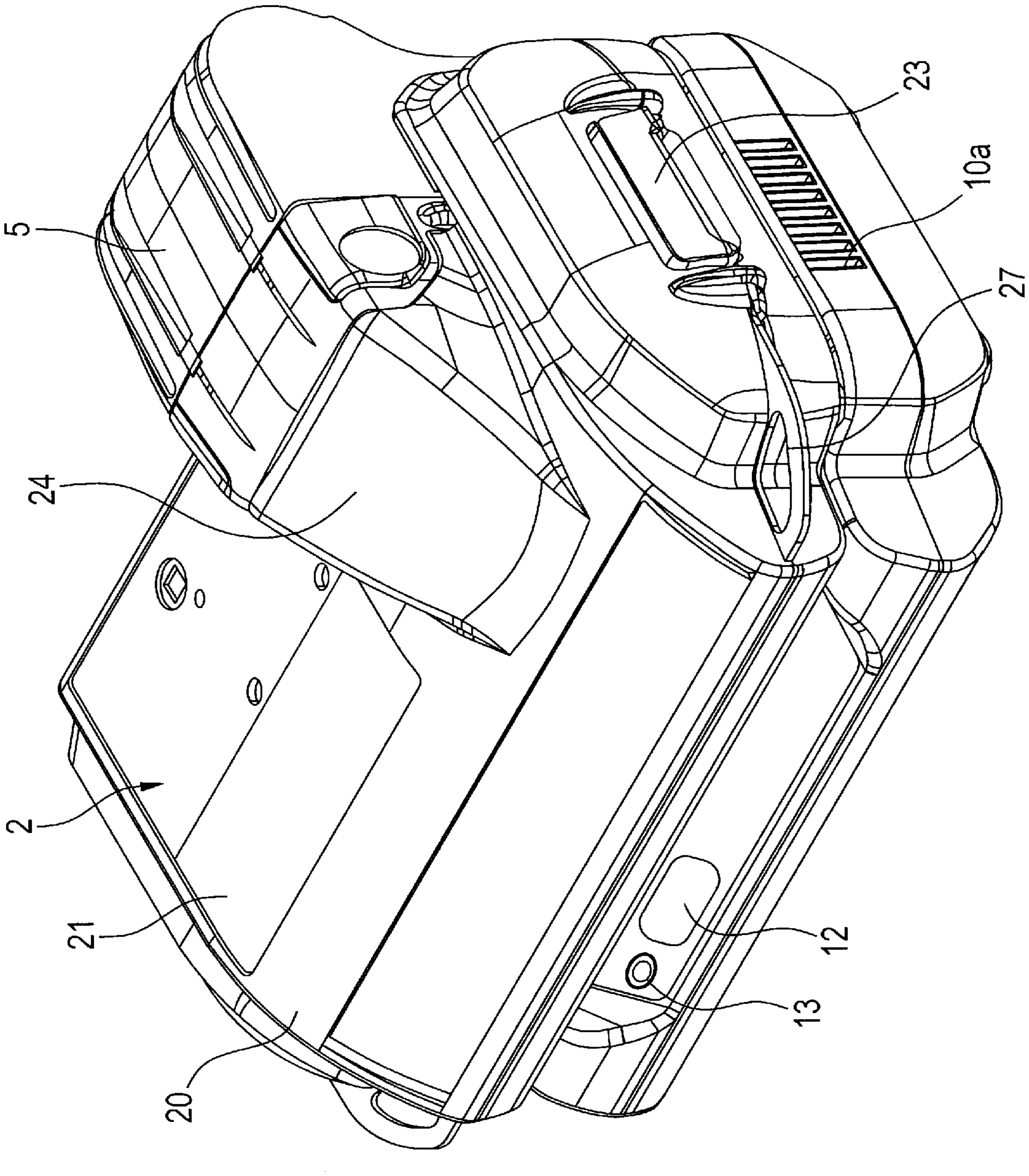
[Fig. 5]

FIG.5



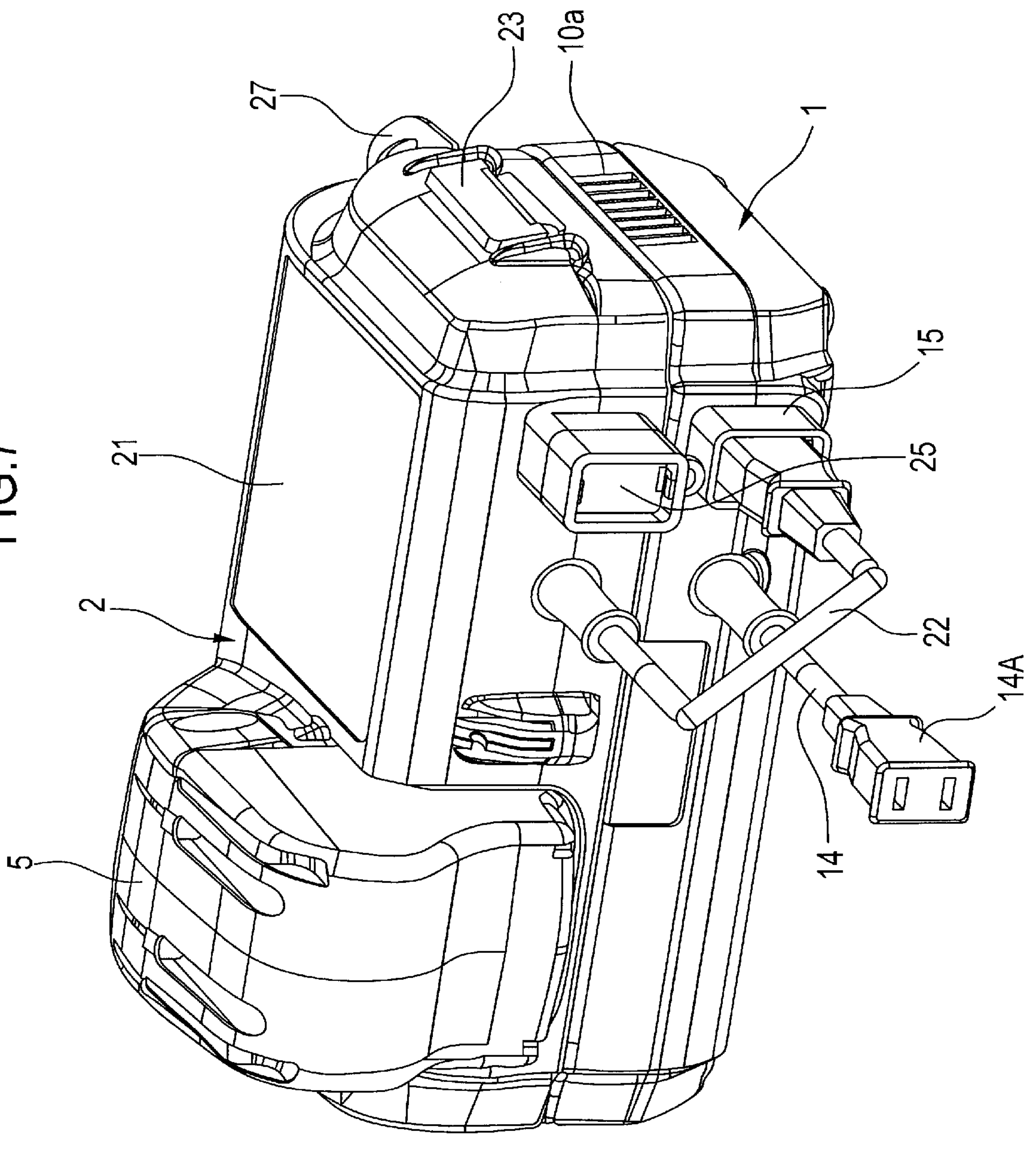
[Fig. 6]

FIG.6



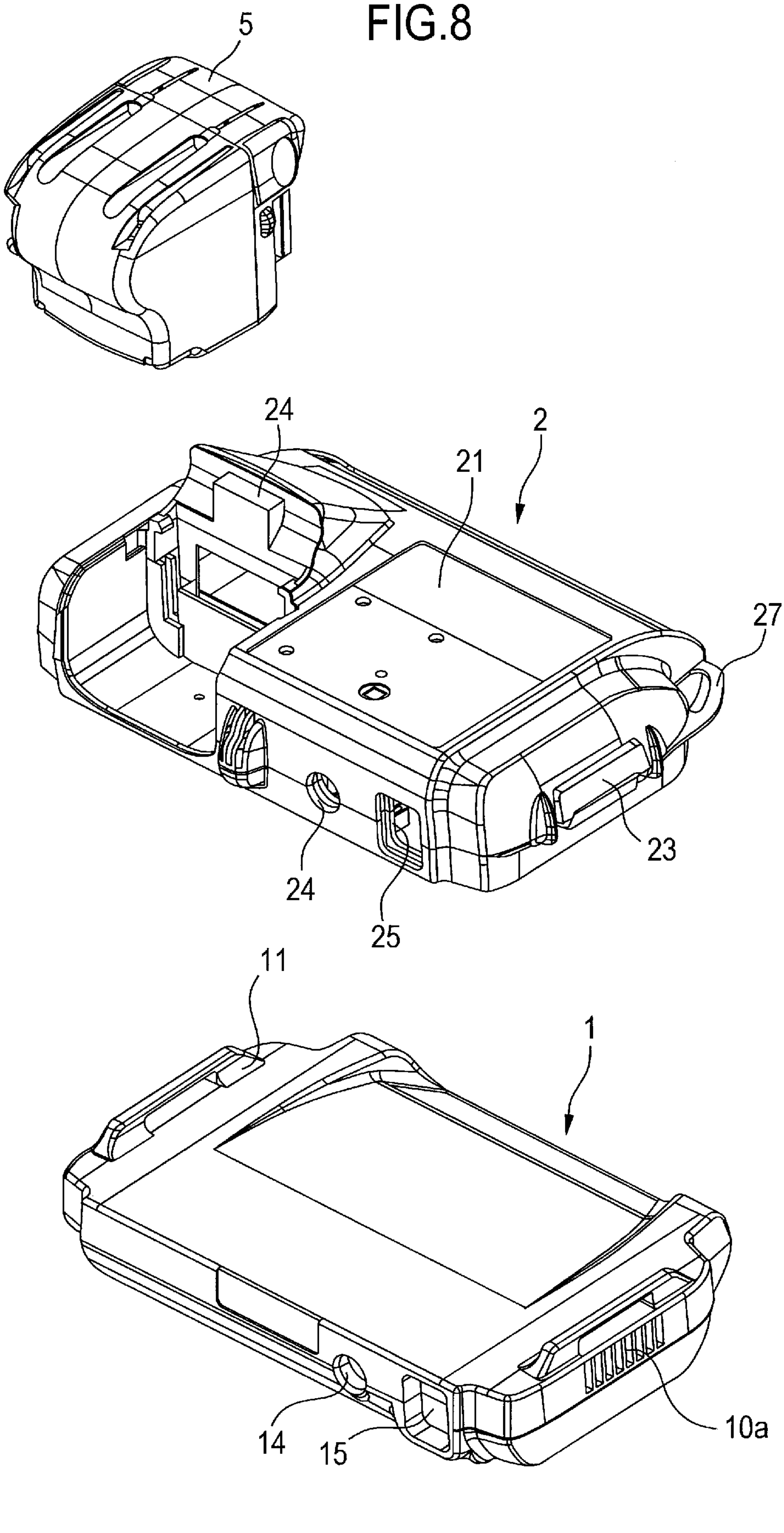
[Fig. 7]

FIG.7



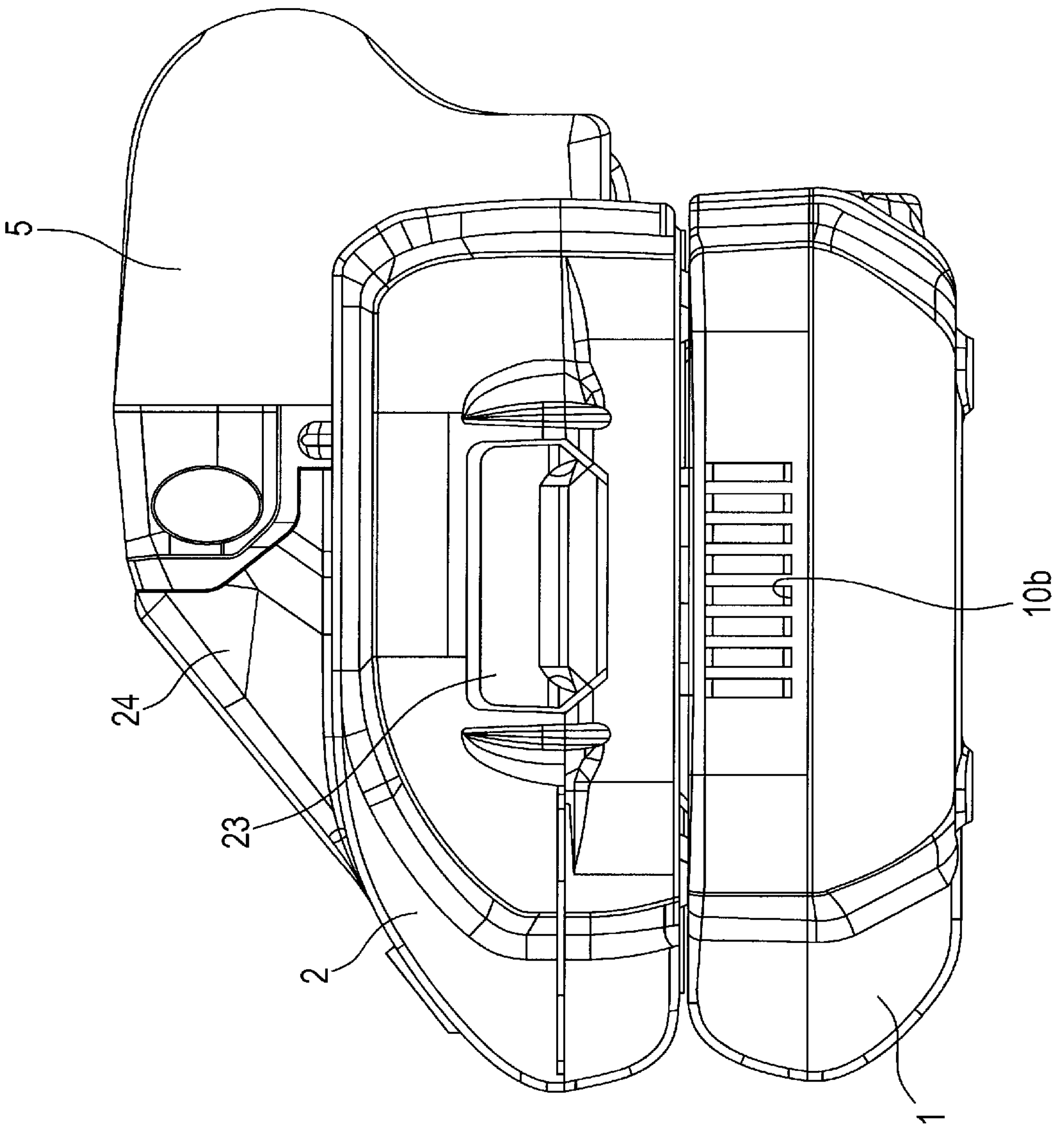
[Fig. 8]

FIG.8



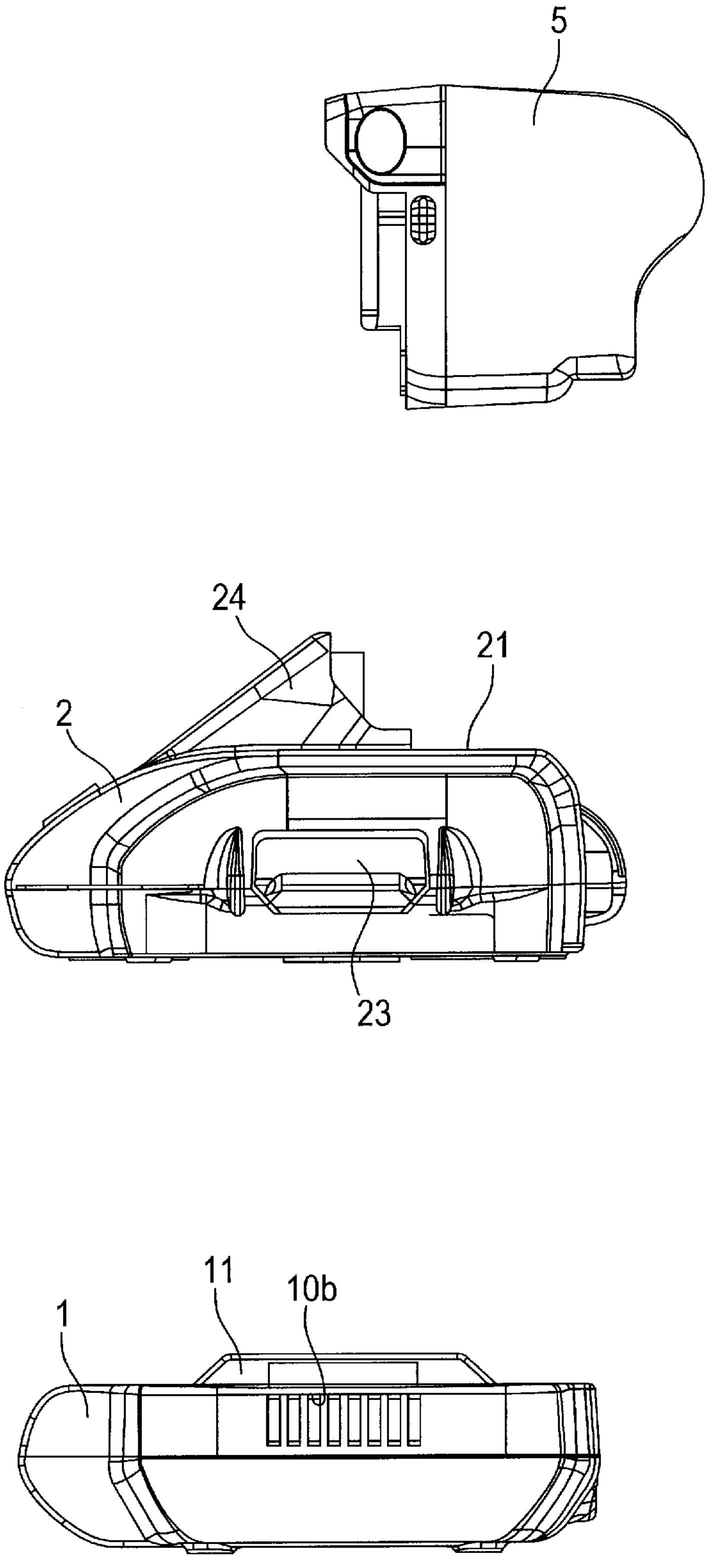
[Fig. 9]

FIG.9



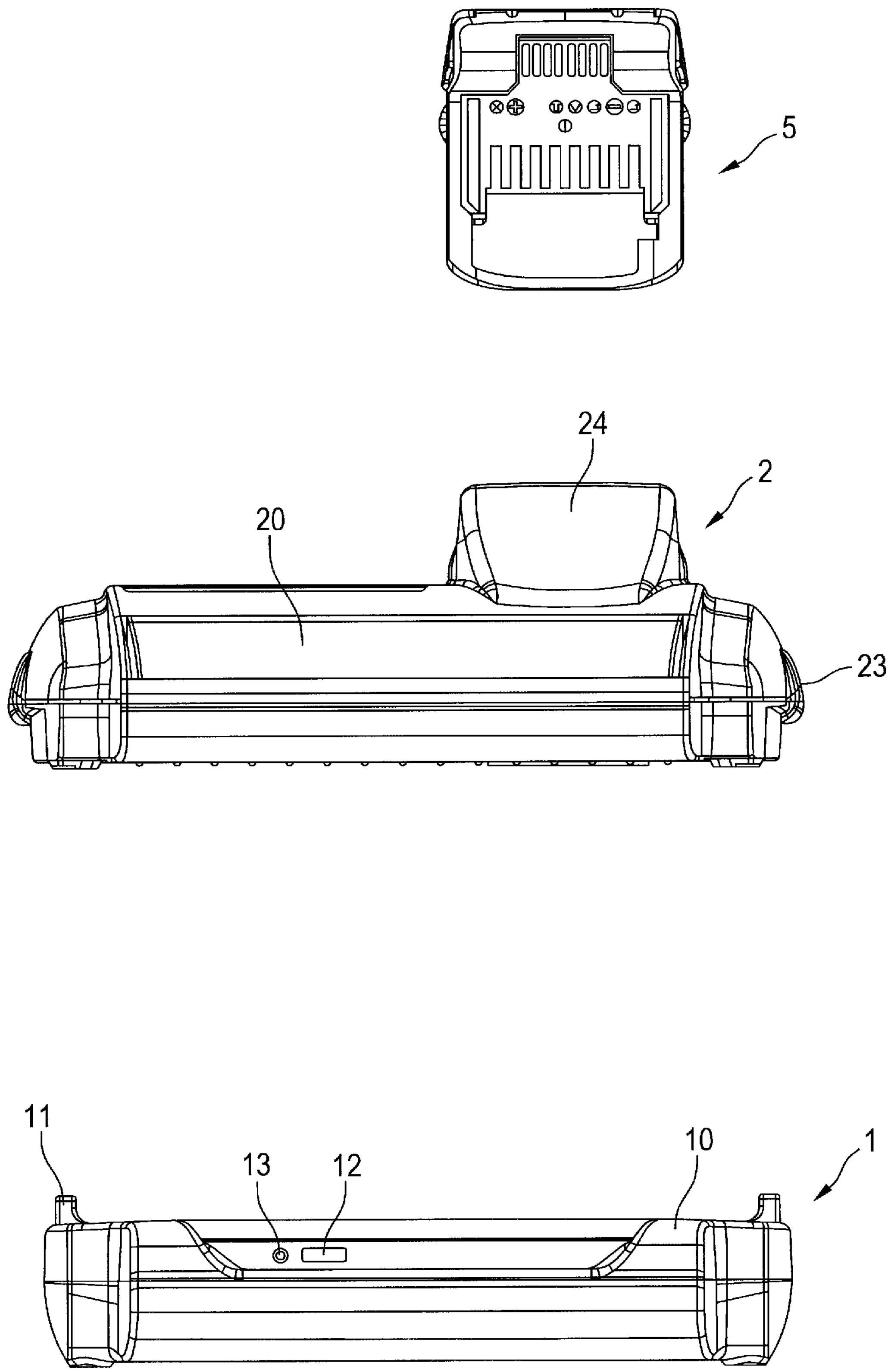
[Fig. 10]

FIG.10



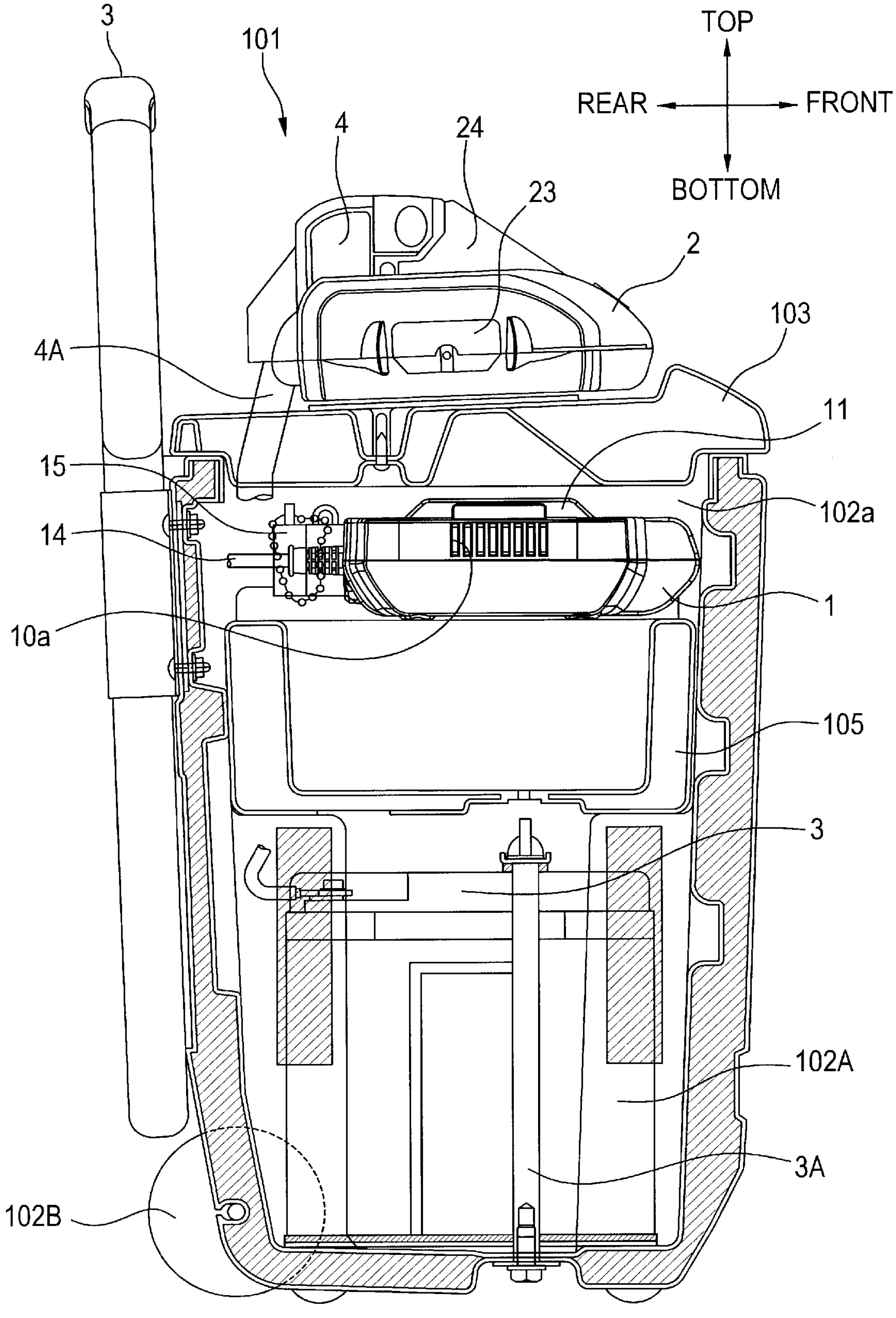
[Fig. 11]

FIG.11



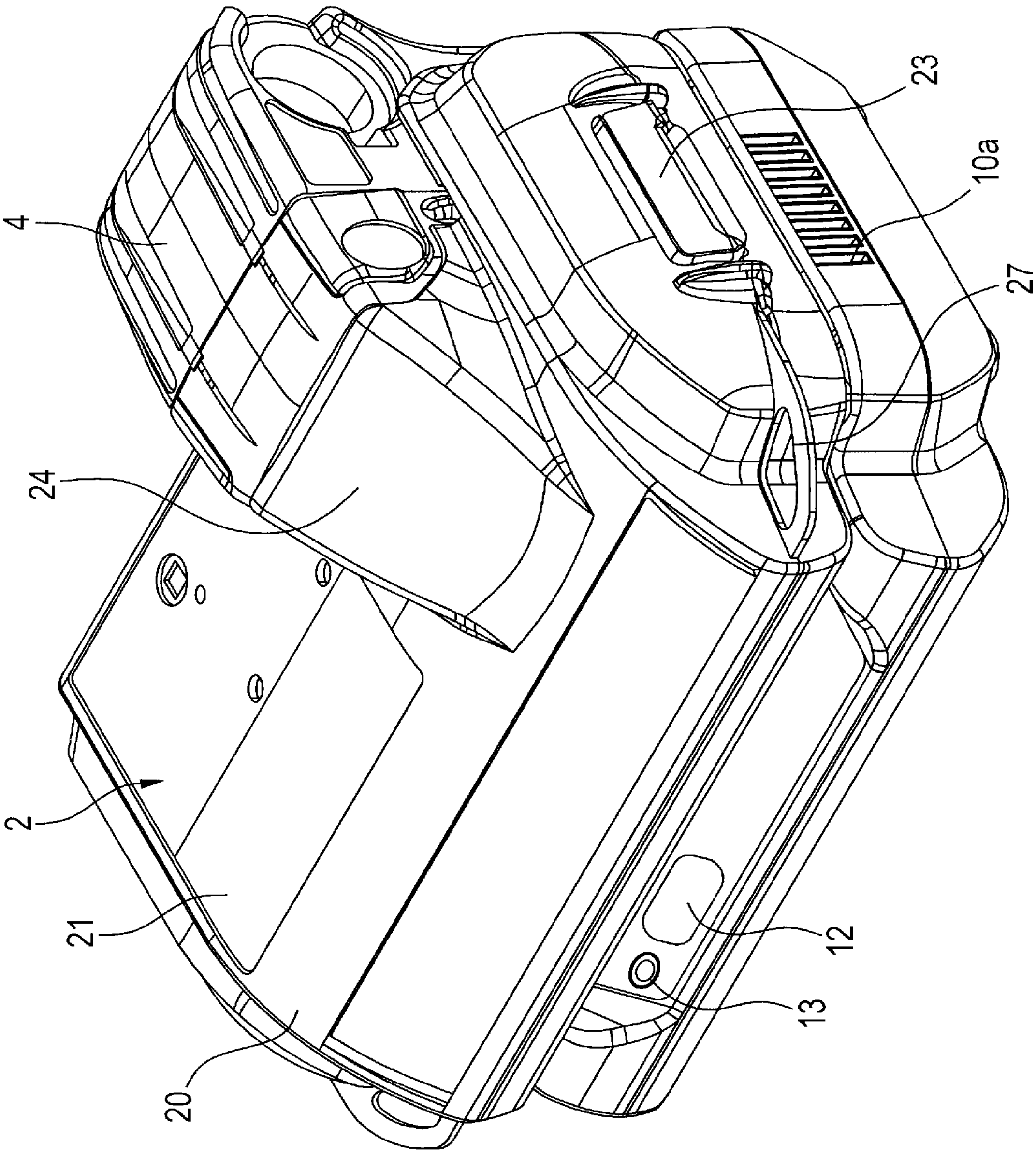
[Fig. 12]

FIG.12


3
101
4
24
23
2
103
TOP
REAR
FRONT
BOTTOM
4A
11
15
102a
14
1
10a
105
3
102A
3A
102B

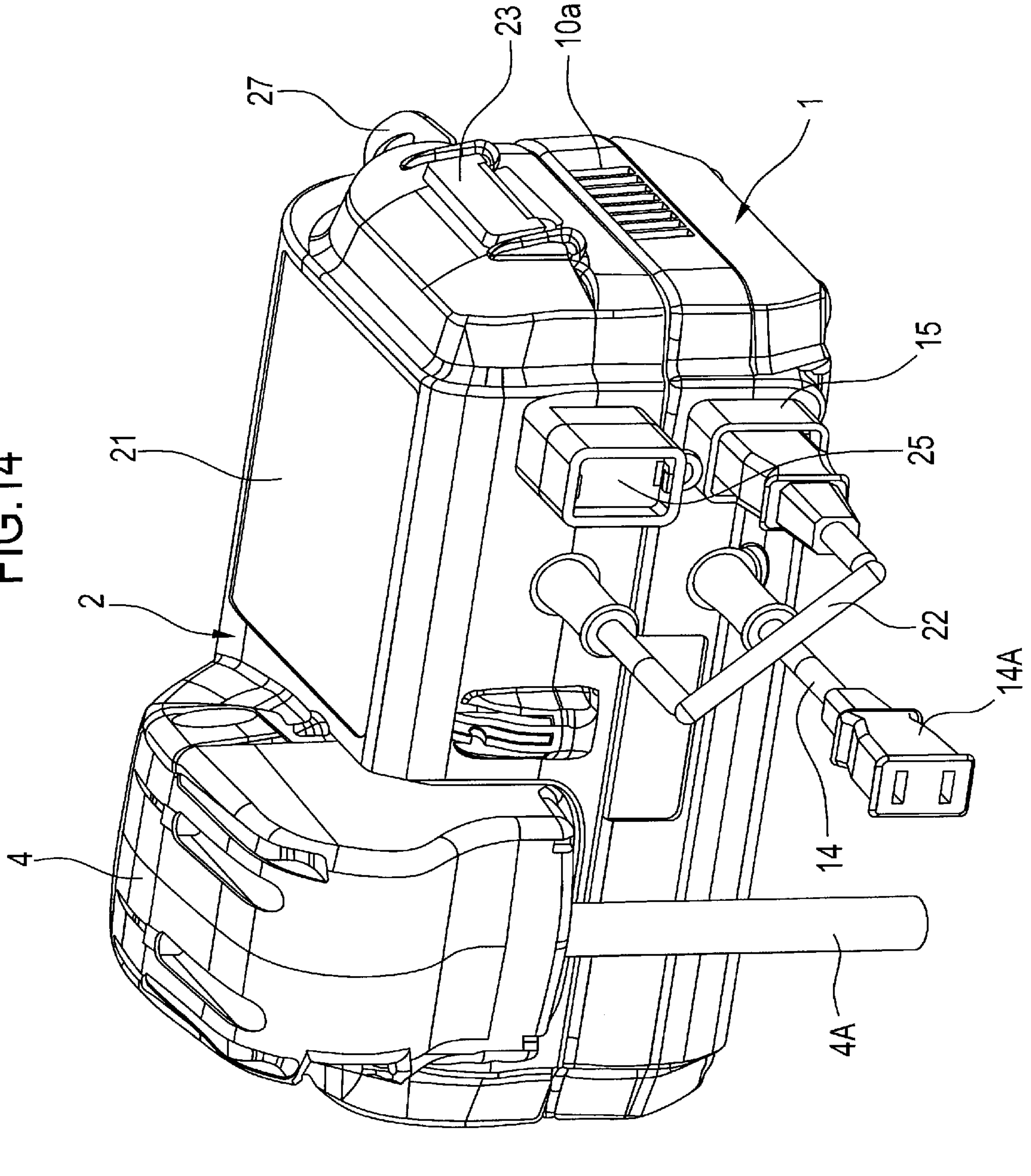
[Fig. 13]

FIG.13



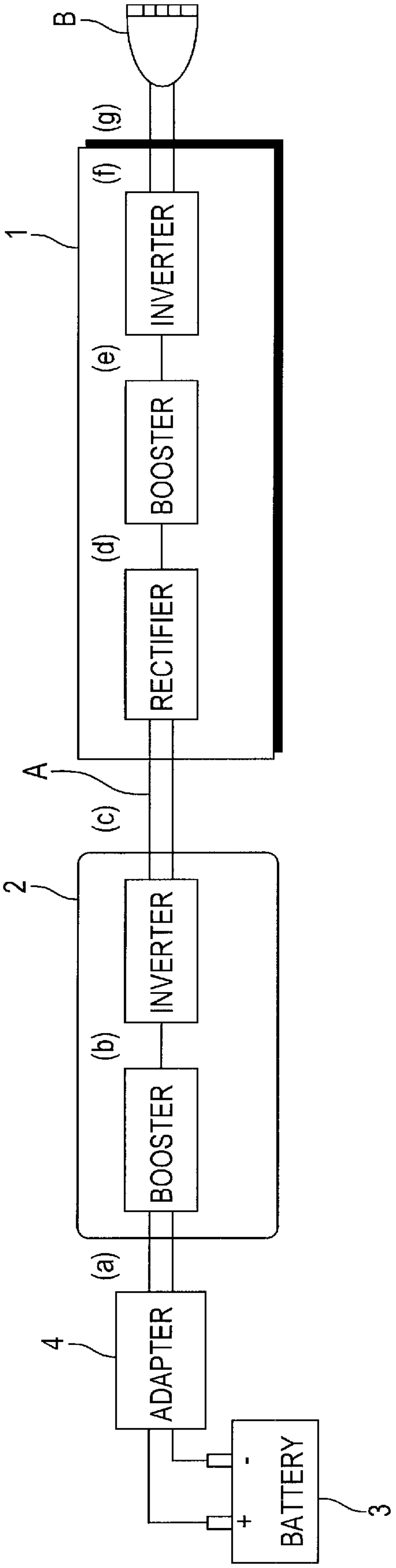
[Fig. 14]

FIG.14



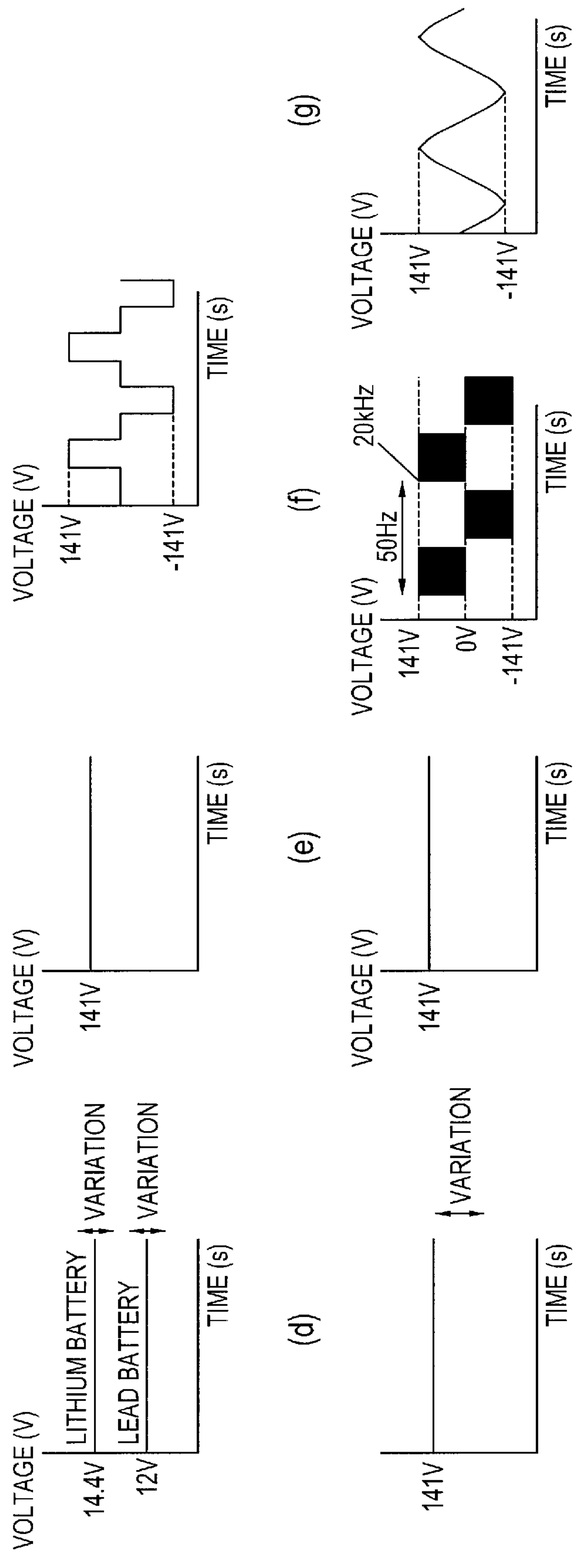
[Fig. 15]

FIG.15


B
(g)
(f)
1
INVERTER
(e)
BOOSTER
(d)
RECTIFIER
A
(c)
2
INVERTER
(b)
BOOSTER
(a)
4
ADAPTER
-
+
BATTERY
3

[Fig. 16]

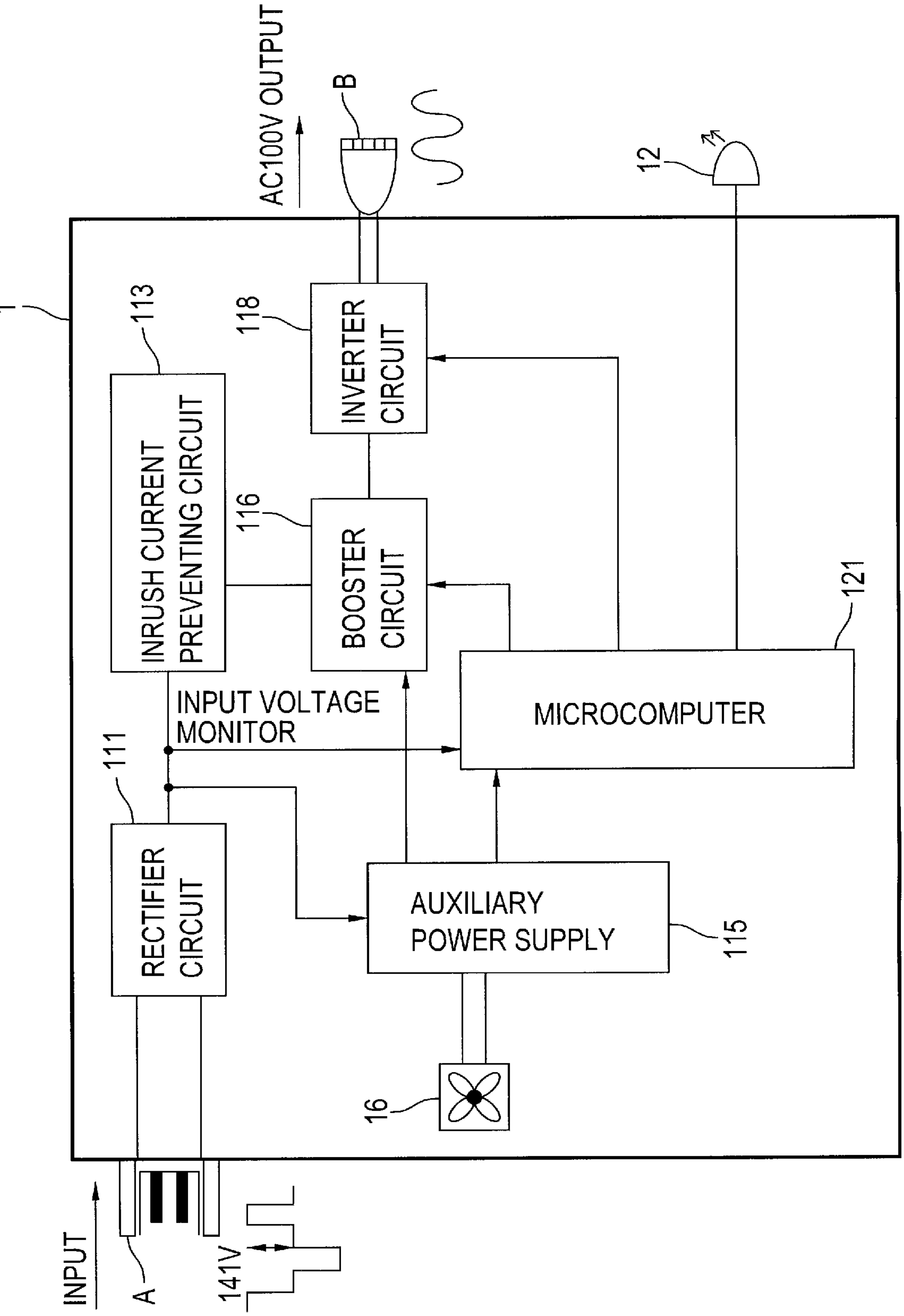
FIG.16



(a)
VOLTAGE (V)
14.4V
12V
LITHIUM BATTERY
LEAD BATTERY
VARIATION
VARIATION
TIME (s)
(b)
VOLTAGE (V)
141V
TIME (s)
(c)
VOLTAGE (V)
141V
-141V
TIME (s)
(d)
141V
VARIATION
TIME (s)
(e)
VOLTAGE (V)
141V
TIME (s)
(f)
VOLTAGE (V)
141V
0V
-141V
50Hz
20kHz
TIME (s)
(g)
VOLTAGE (V)
141V
-141V
TIME (s)

[Fig. 17]

FIG.17


AC100V OUTPUT
B
12
1
113
118
INVERTER CIRCUIT
INRUSH CURRENT PREVENTING CIRCUIT
116
BOOSTER CIRCUIT
121
INPUT VOLTAGE MONITOR
MICROCOMPUTER
111
RECTIFIER CIRCUIT
AUXILIARY POWER SUPPLY
115
16
INPUT
A
141V

[Fig. 18A]

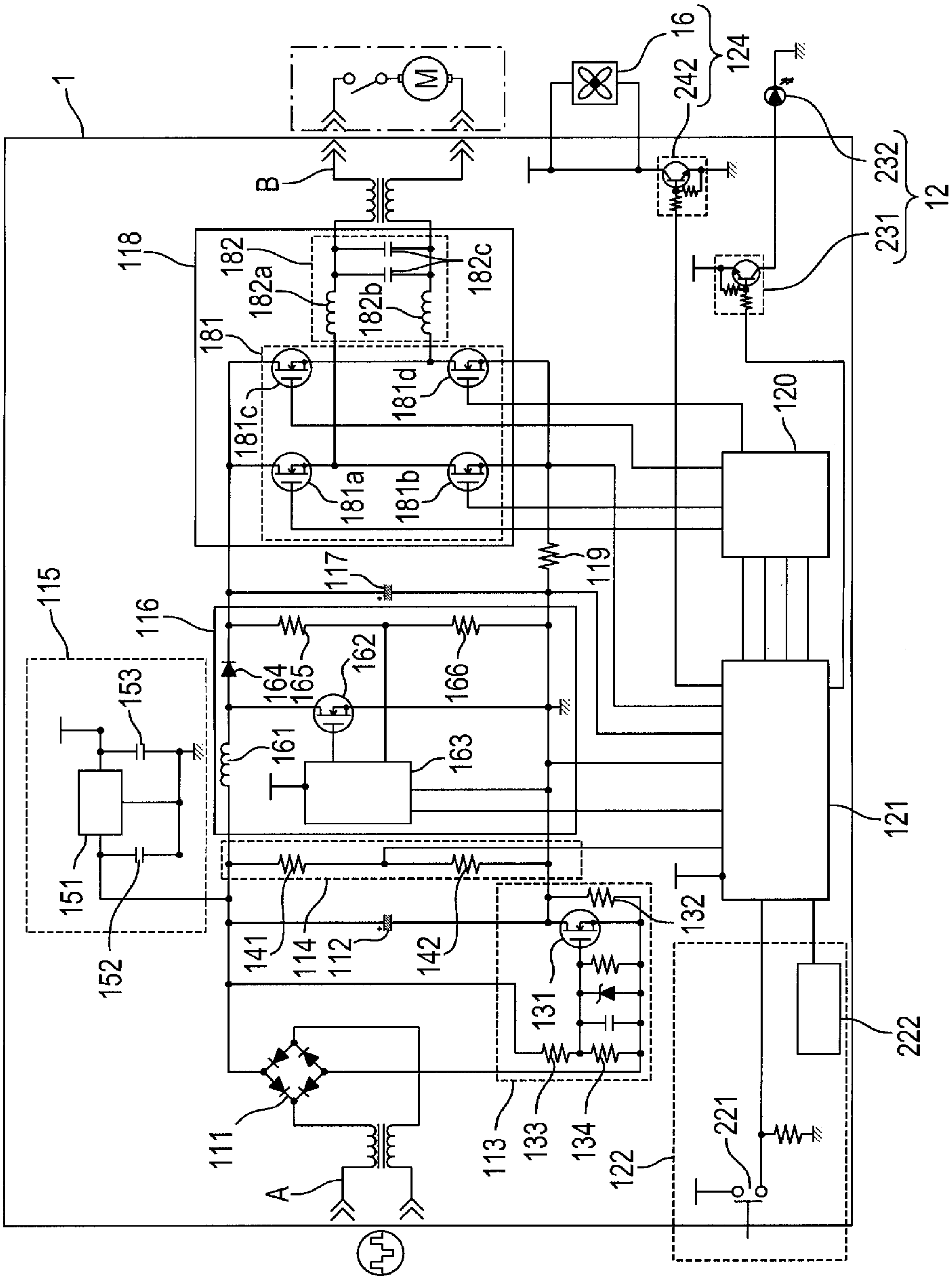
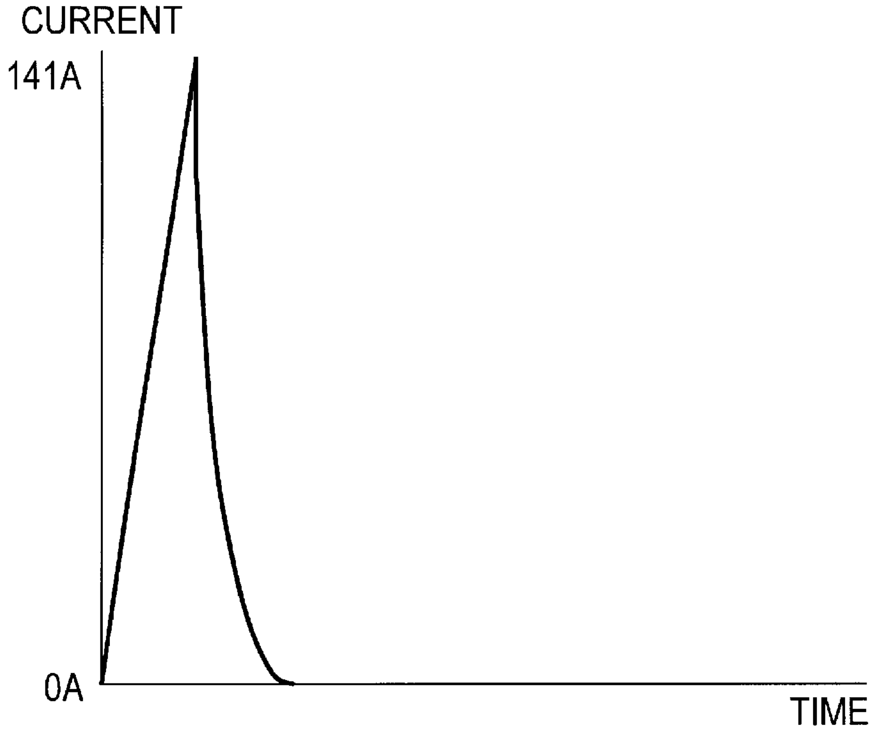


FIG.18A

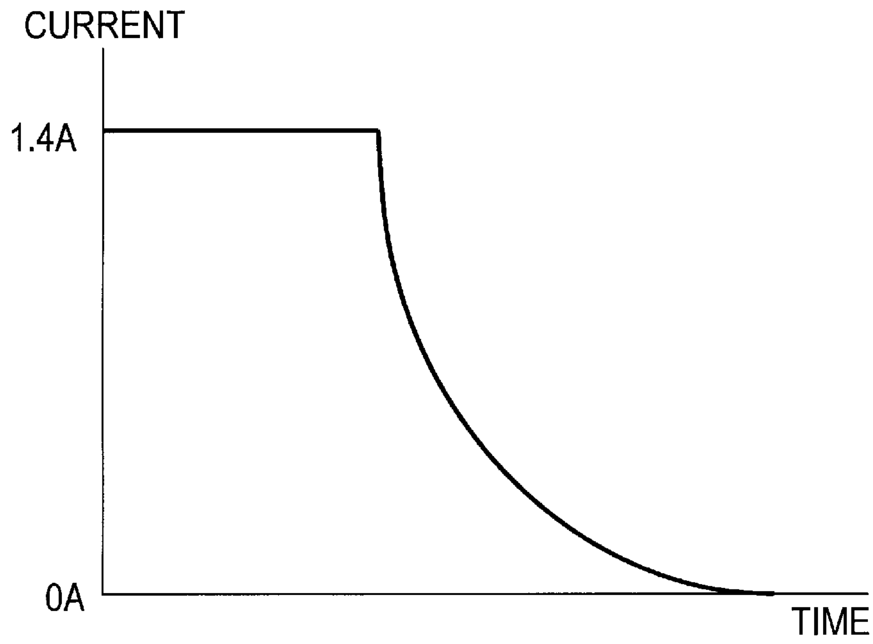
[Fig. 18B]

FIG.18B



[Fig. 18C]

FIG.18C



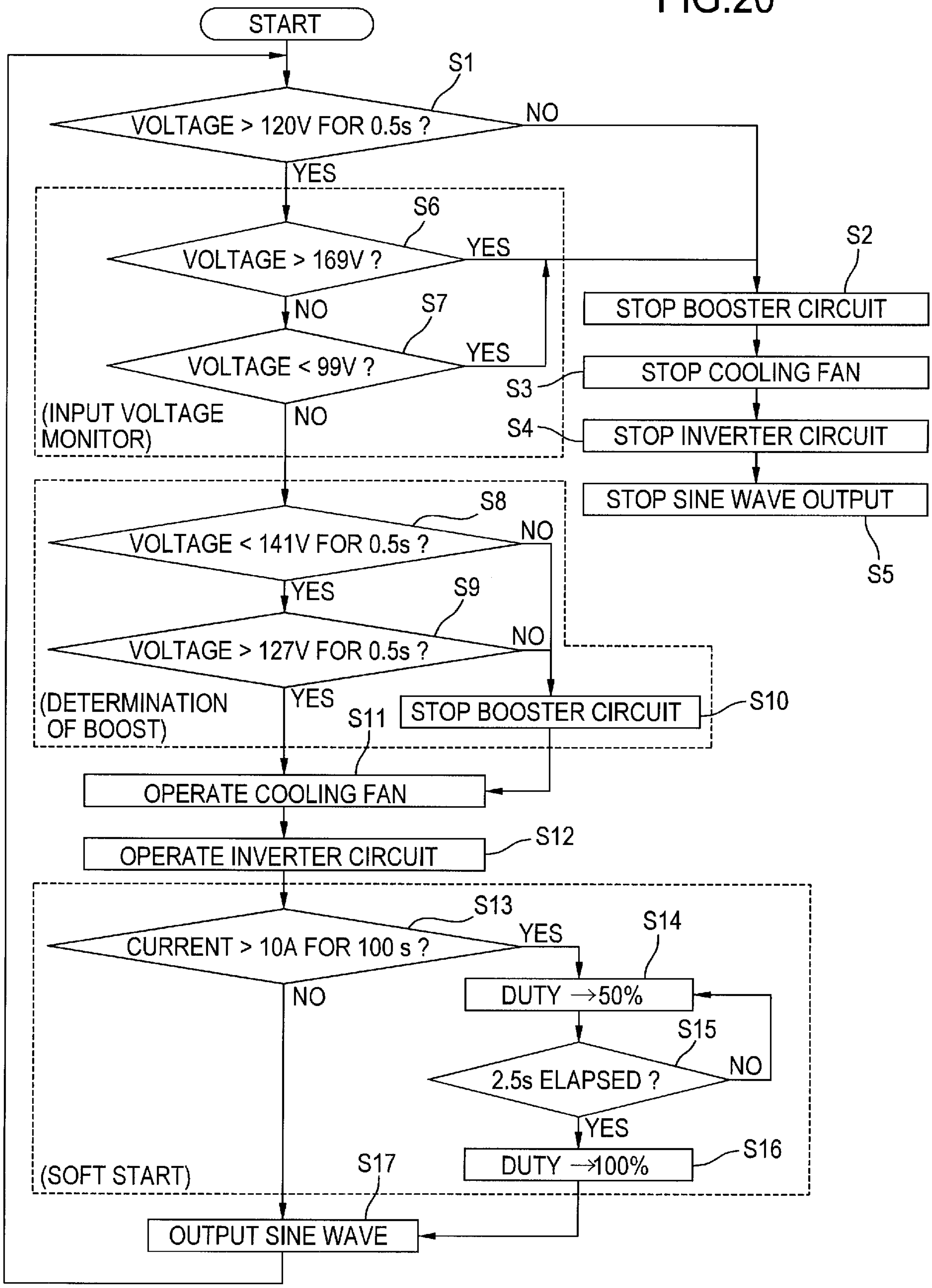
[Fig. 19]

FIG.19

	LED		STATUS
	50HzLED	60HzLED	
1	OFF	OFF	WHEN NOT OPERATED
2	GREEN	OFF	WHEN OPERATED AT 50Hz
3	OFF	GREEN	WHEN OPERATED AT 60Hz
4	RED		WHEN CURRENT IS 4A OR HIGHER
5	GREEN BLINK		WHEN TEMPERATURE IS 100 °C OR HIGHER
6	LED BLINK		WHEN CURRENT IS 5A OR HIGHER
7	ORANGE BLINK (0.5s CYCLE) →ORANGE BLINK (0.2s CYCLE) →GREEN		WHEN FREQUENCY IS SWITCHED

[Fig. 20]

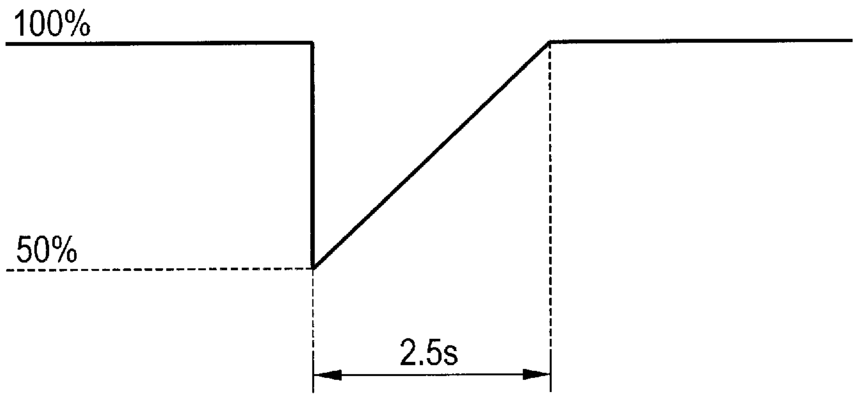
FIG.20



START
S1
VOLTAGE > 120V FOR 0.5s ?
NO
YES
S6
VOLTAGE > 169V ?
YES
NO
S7
VOLTAGE < 99V ?
YES
NO
(INPUT VOLTAGE MONITOR)
S2
STOP BOOSTER CIRCUIT
S3
STOP COOLING FAN
S4
STOP INVERTER CIRCUIT
STOP SINE WAVE OUTPUT
S5
S8
VOLTAGE < 141V FOR 0.5s ?
NO
YES
S9
VOLTAGE > 127V FOR 0.5s ?
NO
YES
(DETERMINATION OF BOOST)
S10
STOP BOOSTER CIRCUIT
S11
OPERATE COOLING FAN
S12
OPERATE INVERTER CIRCUIT
S13
CURRENT > 10A FOR 100 s ?
YES
NO
S14
DUTY →50%
S15
2.5s ELAPSED ?
NO
YES
S16
DUTY →100%
(SOFT START)
S17
OUTPUT SINE WAVE

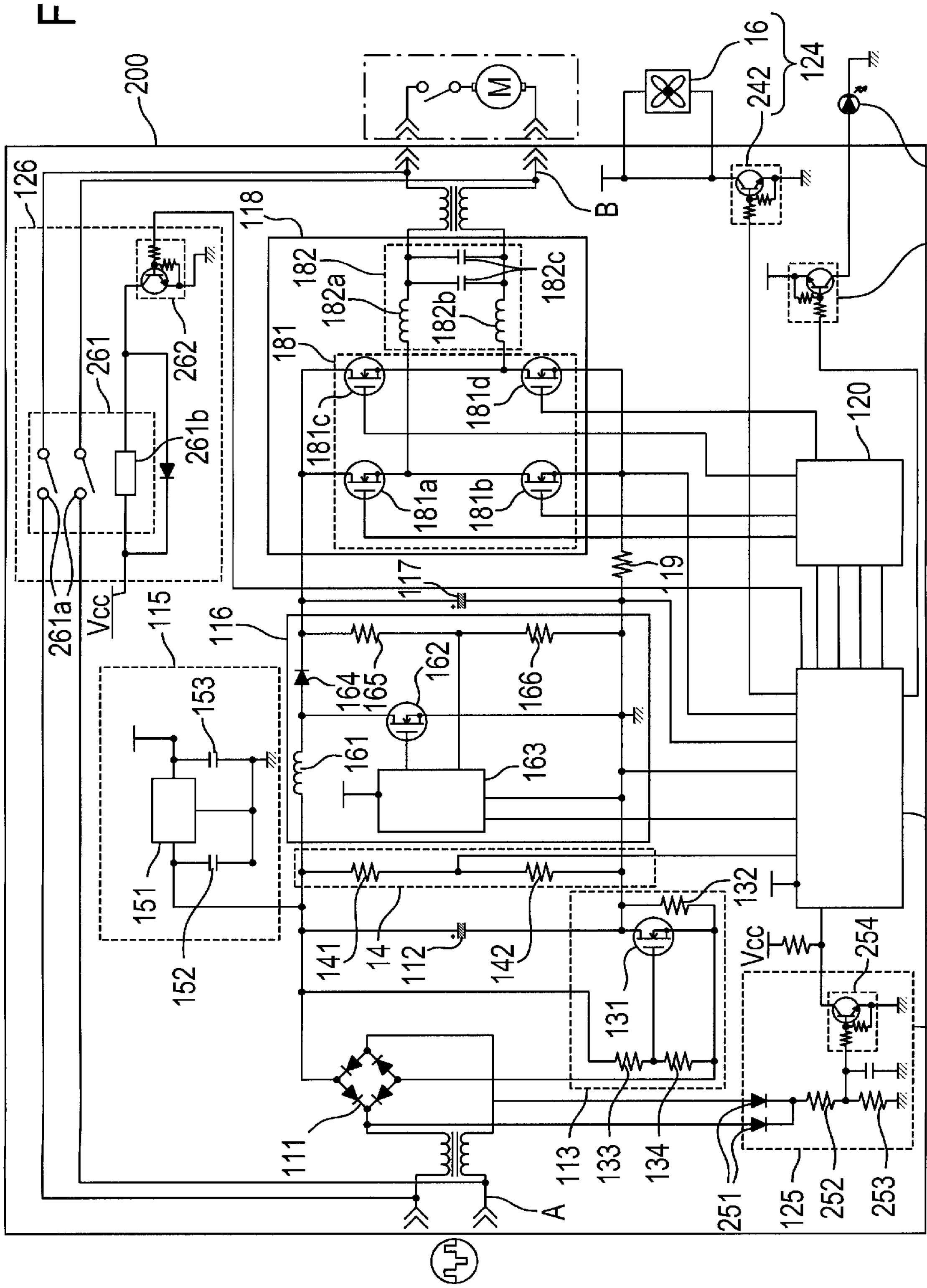
[Fig. 21]

FIG.21



[Fig. 22A]

FIG.22A



[Fig. 22B]

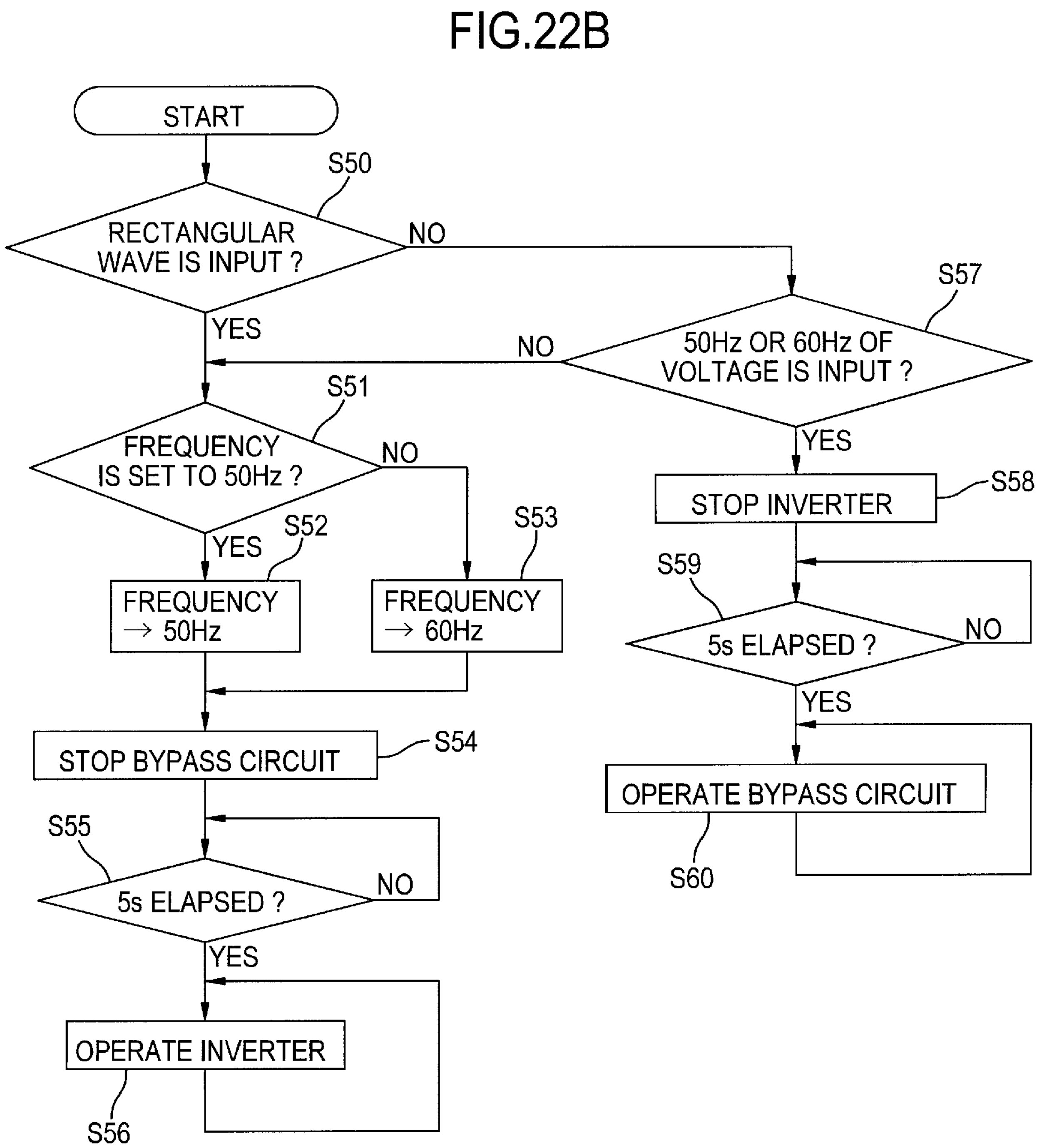
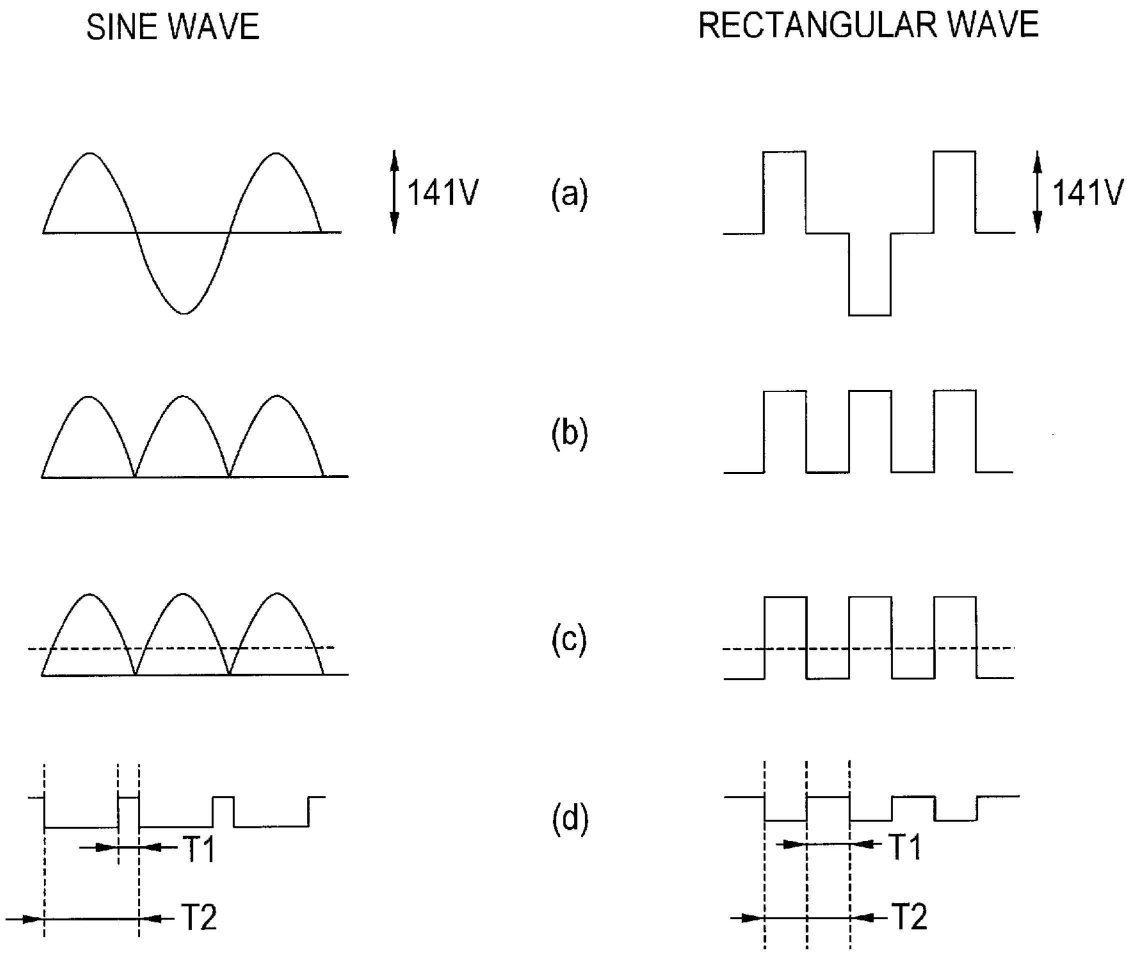


FIG.22B
START
S50
RECTANGULAR WAVE IS INPUT ?
NO
YES
S57
50Hz OR 60Hz OF VOLTAGE IS INPUT ?
NO
YES
S51
FREQUENCY IS SET TO 50Hz ?
NO
YES
S52
FREQUENCY → 50Hz
S53
FREQUENCY → 60Hz
STOP BYPASS CIRCUIT
S54
S55
5s ELAPSED ?
NO
YES
OPERATE INVERTER
S56
STOP INVERTER
S58
S59
5s ELAPSED ?
NO
YES
OPERATE BYPASS CIRCUIT
S60

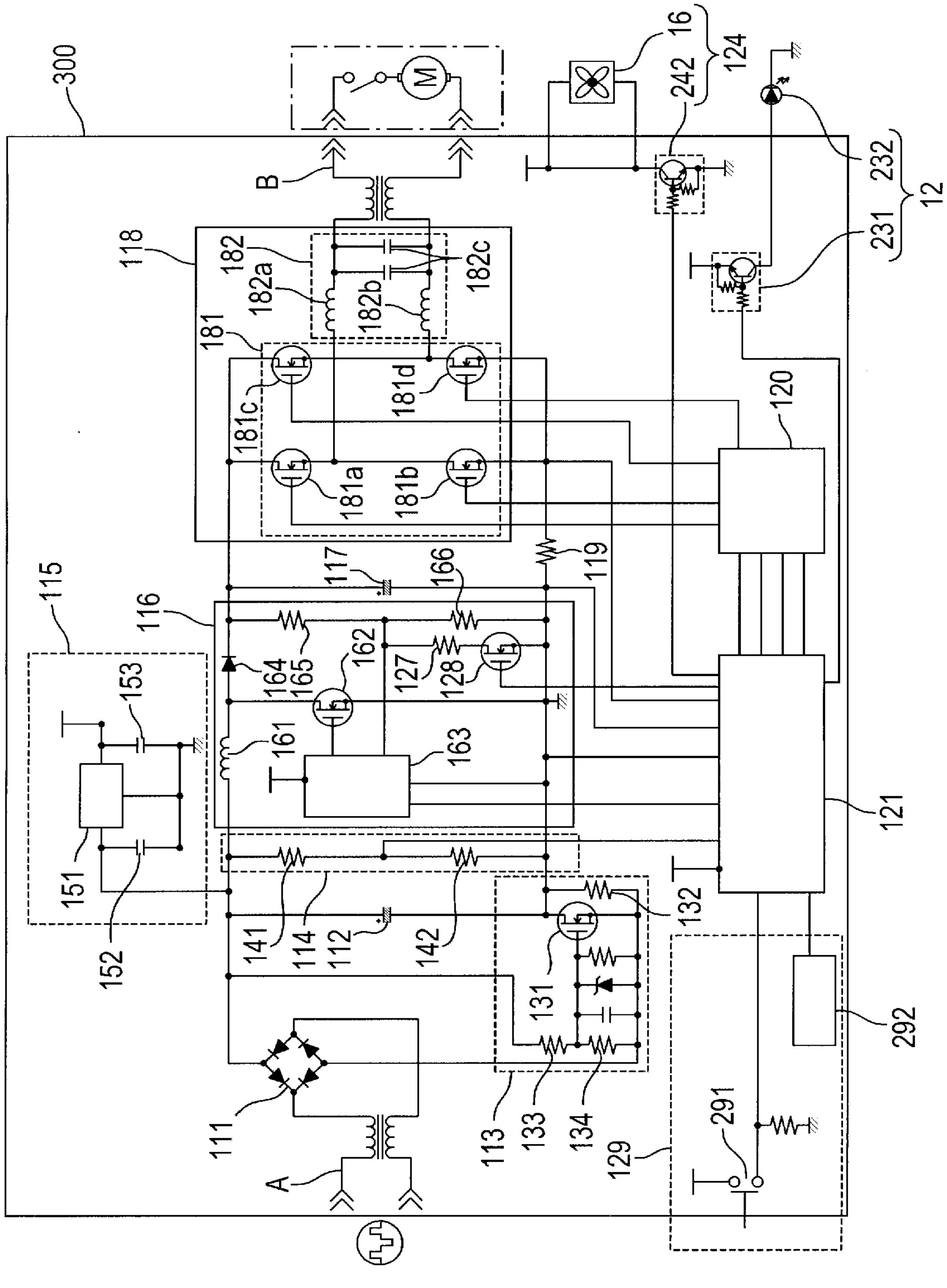
[Fig. 23]

FIG.23



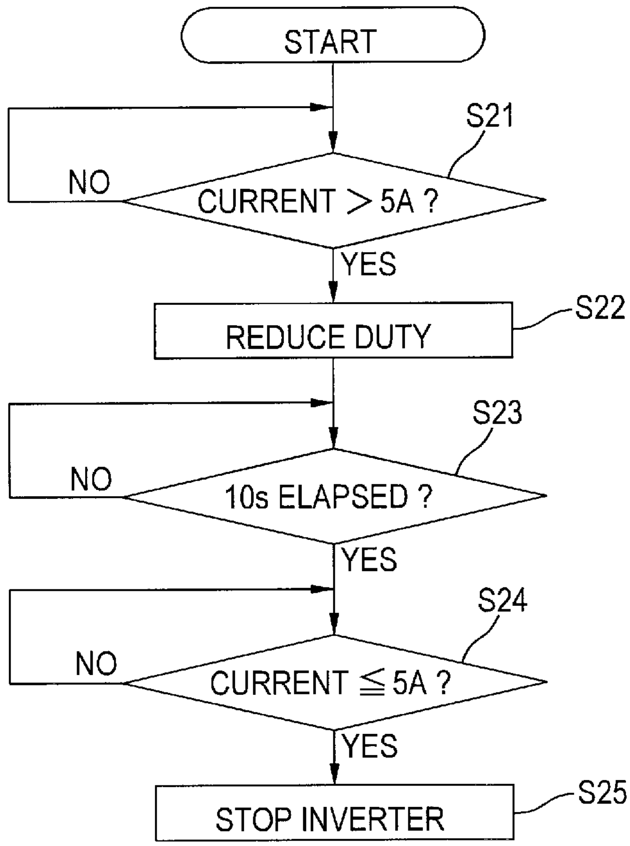
[Fig. 24]

FIG.24


300
16
124
242
232
231
12
B
118
182
182a
182b
182c
181
181a
181b
181c
181d
120
117
119
166
116
115
153
164
165
162
127
128
161
163
121
151
152
141
114
112
142
132
131
113
133
134
111
A
129
291
292
M

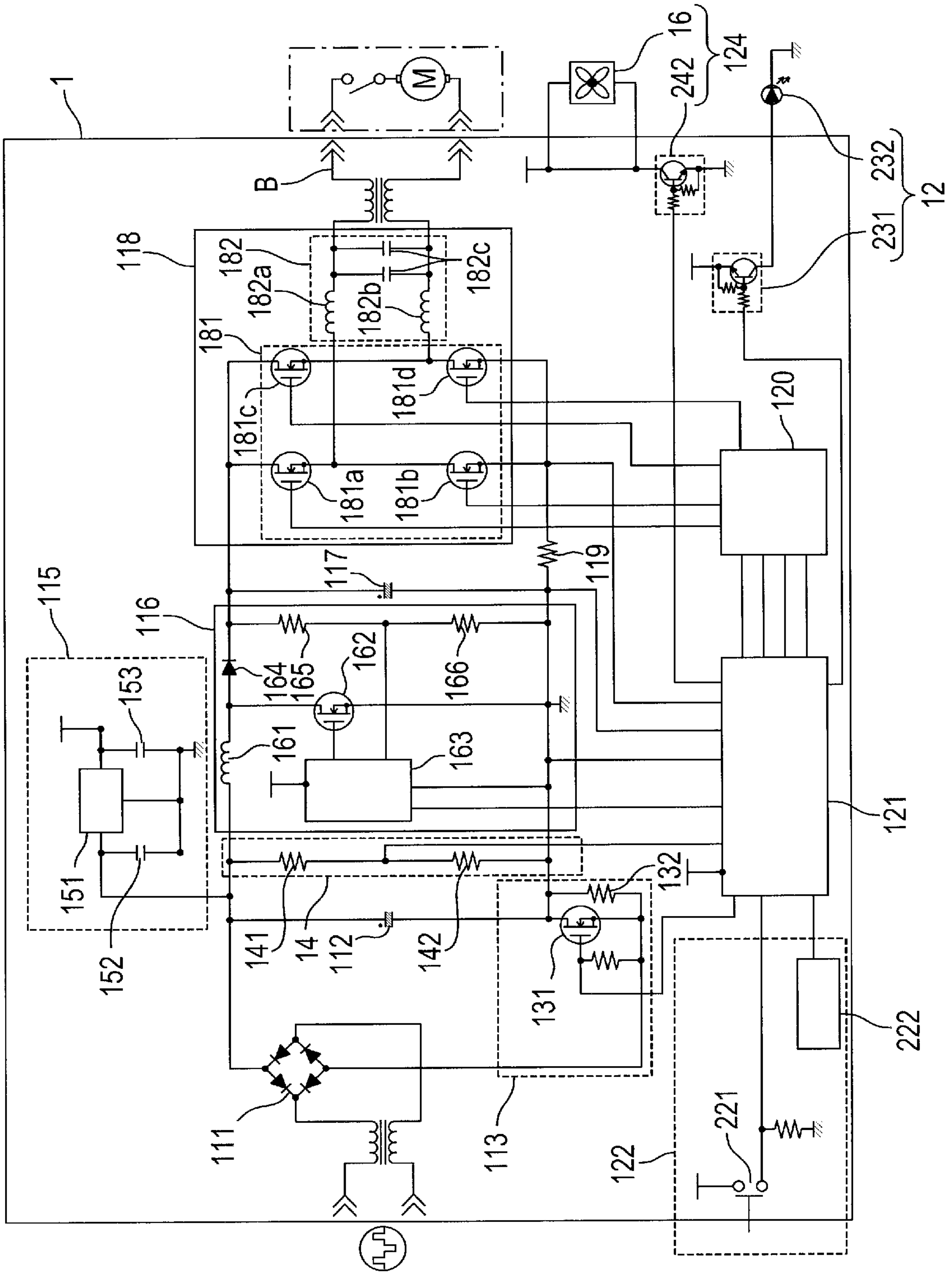
[Fig. 25]

FIG.25


START
S21
NO
CURRENT > 5A ?
YES
S22
REDUCE DUTY
S23
NO
10s ELAPSED ?
YES
S24
NO
CURRENT ≦ 5A ?
YES
S25
STOP INVERTER

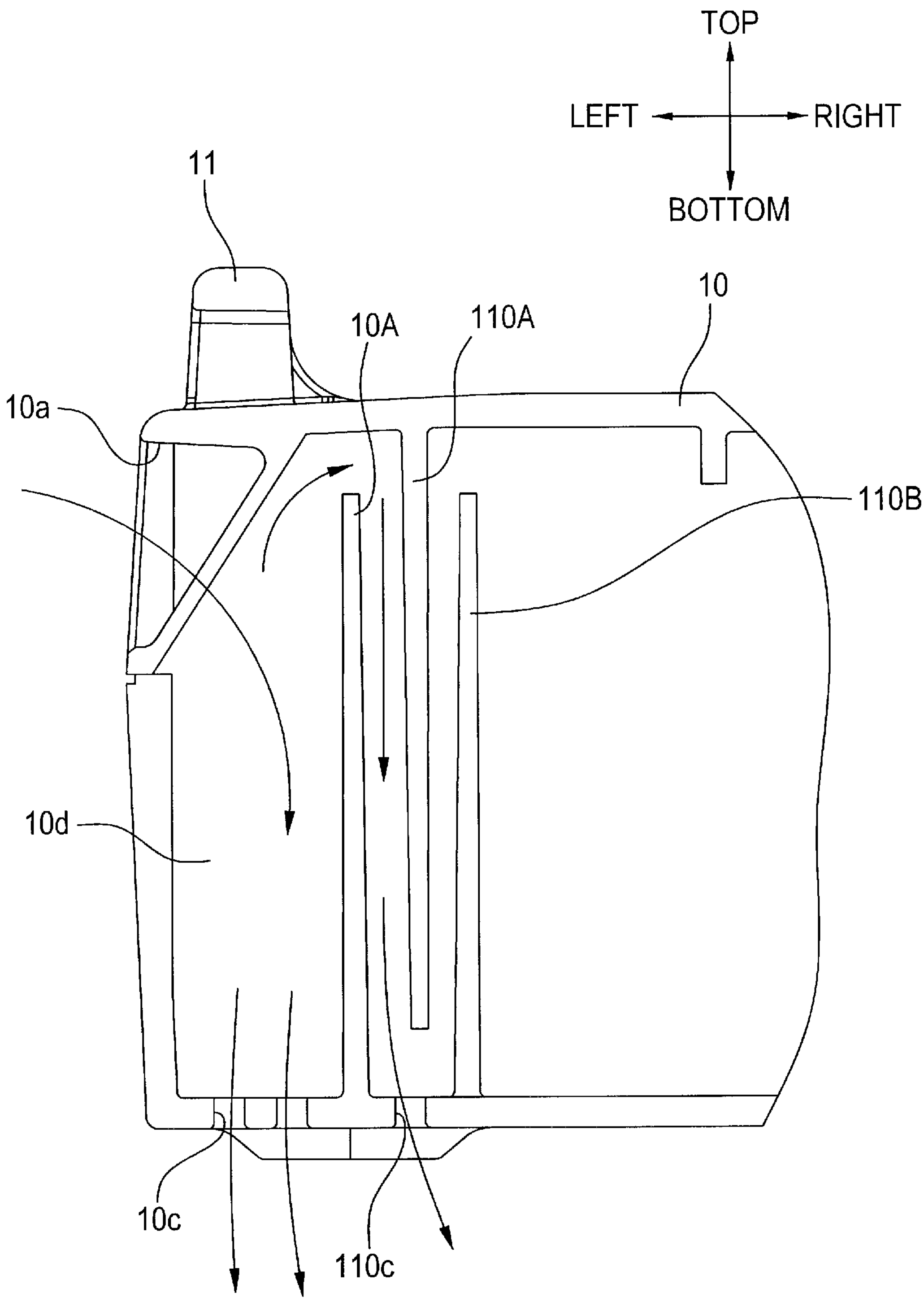
[Fig. 26]

FIG.26


1
B
M
16
124
242
232
12
231
118
182
182a
182b
182c
181
181c
181d
181a
181b
120
117
119
115
116
153
164
165
162
166
161
163
151
152
141
14
112
142
132
131
121
111
113
122
221
222

[Fig. 27]

FIG.27



[Fig. 28]

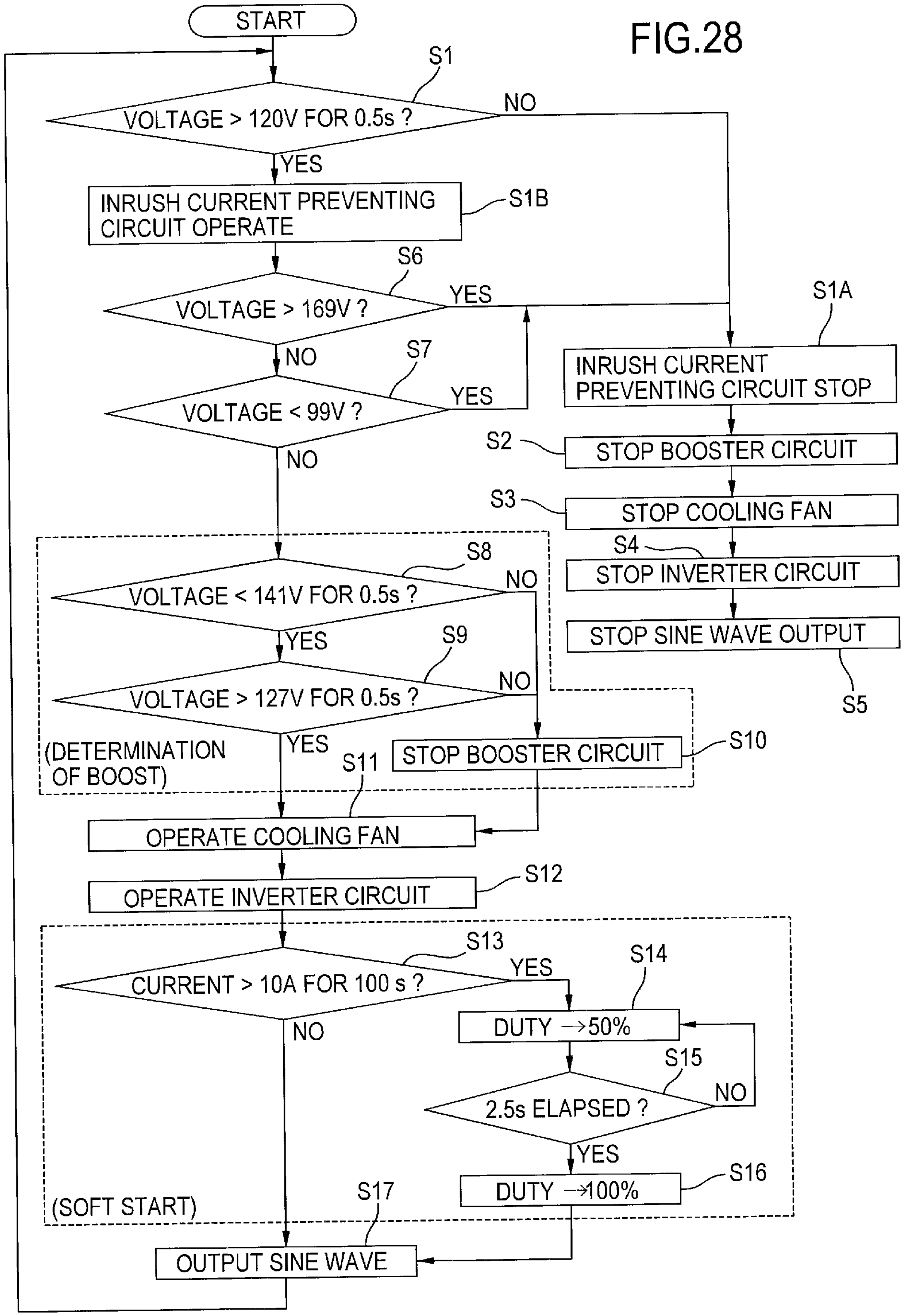

START
S1
VOLTAGE > 120V FOR 0.5s ?
NO
YES
INRUSH CURRENT PREVENTING CIRCUIT OPERATE
S1B
S6
VOLTAGE > 169V ?
YES
NO
S7
VOLTAGE < 99V ?
YES
NO
S1A
INRUSH CURRENT PREVENTING CIRCUIT STOP
S2
STOP BOOSTER CIRCUIT
S3
STOP COOLING FAN
S4
STOP INVERTER CIRCUIT
STOP SINE WAVE OUTPUT
S5
S8
VOLTAGE < 141V FOR 0.5s ?
NO
YES
S9
VOLTAGE > 127V FOR 0.5s ?
NO
YES
(DETERMINATION OF BOOST)
S11
STOP BOOSTER CIRCUIT
S10
OPERATE COOLING FAN
OPERATE INVERTER CIRCUIT
S12
S13
CURRENT > 10A FOR 100 s ?
YES
S14
NO
DUTY →50%
S15
2.5s ELAPSED ?
NO
YES
DUTY →100%
S16
(SOFT START)
S17
OUTPUT SINE WAVE

FIG.28