(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 904 174 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
03.11.2021 Bulletin 2021/44

(21) Application number: **19905746.4**

(22) Date of filing: **29.10.2019**

(51) Int Cl.:
B61C 17/00 *(2006.01)*

(86) International application number:
PCT/JP2019/042270

(87) International publication number:
WO 2020/137133 (02.07.2020 Gazette 2020/27)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **26.12.2018 JP 2018242977**

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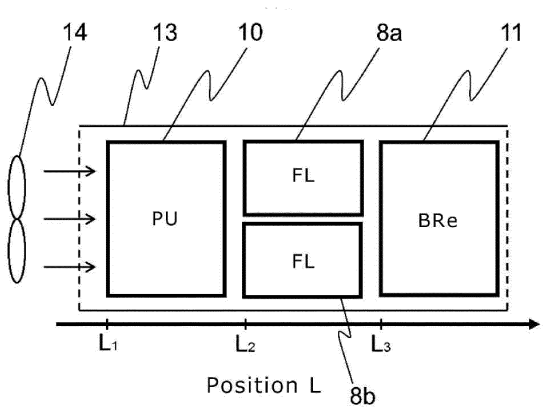
(54) POWER CONVERSION DEVICE FOR RAILWAY VEHICLE

(57) In a case where a plurality of heat generating bodies are disposed within a single wind tunnel mounted below a floor of a railway vehicle, when heat calculation is performed for the entire interior of the wind tunnel in a state in which each of the heat generating bodies is generating the maximum amount of heat, the design will have a large margin resulting in the amount of heat generated being estimated to be higher than the actual amount, which leads to larger sizes for mounted equipment and cooling mechanisms. In order to avoid the foregoing, provided is a power conversion device rigged below the floor of a vehicle in order to drive an electric motor used by a railway vehicle. The equipment that forms the power conversion device and that is associated with heat generation is housed in a storage space through which cooling air flows, and equipment with a different maximum heat generation period is disposed in series with respect to the flow of the cooling air.

FIG. 3



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Description

Technical Field

[0001] This invention relates to a power conversion device for railway vehicle.

Background Art

[0002] In some of the conventional power conversion devices for railway vehicle, a cooling mechanism is individually provided in each heat generating body forming the power conversion device, so that the heat generating bodies can be surely cooled.

[0003] On the other hand, in the case of adopting an air-cooling device as one of the cooling mechanism, Patent Literature 1 discloses that a plurality of heat generating bodies are arranged within the same wind tunnel at the lower part of a control box mounted under the floor of the electric vehicle and that the cooling wind from a fan is used for cooling these heat generating bodies.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Unexamined Patent Application Publication No.7-277187

Summary of Invention

Technical Problem

[0005] In the case where a plurality of heat generating bodies are arranged within a single wind tunnel as disclosed in Patent Literature 1, when heat calculation is performed on the whole wind tunnel in the state in which each of the heat generating bodies is generating the maximum load (maximum heat amount), the design will have a large margin with the heat generation amount estimated more than the actual amount, which leads to upsize the mounted devices and cooling mechanisms.

[0006] The invention aims to provide an arrangement of devices for downsizing the power conversion device for railway vehicle more than the conventional one when the wind from a fan or a running vehicle is used as a cooling wind to cool a plurality of heat generating bodies within the power conversion device in the same wind tunnel.

Solution of Problem

[0007] In order to solve the above problem, a power conversion device rigged below a floor of a railway vehicle for driving an electric motor for use in the vehicle, is characterized in that devices generating heat and forming the power conversion device are stored in a storage where a cooling wind flows and that the devices having different maximum heat generation periods are arranged in series to a flow of the cooling wind.

Advantageous Effects of Invention

[0008] With consideration taken to the respective maximum heat generation periods of a plurality of heat generating bodies and the arrangement of the heat generating bodies having different maximum heat generation periods, it is possible to downsize the heat generating bodies and the fan and further the whole body of the power conversion device for railway vehicle, thereby enabling the installation within a limited rigging space.

Brief Description of Drawings

[0009]

Fig. 1 is a perspective view showing the state where a power conversion device for railway vehicle is mounted in a car-body.

Fig. 2 is a view showing one example of a main circuit structure of the power conversion device for railway vehicle.

Fig. 3 is a view showing an arrangement of the devices within the power conversion device for railway vehicle according to a first embodiment of the invention.

Fig. 4 is a graph showing a relation between the position and the temperature of the cooling wind passing through a storage (wind tunnel) in the case of not considering the maximum heat generation period of each heat generating body.

Fig. 5 is a graph showing a relation between the position and the temperature of the cooling wind passing through the storage (wind tunnel) in the case of considering the maximum heat generation period of each heat generating body.

Fig. 6 is a view showing the arrangement of the devices within the power conversion device for railway vehicle according to a second embodiment of the invention.

Fig. 7 is a view showing a variation example of the arrangement according to the second embodiment.

Description of Embodiments

[0010] Hereinafter, first and second embodiments of the invention will be described using the drawings, as the form for carrying out the invention.

[0011] Fig. 1 is a perspective view showing the state where a power conversion device for railway vehicle is mounted in a car-body. The power conversion device 2 mounted in a railway vehicle is suspended below the floor of the car-body 1.

[0012] Fig. 2 is a view showing one example of a main circuit structure of the power conversion device 2 for railway vehicle.

[0013] By turning on a high speed circuit breaker (HB) 5 and an electromagnetic contactor (LB) 6a, the direct current power taken from an overhead contact line 3 according to a rise of a pantograph 4 passes through the high speed circuit breaker (HB) 5 → the electromagnetic contactor (LB) 6a → charge resistor (CHRe) 7 → filter reactor (FL) 8, to charge a filter capacitor (FC) 9. Thereafter, the electromagnetic contactor (LB) 6b is turned on, three phase alternating current power is supplied to a traction motor 12, by switching of a power device element within a power unit (PU) 10, and the traction motor 12 outputs a driving torque.

[0014] These devices generate not a little heat at their use and therefore, that one having a large amount of heat generation has to be positively cooled.

[0015] Here, the filter reactor (FL) 8 and the brake resistor (BRe) 11 as a main heat generating body in the above-mentioned main circuit are the heat generating bodies having different maximum heat generation periods.

[0016] Since a reactor has a function of suppressing a voltage change, the filter reactor (FL) 8, with a proper reactor value set, mainly aims to suppress a high frequency noise of the voltage generated by switching of a semiconductor element within an inverter, to protect the overhead contact line, and to suppress a rapid discharge of electric current at a shirt-circuit accident.

[0017] Further, the brake resistor (BRe) 11 mainly aims to discharge electric energy within the circuit through itself at a regeneration impossible time and at an overvoltage time of the filter capacitor (FC) 9.

[0018] These two devices do not have the maximum heat generation amounts at the same time; therefore, the maximum heat generation periods are different. Here, the maximum heat generation period means a period during which the maximum load is imposed on the heat generating body, and in short, it is a period of generating the maximum heat generation amount.

First Embodiment

[0019] Fig. 3 is a view showing an arrangement of the devices within the power conversion device for railway vehicle according to a first embodiment of the invention. It shows the arrangement when the bottom of the floor surface of the railway vehicle is upwardly viewed from the ground surface: the horizontal direction of the paper is a proceeding direction of the vehicle and the vertical direction is a width (sleeper) direction of the railway track.

[0020] A storage 13 housing a plurality of heat generating bodies (the filter reactors (FL) 8a and 8b, the power unit (PU) 10, and the brake resistor (BRe) 11) can be regarded as a wind tunnel because the cooling wind flows there. Within the storage (wind tunnel) 13, these heat generating bodies are arranged in series or in parallel to the flow of the cooling wind from a fan 14.

[0021] Here, the fan 14 may be put anywhere inside and outside of the storage (wind tunnel) as far as it can serve a role of running the cooling wind within the storage (wind tunnel) 13, or the wind inlet and the wind outlet of the cooling wind may be inverted as far as it can satisfy the cooling performance. Further, the fan 14 does not have to be particularly provided as far as the vehicle running wind satisfies the cooling performance.

[0022] Further, the filter reactors (FL) 8a and 8b arranged in parallel in Fig. 3 are assumed in the case where the filter reactors (FL) are provided respectively on the positive potential side and the negative potential side or the ground side within the main circuit (not illustrated in Fig. 2); however, it is not absolutely essential but they may be formed only on the positive potential side.

[0023] As mentioned above, when the plural heat generating bodies are arranged within the same storage (wind tunnel), it is necessary to design each size and arrangement of the respective heat generating bodies, considering the influence by the respective heat generating bodies on the temperature of the cooling wind.

[0024] As shown in Fig. 3, in the first embodiment, the filter reactors (FL) 8a and 8b having the same maximum heat generation periods are arranged in parallel to a flow of the cooling wind, and the brake resistor (BRe) 11 having the maximum heat generation period different from that of the filter reactors (FL) 8a and 8b is arranged in series to a flow of the cooling wind.

[0025] In short, the invention is to arrange the heat generating bodies having different maximum heat generation periods in series to a flow of the cooling wind and arrange the heat generating bodies having the same or almost equal maximum heat generation periods in parallel to a flow of the cooling wind.

[0026] Further, even in the different heat generating bodies with the overlapping maximum heat generation periods, when one has a smaller temperature rise amount due to the heat generation than the other, the above one may be arranged within the same storage (wind tunnel) together with the other heat generating body.

[0027] Consideration is given to, for example, the power unit (PU). The power unit (PU) contains a semiconductor element as a power device: according to switching of this semiconductor element, the unit converts direct current power to three phase alternating current power at power running and converts the power in an inverse direction at power regeneration, hence to do a torque control of the traction motor.

[0028] Although the power unit (PU) 10 generates heat according to the switching of the semiconductor element, the temperature rise amount due to the heat generation is comparatively smaller than those of the filter reactors (FL) 8a and 8b and the brake resistor (BRe) 11, and therefore, as shown in Fig. 3, the above unit is arranged on the windward side from these devices.

[0029] The reason why the above unit is arranged on the windward side is that if it is arranged on the leeward side, the unit receives the cooling wind having passed through the filter reactors (FL) 8a and 8b and the brake

resistor (BRe) 11, causing a necessity for withstanding the exhaust heat; therefore, in order to satisfy this, the power unit (PU) 10 has to be upsized.

[0030] Further, in the first embodiment, as shown in Fig. 3, the power unit (PU) 10, the filter reactors (FL) 8a and 8b in parallel, and further the brake resistor (BRe) 11 are arranged in this order from the windward side; according to this order, the device having a small margin to the temperature is arranged on the windward side and the device having a large margin is arranged on the leeward side.

[0031] Here, the "margin" is a tolerance value obtained by subtracting the temperature of a device after a temperature rise due to heat generation from the heat resistant temperature of the device. When the plural heat generating bodies are arranged in series within the same wind tunnel, the temperature of the cooling wind becomes higher due to the heat generation of the heat generating bodies according as they are positioned further on the leeward side. Therefore, that one having a high margin has to be arranged on the leeward side. However, if the difference heat generating bodies have the same margin, they may be arranged on any side of the windward and the leeward.

[0032] Next, the temperature of the cooling wind passing through the storage (wind tunnel) is examined in the case of not considering the maximum heat generation period of each heat generating body and in the case of considering the above. Fig. 4 is a graph showing a relation between the position and the temperature of the cooling wind passing through the storage (wind tunnel) in the case of not considering the maximum heat generation period of each heat generating body, while Fig. 5 is a graph showing the above relation in the case of considering the maximum heat generation period of each heat generating body.

[0033] In the case of not considering the maximum heat generation period of each heat generating body, the temperature of the cooling wind passing through the storage (wind tunnel) is estimated as the addition of each temperature rise, supposing the time when each of the heat generating bodies generates heat at the maximum load, as shown in Fig. 4.

[0034] On the other hand, in the case of considering the maximum heat generation period of each heat generating body, the temperature of the cooling wind passing through the storage (wind tunnel) generates a difference whether or not each heat generating body is in the maximum heat generation period. For example, at a regeneration impossible time, the brake resistor (BRe) 11 is used to discharge electric energy within the circuit, when the filter reactors (FL) 8a and 8b are not used or not in the maximum load state; therefore, the heat generation amount can be regarded small. Therefore, the temperature rise of the cooling wind within the storage (wind tunnel) can be estimated as shown in Fig. 5.

[0035] Compared with the case of not considering the heat generation timing of each heat generating body in Fig. 4, it is possible to design the brake resistor (BRe) 11 with the cooling wind temperature closer to the temperature TO of the inlet wind, or set the temperature within the storage (wind tunnel) and the temperature of the exhaust wind from the storage (wind tunnel). Similarly, at the maximum load time of the filter reactors (FL) 8a and 8b, the brake resistor (BRe) 11 is not used or it is not in the maximum load state, and therefore, the temperature rise amount can be estimated with the heat generation amount regarded small.

[0036] As mentioned above, in the power conversion device for railway vehicle, heat generation of the filter reactor (FL) and the brake resistor (BRe) is dominant in a temperature rise within the storage (wind tunnel), and also their physical largeness (size) is generally dominant within the power conversion device. In this situation, by adopting the invention, the total heat generation amount when the heat generating bodies are arranged in series within the storage (wind tunnel) is estimated more properly than in the case of the conventional arrangement and estimated smaller; therefore, it is possible to downsize the highly densified heat generating bodies and the fan, and further downsize the whole body of the power conversion device. As the result, it is possible to mount the devices within a limited rigging space.

[0037] Further, in the first embodiment, the power unit (PU) with a comparatively smaller temperature rise is arranged in series with the filter reactors (FL) and the brake resistor (BRe) within the storage (wind tunnel), hence to reduce the number of fans and the number of parts.

Second Embodiment

[0038] Fig. 6 is a view showing the arrangement of the devices within the power conversion device for railway vehicle according to a second embodiment of the invention. Fig. 7 is a view showing a variation example of the arrangement. The same reference signs are attached to the same devices as those having been described in the first embodiment and their detailed description is omitted. Similarly to Fig. 3, the arrangement on the floor surface of the railway vehicle is viewed upwardly from the ground surface: the horizontal direction of the paper is a proceeding direction of the vehicle and the vertical direction of the paper is a width (sleeper) direction of the railway track.

[0039] Here, the fan 30 may be arranged anywhere inside and outside of the storage as far as it can serve a role of running the cooling wind in the storage (wind tunnel) 13, and further, as far as it can satisfy the cooling performance, the wind inlet and the wind outlet of the cooling wind may be inverted. Furthermore, as far as the cooling performance can be satisfied with the vehicle running wind, the fan 30 does not have to be provided particularly.

[0040] In the arrangement as shown in Fig. 6, the storage (wind tunnel) 13 is divided into two of 13a and 13b: in the storage (wind tunnel) 13b, the filter reactor (FL) 8

and the brake resistor (BRe) 11 having different maximum heat generation periods are arranged in series, and the power unit (PU) 10 with a comparatively smaller heat generation amount and the maximum heat generation period overlapping with that of the other heat generating bodies is arranged in the storage (wind tunnel) 13a.

[0041] After this, the cooling wind from the fan 30 flows to the storages (wind tunnel) 13a and 13b in a given distribution of wind amount capable of satisfying the cooling performance, to cool the respective heat generating bodies. Here, when flowing in the given distribution of the wind amount, an aperture ratio of the storages (wind tunnel) 13a and 13b is the value necessary for obtaining the above wind amount distribution ratio (the case of the aperture ratio 3:7 in Fig. 6) . According to this, the wind amount of the cooling wind can be effectively used.

[0042] Further, in the arrangement as shown in Fig. 7, the storage (wind tunnel) 13 is divided into two on the half way, the power unit (PU) 10 and the filter reactor (FL)8 are respectively arranged there, and the brake resistor (BRe) 11 with a large heat generation amount is arranged in a way of covering the leeward side of the both.

[0043] After this, the cooling wind from the fan 30 flows to a side of the power unit (PU) 10 and a side of the filter reactor (FL) 8 in the storage (wind tunnel) 13 in a given distribution of the wind amount capable of satisfying the cooling performance (the case of the aperture ratio 3:7 in Fig. 7), and the cooling wind flows to the brake resistor (BRe) 11 from the both. According to this, the wind amount of the cooling wind can be effectively used. Here, the aperture ratio is not restricted to the ratio (3:7) shown in Figs. 6 and 7.

[0044] Here, the filter reactor (FL) 8 and the brake resistor (BRe) 11 have different maximum heat generation periods; therefore, similarly to the case of the first embodiment, by considering the maximum heat generation period of each heat generating body, assuming that the temperature of the cooling wind is nearer to the temperature of the inlet wind than in the case of not considering the above, the filter reactor (FL) 8 and the brake resistor (BRe) 11 can be designed or the temperature within the storage (wind tunnel) 13 and the temperature of the exhaust wind from the storage (wind tunnel) 13 can be set.

[0045] As mentioned above, also according to the second embodiment, the same effect as that having been described in the first embodiment can be obtained. Further, in the second embodiment, the power unit (PU) with a comparatively smaller temperature rise than those of the filter reactor (FL) and the brake resistor (BRe) but the maximum heat generation period overlapping with those of the above is arranged within the other storage (wind tunnel) in parallel, and by effectively making use of the cooling wind divided in a given wind amount, it is possible to reduce the number or the ability of fans and further the number of the parts.

List of Reference Signs

[0046] 1 car-body, 2 power conversion device, 3 overhead contact line, 4 pantograph, 5 high speed circuit breaker (HB), 6a, 6b electromagnetic contactor (LB), 7 charge resistor (CHRe), 8, 8a, 8b filter reactor (FL), 9 filter capacitor (FC), 10 power unit (PU), 11 brake resistor (BRe), 12 traction motor (M1 - M4), 13, 13a, 13b storage (wind tunnel), 14, 30 fan

Claims

1. A power conversion device for railway vehicle rigged below a floor of the railway vehicle to supply power to an electric motor of driving the railway vehicle, **characterized in that**

   a device forming the power conversion device, which generates heat, is stored in a storage where a cooling wind flows, and
   the devices having different maximum heat generation periods are arranged in series to a flow of the cooling wind.

2. The power conversion device for railway vehicle according to claim 1, **characterized in that**
   the devices having the same or almost similar maximum heat generation periods are arranged in parallel to the flow of the cooling wind.

3. The power conversion device for railway vehicle according to claim 1 or 2, **characterized in that**
   the device having a smaller one, of a tolerance value obtained by subtracting a temperature of the device after a temperature rise due to heat generation from a heat resistant temperature of the device, is arranged on a windward side of the cooling wind and the device having a larger tolerance value is arranged on a leeward side of the cooling wind.

4. The power conversion device for railway vehicle according to one of claims 1 to 3, **characterized in that**
   of the different devices having the overlapping maximum heat generation periods, a first device having a smaller temperature rise due to heat generation than that of the other device is arranged together within the storage.

5. The power conversion device for railway vehicle according to claim 4, **characterized in that**

   the storage is divided in parallel to the flow of the cooling wind, and
   the first device is arranged in one part of the storage and the other devices having the same maximum heat generation periods are arranged in the other part of the storage.

6. The power conversion device for railway vehicle according to claim 5, **characterized in that** the cooling wind is divided in a given wind amount and fed to the one and the other parts of the storage.

7. The power conversion device for railway vehicle according to one of claims 1 to 6, **characterized in that** the cooling wind is a wind fed by a fan provided inside or outside of the storage, or a vehicle running wind.

8. The power conversion device for railway vehicle according to claim 1, **characterized in that** a filter reactor and a brake resistor as the devices are arranged in this order from the windward side of the cooling wind.

9. The power conversion device for railway vehicle according to claim 3, **characterized in that** a power unit, a filter reactor, and a brake resistor as the devices are arranged in this order from the windward side of the cooling wind.

10. The power conversion device for railway vehicle according to claim 5, **characterized in that**

the first device is a power unit, and
a filter reactor and a brake resistor as the other devices are arranged in this order from the windward side of the cooling wind.

FIG. 1

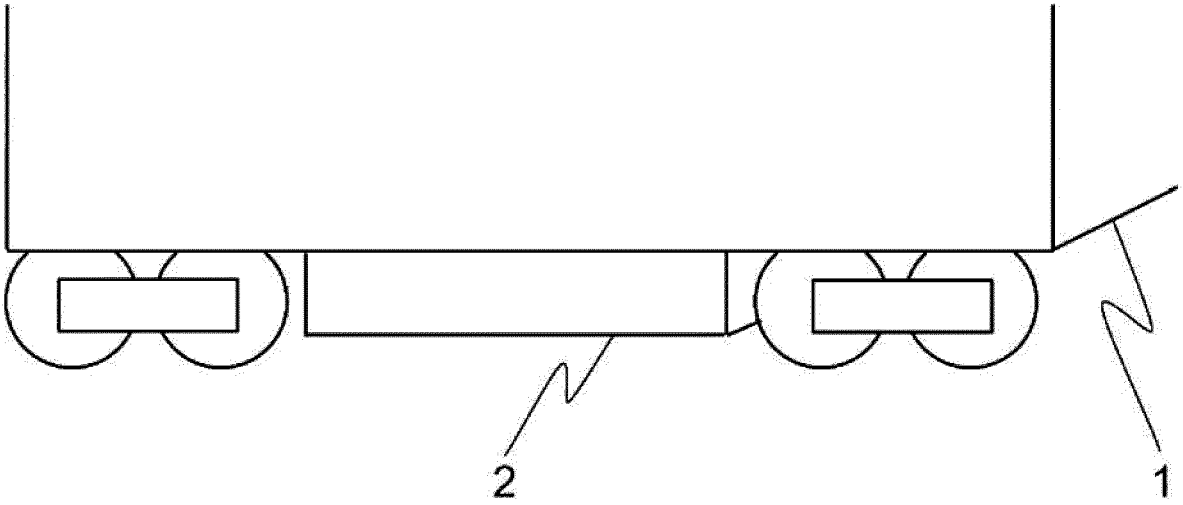


FIG. 2

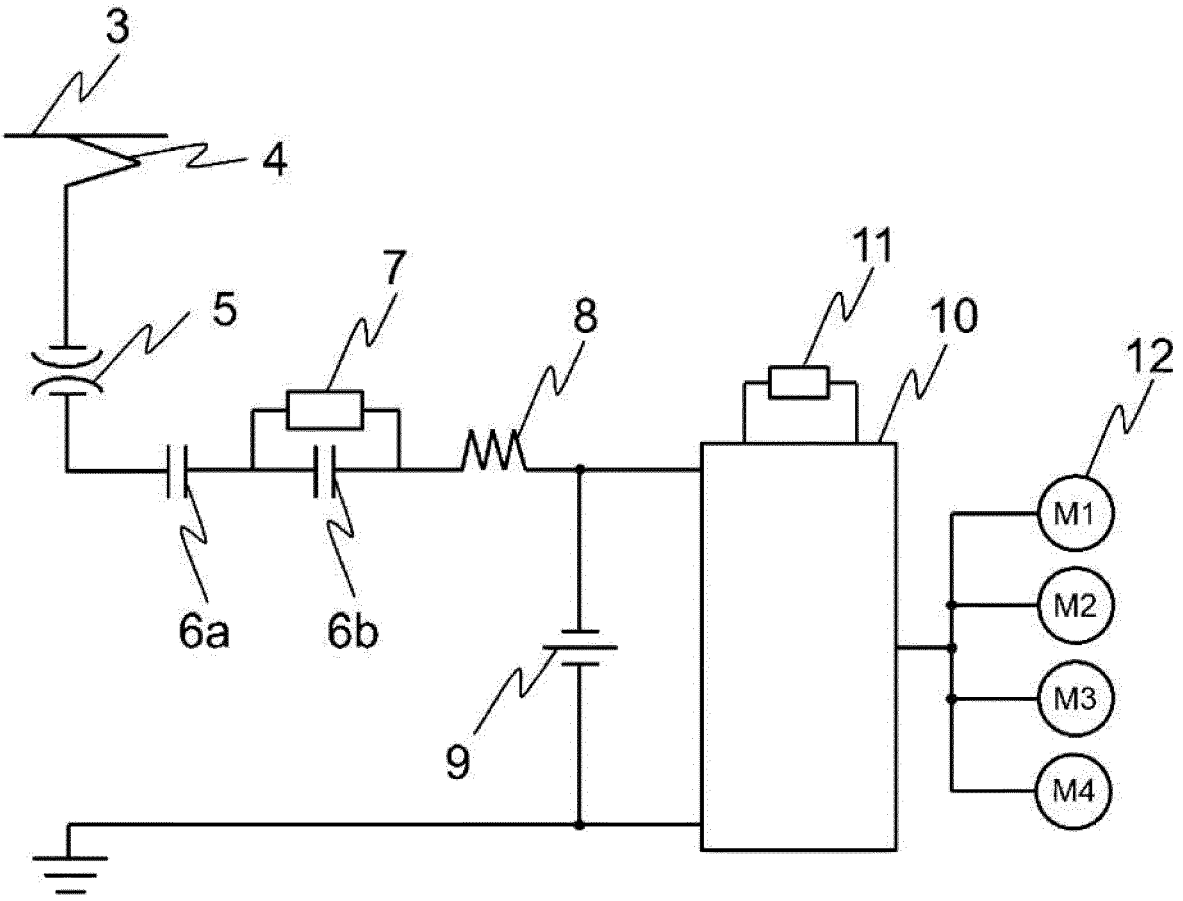


FIG. 3

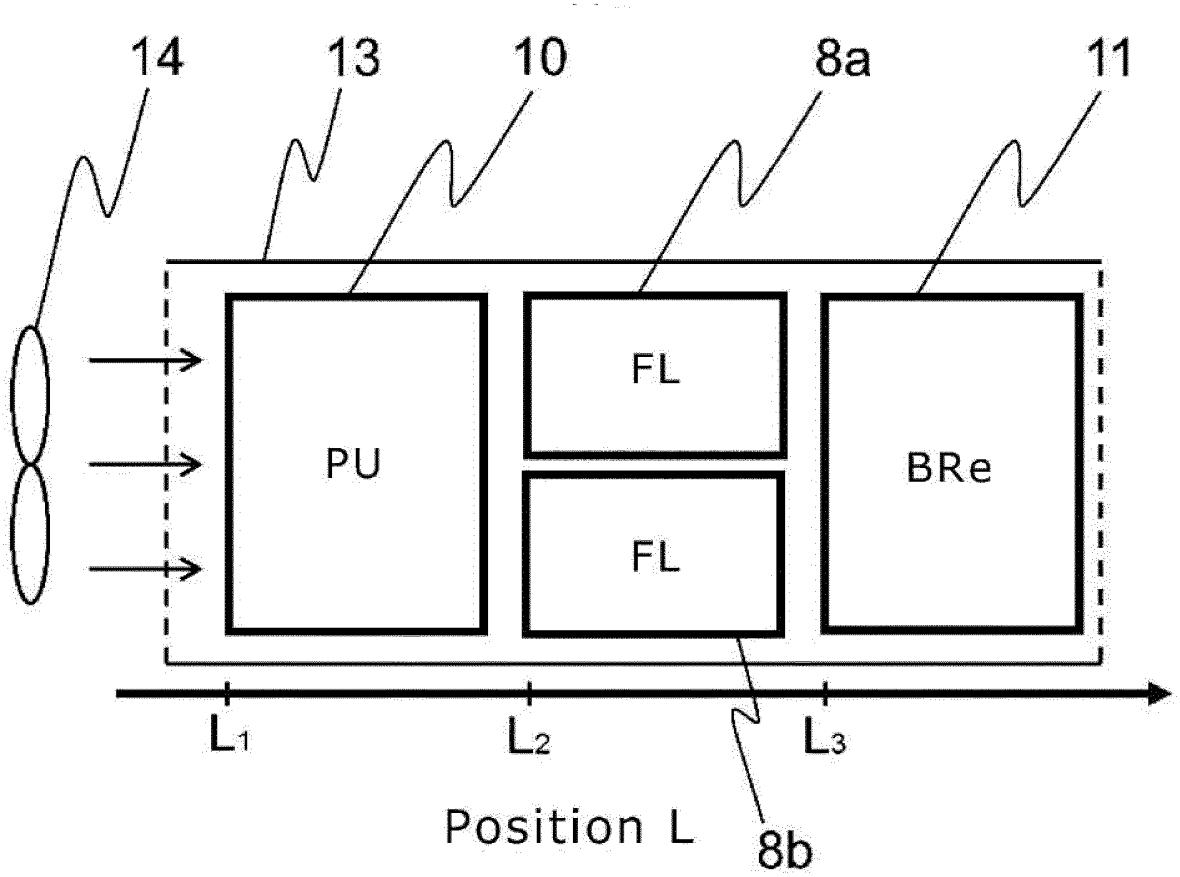

14
13
10
8a
11
PU
FL
FL
BRe
L1
L2
L3
Position L
8b

FIG. 4

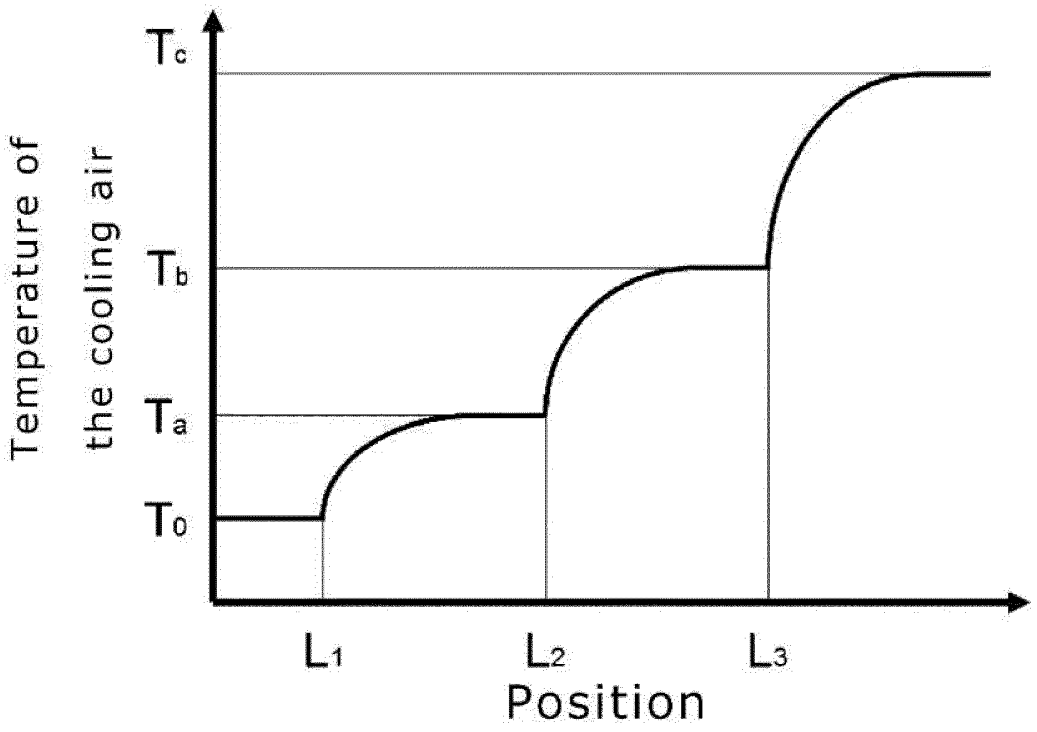

Tc
Tb
Ta
T0
Temperature of the cooling air
L1
L2
L3
Position

FIG. 5

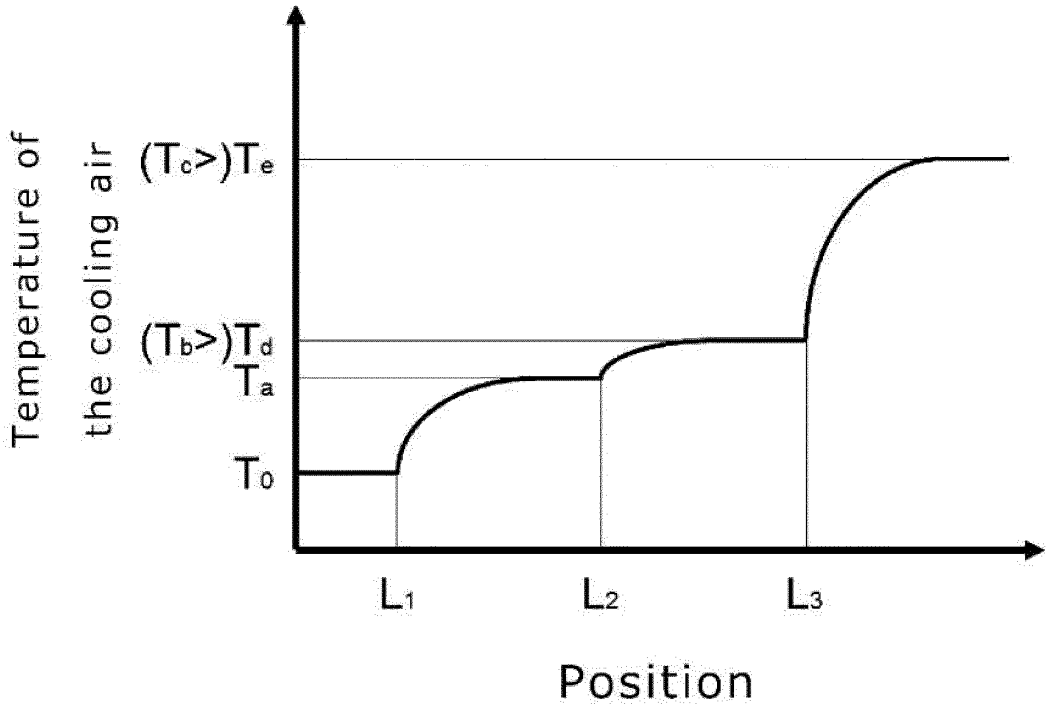

Temperature of the cooling air
(Tc>)Te
(Tb>)Td
Ta
T0
L1
L2
L3
Position

FIG. 6

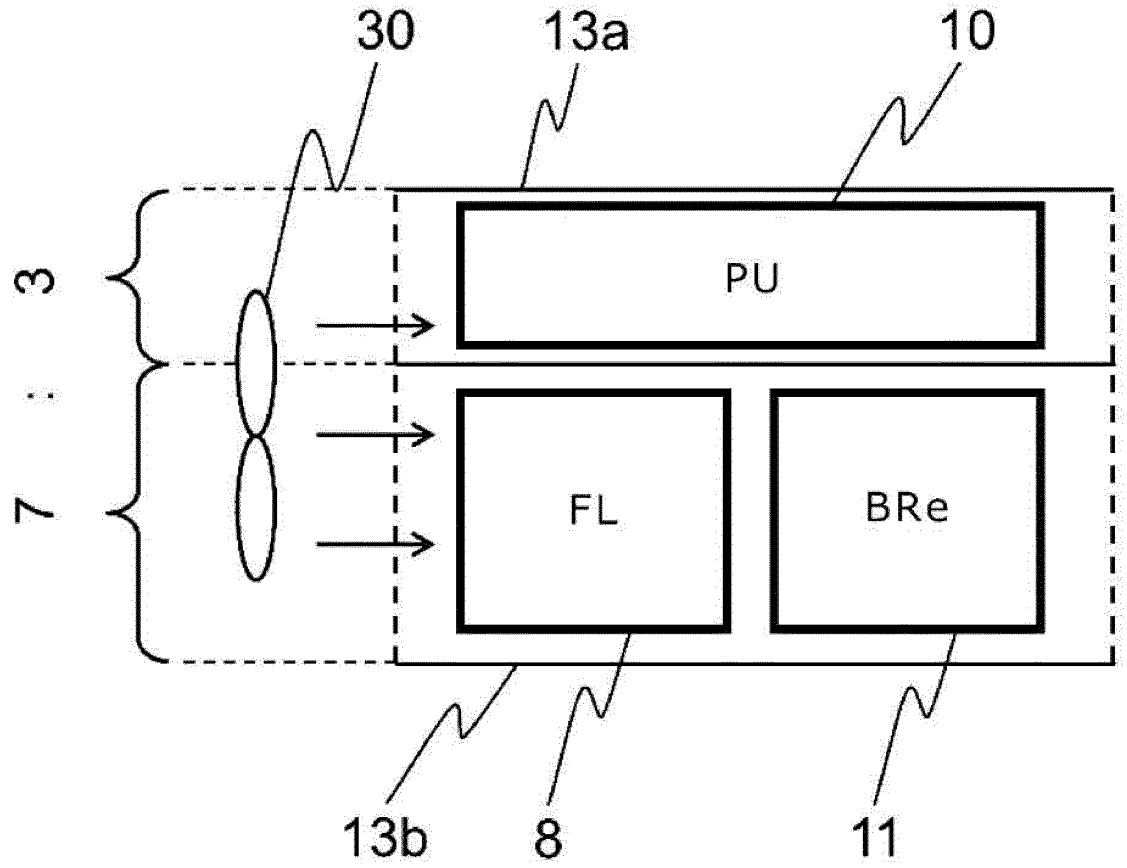
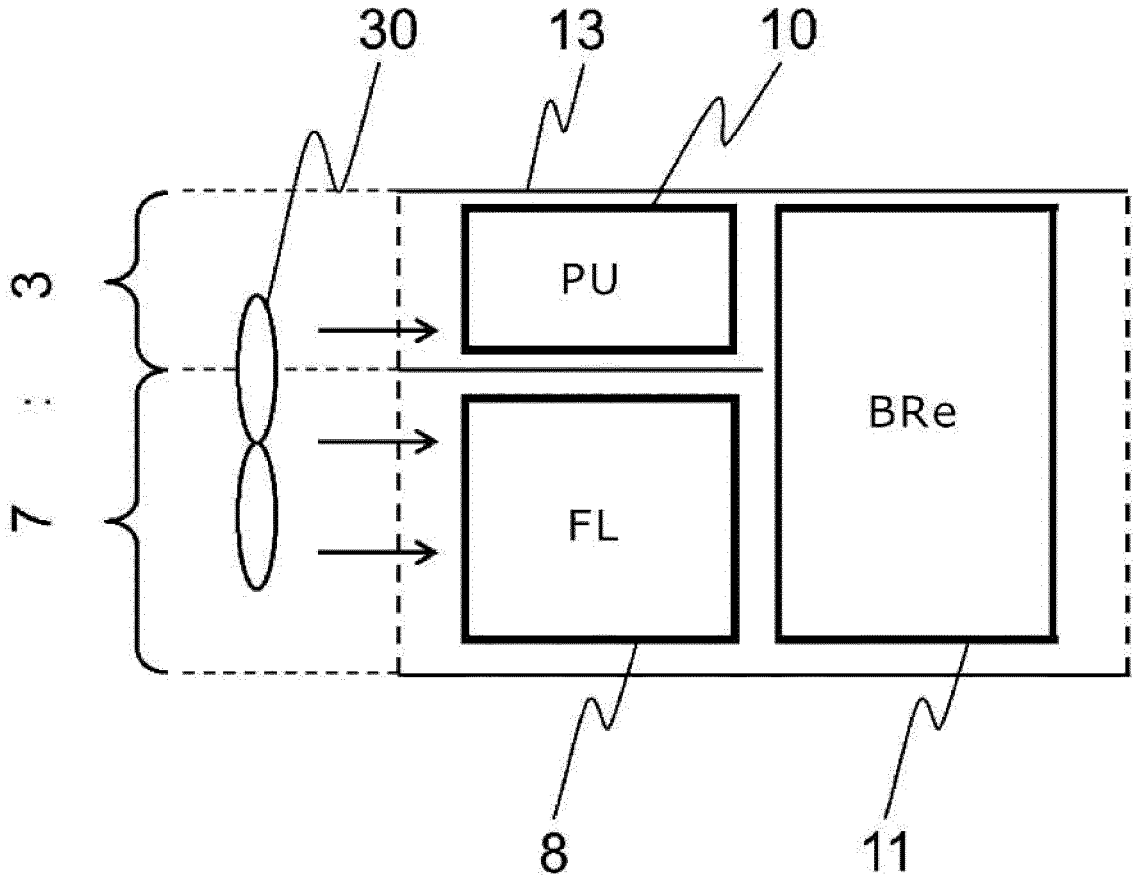

30
13a
10
3
7
PU
FL
BRe
13b
8
11

FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/042270

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. B61C17/00(2006.01)i
FI: B61C17/00C, B61C17/00E

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. B61C17/00, H05K7/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2005-1598 A (TOSHIBA CORPORATION) 06 January 2005, claims 1-3, paragraphs [0014]-[0017], fig. 1	1-2, 7 3-6, 8-10
Y	JP 10-95334 A (TOSHIBA TRANSPORT ENG INC.) 14 April 1998, paragraphs [0005], [0011], fig. 1	3-6
Y	CA 2324432 A1 (DAIMLERCHRYSLER AG) 26 April 2001, page 7, line 13 to page 8, line 7, fig. 1-5	8-10
E, X	JP 2019-189211 A (HITACHI, LTD.) 31 October 2019, paragraphs [0044], [0045], fig. 1, 6, 7	1, 7-8

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search 14.01.2020	Date of mailing of the international search report 28.01.2020
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2019/042270

JP 2005-1598 A	06 January 2005	(Family: none)	
JP 10-95334 A	14 April 1998	(Family: none)	
CA 2324432 A1	26 April 2001	EP 1095836 A2 DE 19951356 A1	
JP 2019-189211 A	31 October 2019	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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