Abstract: An electric power supply device includes a first battery module, a second battery module, a case, and a cooling structure. The cooling structure includes a first and a second passages and distributes a refrigerant from the first passage to the second passage. The first passage extends in a stacking direction of the batteries. The second passage is formed between the stacked batteries. The first and the second battery modules are arranged such that at least a portion of the refrigerant discharged from the first passage of the first battery module and at least a portion of the refrigerant discharged from the second passage of the second battery module face and hit each other. The refrigerant discharged from the first battery module and the second battery module spreads, is retained in a space formed between each of the battery modules and the case, and is then discharged from the discharge port.

FIG. 1
1. Field of the Invention

[0001] The invention relates to an electric power supply device that is mounted in a vehicle, for example.

2. Description of Related Art

[0002] For example, Japanese Patent Application Publication No. 2011-44275 (JP 2011-44275 A) describes an electric power supply device in which plural battery modules are housed in a housing case, and each of the battery modules is constructed by stacking a large number of single batteries. In this electric power supply device, a cooling wind passage is formed between two each of the single batteries in each of the above battery modules, and each of the single batteries is cooled when cooling wind that is supplied from outside of the housing case flows through the cooling wind passage. In addition, another cooling wind passage is formed between the two adjacent battery modules, and the cooling wind passage communicates with a discharge port that is formed in the housing case. It is described in JP 2011-44275 A that the cooling wind that is discharged from the each battery module is discharged to the cooling wind passage in a direction to oppose each other, and is then discharged from the discharge port to the outside of the housing case via the cooling wind passage.

SUMMARY OF THE INVENTION

[0003] In the case where the plural batteries are stacked to constitute the battery module as in the electric power supply device of above JP 2011-44275 A, a temperature fluctuates among the batteries unless cooling performance of the batteries by the cooling wind is equalized. At this time, a lifetime also fluctuates among the plural batteries that constitute the electric power supply device since a charging and discharging
characteristic or a degree of deterioration differs among the batteries. This causes a problem of a shortened lifetime of the entire electric power supply device.

[0004] In addition, when the electric power supply device is mounted in a vehicle, a particular battery provided in the electric power supply device possibly reaches a higher temperature than another battery due to an external influence, such as solar radiation, depending on a mounted position. This possibly causes the fluctuations in temperature, and further causes the same problem as described above.

[0005] Furthermore, similar to the electric power supply device of JP 201 1-44275 A, in the case where a configuration that the cooling wind passage is formed between the adjacent battery modules and that the cooling wind discharged from the each battery module is discharged to the outside of the case via the cooling wind passage is adopted, a member that forms the cooling wind passage has to be arranged in the case. This increases the size of the electric power supply device.

[0006] An object of the invention is to provide an electric power supply device that includes first and second battery modules, each of which is constructed by stacking plural batteries, and that suppresses fluctuations in temperature among the batteries.

[0007] According to an aspect of the invention, an electric power supply device includes a first battery module, a second battery module, a case, and a cooling structure. The first battery module and the second battery module are each constructed by stacking plural batteries. The case includes a discharge port and houses the first battery module and the second battery module. The cooling structure includes a first passage and a second passage. The cooling structure is configured to distribute a refrigerant from the first passage to the second passage, so as to cool the batteries. The refrigerant is supplied from the outside of the case. The first passage extends in a stacking direction of the batteries. The second passage is a passage formed between the stacked batteries. The first battery module and the second battery module are arranged such that at least a portion of the refrigerant discharged from the second passage of the first battery module and at least a portion of the refrigerant discharged from the second passage of the second battery module face and hit each other. The refrigerant discharged from the first battery
module and the second battery module spreads and is retained in a space formed between each of the battery modules and the case, and is then discharged from the discharge port.

[0008] In the above aspect, the refrigerant may be introduced into the second passage from a lower surface side of each of the first battery module and the second battery module in a state that the electric power supply device is installed, may flow along the second passage in a curved shape, and then may be discharged from each of side surfaces that face each other in the first battery module and the second battery module.

[0009] In addition, in the above aspect, the electric power supply device may be mounted in a vehicle, and a bottom section of the case may be installed on a floor panel of the vehicle.

[0010] In the above aspect, the first battery module and the second battery module are arranged such that the refrigerant discharged from a refrigerant passage of the first battery module and the refrigerant discharged from a refrigerant passage of the second battery module face and hit each other. Accordingly, pressure loss (that is, flow passage resistance) during discharging of the refrigerant between the first and second battery modules is significant on an upstream side of a refrigerant supply passage. Thus, a flow amount of the refrigerant that flows into the refrigerant passage between the batteries can be suppressed. On the contrary, the flow amount of the refrigerant is increased by a suppressed flow amount in the refrigerant passage that is located on a downstream side of the refrigerant supply passage. As a result, the flow amount of the refrigerant that is distributed to the refrigerant passage between the batteries is equalized in the entire stacking direction, and thus cooling performance is substantially equalized for the batteries. Thus, it is possible to suppress fluctuations in temperature among the batteries that constitute each of the battery modules provided in the electric power supply device.

[0011] In addition, in the above aspect, the refrigerant discharged from each of the first and second battery modules does not flow through a discharge passage but spreads and is retained in the space formed between each of the battery modules and the
case. Then, the refrigerant is discharged from the discharge port provided in the case. Accordingly, since the above space functions as an air heat-insulating layer, the fluctuations in temperature among the batteries that constitute each of the battery modules are unlikely to occur by a thermal influence from the outside of the case.

Furthermore, in the above aspect, it is configured that the refrigerant discharged from the first and second battery modules spread and is retained in the case and is then discharged. Thus, a discharge duct does not have to be provided in the case, and the electric power supply device can thereby be downsized by elimination of the duct.

BRIEF DESCRIPTION OF THE DRAWINGS

Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a view that schematically shows an overall configuration of an electric power supply device as a first embodiment of the invention as seen from above;

FIG. 2 is an exploded perspective view of the electric power supply device in FIG. 1;

FIG. 3 is a cross-sectional view of the electric power supply device that is taken along line A-A in FIG. 2;

FIG. 4 is a view that schematically shows one example of a partitioning member that is provided in a battery module for constituting the electric power supply device in FIG. 1 when seen in an X-direction;

FIG. 5 is a view that schematically shows the one example of the partitioning member in FIG. 4 when seen in a Y-direction;

FIG. 6 is a view of a situation where a refrigerant flows in the electric power supply device in FIG. 1;

FIG. 7 is a view of a situation where the refrigerant flows in an electric power supply device as a second embodiment of the invention;
FIG. 8 is a view of a situation where the refrigerant flows in one battery module that constitutes the electric power supply device in FIG. 7; and

FIG. 9 is a view of one example of an installed state of the electric power supply device that is mounted in a vehicle.

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DETAILED DESCRIPTION OF EMBODIMENTS

[0014] A detailed description will hereinafter be made on embodiments according to the invention with reference to the accompanying drawings. In this description, specific shapes, materials, numerical values, directions, and the like are all illustrative for a purpose of promoting understanding of the invention, and thus can appropriately be changed in accordance with an application, purpose, specification, or the like. In addition, in the case where plural embodiments, modifications, or the like are included in the following description, it is anticipated from the beginning that characteristic parts of these are appropriately combined to be used.

10 [0015] FIG. 1 is a view that schematically shows an overall configuration of an electric power supply device 100 as a first embodiment of the invention as seen from above. In FIG. 1, an upper wall section of a case 50 is removed so that the configuration of the electric power supply device 100 can easily be seen. FIG. 2 is an exploded perspective view of the electric power supply device 100 in FIG. 1. In addition, FIG. 3 is a cross-sectional view of the electric power supply device 100 that is taken along line A-A in FIG. 2.

[0016] In FIG. 1 to FIG. 3, an X-direction, a Y-direction, and a Z-direction are directions that are orthogonal to each other. An up-down direction, a right-left direction, and the like change in accordance with a mounted state of the electric power supply device 100 or a direction in which the electric power supply device 100 is seen. However, as a matter of convenience, the Z-direction corresponds to a vertical direction (the up-down direction), and an upper side in each of the drawings is designated as the "upper side" with each of the drawings being a reference in the following description. In addition, the Y-direction corresponds to the right-left direction with each of the
drawings being the reference. Furthermore, the X-direction corresponds to a stacking direction of batteries that constitute a battery module provided in the electric power supply device 100.

[0017] The electric power supply device 100 can be mounted in a vehicle. As the vehicle, a hybrid vehicle and an electric vehicle are available. The hybrid vehicle is a vehicle that includes an electric motor and an internal combustion engine as power sources for running the vehicle. The electric vehicle is a vehicle that only includes the electric motor as the power source of the vehicle. In either case, the electric power supply device 100 may be used as an electric power source of the electric motor.

[0018] The electric power supply device 100 includes a first battery module 1, a second battery module 2, and the case 50.

[0019] The first battery module 1 has plural single batteries 10. As shown in FIG. 1 and FIG. 2, the plural single batteries 10 are aligned (stacked) in the X-direction. The second battery module 2 is configured in the same manner as the first battery module 1. The first battery module 1 and the second battery module 2 are aligned in the Y-direction with a gap having a dimension d1 being interposed therebetween.

[0020] The case 50 is an exterior member that houses the entire first and second battery modules 1, 2. Regarding the first and second battery modules 1, 2, the case 50 has: an upper wall section 52 and a bottom wall section 54 that respectively cover upper and lower surfaces; side wall sections 56a, 56b that cover both sides in the battery stacking direction (the X-direction); and side wall sections 58a, 58b that cover both sides in the right-left direction (the Y-direction). The case 50 is, for example, formed of a metal (for example, a sheet metal member).

[0021] A refrigerant supply duct 60 is fixed to the one side wall section 56a in the X-direction of the case 50. The refrigerant supply duct 60 supplies a refrigerant for cooling the electric power supply device 100 from outside of the case 50 to each of the battery modules 1, 2 in the case 50. Preferably, air can be used as the refrigerant. However, the refrigerant is not limited to the air and may be a fluid such as water.
[0022] One end in the X-direction of the refrigerant supply duct 60 is projected to an outer side of the side wall section 56a and forms a refrigerant supply port 62. The refrigerant supply duct 60 is formed of a metal, a resin, or the like, for example. In addition, the refrigerant supply duct 60 may integrally be molded or may be constructed of plural members. Another end in the X-direction of the refrigerant supply duct 60 is branched into two in the case 50 and respectively connected to refrigerant supply passages S2 of the first battery module 1 and the second battery module 2. A connection part between the other end of the refrigerant supply duct 60 and an end of the refrigerant supply passage S2 of each of the battery modules 1, 2 is preferably closed by an appropriate seal member in an airtight state. In this way, leakage of the refrigerant can be prevented in the above connection part.

[0023] Noted that it is described in this embodiment that the refrigerant supply duct 60 has a shape that is branched into two in the case 50. However, the shape of the refrigerant supply duct 60 is not limited thereto. For example, the refrigerant supply duct 60 may be branched on the outside of the case 50 and then introduced into the case 50 via the side wall section 56a of the case 50.

[0024] As shown in FIG. 3, the refrigerant supply passage S2 is formed on a lower surface side of the single battery 10. The refrigerant is supplied to the refrigerant supply passage S2 from a refrigerant supply source (not shown), such as a blower, on the outside of the electric power supply device 100 via the refrigerant supply duct 60. The refrigerant supply passage S2 extends in the X-direction. One end of the refrigerant supply passage S2 is opened, and another end thereof is closed (see FIG. 1). Further details of the refrigerant supply passage S2 will be described below.

[0025] Plural discharge ports 59 are formed in each of the side wall sections 56a, 56b on both sides in the X-direction of the case 50. The discharge port 59 is an opening through which the refrigerant, which is discharged from each of the battery modules 1, 2, and spreads and is retained in the case 50, is discharged to the outside of the case 50. The number and a shape of the discharge port 59 can appropriately be set.
[0026] A total opening area of the discharge ports 59 that are formed in the one side wall section 56a is preferably set equal to a total opening area of the discharge ports 59 that are formed in the other side wall section 56b. In this way, the refrigerant can flow substantially equally on both of the sides in the X-direction in the case 50. Furthermore, the discharge port 59 does not have to be formed exclusively for a purpose of discharging the refrigerant. The discharge port 59 may be a gap that is formed between the upper wall section 52 and each of the side wall sections 56a, 56b, 58a, 58b. Alternatively, the discharge port 59 may be an opening through which an electric power cable runs.

[0027] In addition, a notch section 57 is formed in an upper section of the one side wall section 56a of the case 50. In the notch section 57, a smoke discharge duct (not shown) is arranged, and the smoke discharge duct allows a smoke discharge passage S1 of each of the battery modules 1, 2, which will be described below, to communicate with the outside of the case 50. It is configured that gas released from the single batteries 10 of each of the battery modules 1, 2 to the smoke discharge passage S1 is discharged to the outside of the case 50 via this smoke discharge duct. In addition, a gap may be formed between the notch section 57 and the smoke discharge duct, and the gap may be used as a discharge port from which the refrigerant is discharged to the outside of the case 50.

[0028] Since the first battery module 1 and the second battery module 2 have a same configuration, the following description will be made on the first battery module 1 as an example.

[0029] The single battery 10 that constitutes the first battery module 1 may be an arbitrary secondary battery, such as a nickel hydrogen battery or a lithium ion battery. Alternatively, instead of being the secondary battery, the single battery 10 may be an electric double-layered capacitor. Noted that the number of the single battery 10 may appropriately be determined on the basis of requested output of the first battery module 1, requested output of the entire electric power supply device 100, or the like.
As shown in FIG. 2 and FIG. 3, a positive electrode terminal 11 and a negative electrode terminal 12 are provided on an upper surface of the single battery 10. The positive electrode terminal 11 and the negative electrode terminal 12 are provided to separate from each other by a specified distance in the Y-direction. The plural single batteries 10 are electrically connected in series. More specifically, the positive electrode terminal 11 of the one single battery 10 and the negative electrode terminal 12 of the other single battery 10 that is adjacent to the one single battery 10 in the X-direction are electrically connected by a bus bar (not shown).

A valve 13 is provided in the upper surface of the single battery 10. The valve 13 is used to discharge the gas that is generated on the inside of the single battery 10 to the outside of the single battery 10. The inside of the single battery 10 is in an airtight state. Thus, when the gas is generated on the inside of the single battery 10, internal pressure of the single battery 10 is increased in conjunction with generation of the gas. When the internal pressure of the single battery 10 reaches actuation pressure of the valve 13, the valve 13 is changed from a closed state to an opened state. Accordingly, the gas that is generated on the inside of the single battery 10 can be discharged to the outside of the single battery 10.

The valve 13 is arranged between the positive electrode terminal 11 and the negative electrode terminal 12 in the Y-direction. In an example shown in FIG. 3, the valve 13 is arranged at a position, a distance from which to the positive electrode terminal 11 and a distance from which to the negative electrode terminal 12 are equal to each other. Due to the provision of the valve 13 in the upper surface of the single battery 10, the gas that is generated on the inside of the single battery 10 can easily be discharged from the valve 13. Noted that a position at which the valve 13 is provided can appropriately be set.

A partitioning member 30 is arranged between two each of the single batteries 10 that are adjacent to each other in the X-direction. The partitioning member 30 has a function as a spacer. The partitioning member 30 is preferably formed of an insulating material such as a resin. As shown in FIG. 4, the partitioning member 30 has
plural coupling sections 42 that are projected to the upper side and a lower side. More specifically, each of the partitioning members 30 has the two coupling sections 42 on the upper side that are projected on both sides of the valve 13 in the Y-direction, and also has the two coupling sections 42 on the lower side in the same manner. Heights (lengths in the Z-direction) and positions of the coupling sections 42 may differ between those on the upper side and those on the lower side. Noted that further details of the partitioning member 30 will be described below.

[0034] As shown in FIG. 2, paired end plates 41 are arranged at both ends of the first battery module 1 in the X-direction. A metallic restraining member (flat plate band) 46 is joined to the end plate 41. The two restraining members 46 are provided on an upper section side of the first battery module 1. The two restraining members 46 extend in the X-direction while separating from each other in the Y-direction, and both ends of each of the two restraining members 46 are respectively joined to the paired end plates 41. An arbitrary method can be used as a method for fixing the restraining member 46 to the end plate 41, and a fixing method that uses a bolt, a fixing method that uses a rivet, or a fixing method by welding can be used. Similarly, the two restraining members 46 may be provided on a lower section side of the first battery module 1. The restraining member 46 has a function to apply a restraining force to the plural single batteries 10 when both ends thereof, on which a tensile force acts, are respectively fixed to the paired end plates 41. The restraining force is a force to hold the single batteries 10 in the X-direction. For example, expansion of the single batteries 10 can be suppressed by applying the restraining force to the single batteries 10. In a configuration that two each of the restraining members 46 are used on the upper section side and the lower section side of the first battery module 1, it is possible to prevent the restraining force from being concentrated on one position and thus to apply the even restraining force to the single batteries 10.

[0035] As shown in FIG. 3, the smoke discharge passage SI is formed on the upper surface side of the single battery 10. The smoke discharge passage SI communicates with the inside of each of the single batteries 10 via the valve 13 of each
of the single batteries 10. Accordingly, the smoke discharge passage SI has a function
to discharge the gas that is generated on the inside of each of the single batteries 10 to the
outside of the first battery module 1. As shown in FIG. 3, the smoke discharge passage
SI is defined and formed by the coupling sections 42 on the upper side of each of the
partitioning member 30, the upper wall section 52 of the case 50, and the upper surface of
each of the single batteries 10. The smoke discharge passage SI can adopt such a
structure that it extends in the X-direction and that one end is opened and another end is
closed, for example. A seal member 70 is preferably provided between an upper edge
of the coupling section 42 on the upper side of the partitioning member 30 and the upper
wall section 52 of the case 50. The seal member 70 is formed of a sponge, rubber, or
the like, for example. The seal member 70 extends in the X-direction along the
coupling section 42, which is coupled thereto, on the upper side of each of the
partitioning members 30. Due to the provision of the seal member 70, airtightness can
be improved, and thus gas leakage from the smoke discharge passage SI can be reduced.
Noted that the smoke discharge passage SI may have a constant cross section or that the
cross section thereof may change as the smoke discharge passage SI advances along the
X-direction.

[0036] As described above, the refrigerant supply passage S2 is formed on the
lower surface side of the single battery 10. As shown in FIG. 3, the refrigerant supply
passage S2 is defined and formed by the coupling sections 42 on the lower side of each of
the partitioning members 30, the bottom wall section 54 of the case 50, and the lower
surface of each of the single batteries 10. The seal member 70 is preferably provided
between a lower edge of the coupling section 42 on the lower side of each of the
partitioning members 30 and the bottom wall section 54 of the case 50. Due to the
provision of the seal member 70, the airtightness is improved, and leakage of the
refrigerant that flows through the refrigerant supply passage S2 can be reduced. Noted
that the refrigerant supply passage S2 may have a constant cross section or that the cross
section thereof may change as the refrigerant supply passage S2 advances along the
X-direction.
[0037] FIG. 4 is a view that schematically shows one example of the partitioning member 30 when seen in the X-direction, and FIG. 5 a view that schematically shows the one example of the partitioning member 30 when seen in the Y-direction.

[0038] The partitioning member 30 has the coupling sections 42 in an upper section and a lower section. The coupling sections 42 are provided at two positions in the upper section and at two positions in the lower section. As shown in FIG. 3, the coupling sections 42 are projected vertically in the X-direction with respect to the upper surface and the lower surface of the single battery 10 that is adjacently arranged thereto. As shown in FIG. 4, the coupling section 42 is formed to be hollow when seen in the X-direction. In other words, the coupling section 42 has a hole 44 that extends in the X-direction. In addition, as shown in FIG. 5, the coupling section 42 has a large diameter section 42a and a small diameter section 42b. In the coupling section 42, the large diameter section 42a extends in the X-direction toward the adjacent single battery 10 on one side, and the small diameter section 42b extends in the X-direction toward the adjacent single battery 10 on another side. Two each of the partitioning members 30 that are adjacent to each other in the X-direction are coupled when the small diameter section 42b of the one partitioning member 30 is fitted to a hole 43 in the large diameter section 42a of the other partitioning member 30. In this coupling state, the coupling sections 42 on the upper side of the partitioning member 30 form side wall sections of the smoke discharge passage SI, two rows of which extend in the X-direction (see FIG. 3). In addition, in the coupling state, a hollow section that extends in the X-direction is formed when the holes 44 in the coupling sections 42 are coupled to each other. The metallic restraining member (see FIG. 3) is inserted through this hollow section. Furthermore, in this coupling state, the single battery 10 is arranged between two each of the partitioning members 30 that are adjacent to each other in the X-direction. In other words, two each of the partitioning members 30 are coupled to each other when the two each of the partitioning members 30 hold the single battery 10 therebetween from both of the sides of the single battery 10 in the X-direction. In this way, corresponding each of
the single batteries 10 is arranged between two each of the partitioning members 30 that are adjacent to each other in the X-direction.

[0039] As shown in FIG. 5, the partitioning member 30 has ribs 32 that are projected in the X-direction on a surface that faces the single battery 10 on the one side. Meanwhile, in the partitioning member 30, a surface on an opposite side of the surface formed with the ribs 32, that is, a surface that faces the single battery 10 on the other side may be constructed as such a flat surface that comes in contact with a surface of the single battery 10.

[0040] As shown in FIG. 4, the plural ribs 32 are formed in a T shape as a whole. The plural ribs 32 extend in the Z-direction from the lower side (an intake side), are then directed and extend in the Y-direction. In this way, a T-shaped refrigerant passage S3 is defined and formed that extends in the Z-direction from the lower side (the intake side), is then curved in the Y-direction, and extends toward both end sections of the partitioning member 30 in the Y-direction. In other words, the refrigerant passage S3 is defined and formed that is used for the refrigerant to flow in the T shape on an end surface of the single battery 10 in the X-direction. In an example shown in FIG. 4, the plural ribs 32 are formed symmetrically with respect to a center line in the Z-direction that passes through a center of the partitioning member 30 in the Y-direction. More specifically, a central rib 32a extends in the Z-direction from a central position in the Y-direction on the lower side of the partitioning member 30, is then branched and extends to both of the sides in the Y-direction (right and left sides). Ribs 32b, 32c on the right side extend in the Z-direction from the lower side of the partitioning member 30, are then directed and extend to one direction (a right direction) in the Y-direction. Ribs 32b, 32c on the left side extend in the Z-direction from the lower side, are then directed and extend to another direction (a left direction) in the Y-direction. The rib 32d extends in the Y-direction.

[0041] The number of the ribs 32 and a gap between the two adjacent ribs 32 can appropriately be set. In addition, a height (a height in the X-direction) of the rib 32 is preferably set such that a tip of the rib 32 comes in contact with the end surface of the
single battery 10 in the X-direction in order to prevent mixture of the refrigerants, each of
which is distributed to each of the refrigerant passages S3 that are defined and formed by
the ribs 32, in other words, in order for the refrigerants to flow in the T shape on the end
surface (the end surface in the X-direction) of the single battery 10. Noted that the ribs 
32 may be formed on surfaces on both sides of the partitioning member 30.

[0042] Noted that the refrigerant supply passage S2 and the refrigerant passage 
S3 in this embodiment respectively correspond to a refrigerant supply passage and a 
refrigerant passage that constitute a "cooling structure" in the invention.

[0043] Referring again to FIG. 1, the first battery module 1 and the second 
battery module 2 are aligned in Y-direction via a gap 3 having the dimension dl. In 
addition, the partitioning members 30 that are contained in each of the battery modules 1, 
2 face each other in the Y-direction. In other words, such a positional relationship is 
established that discharge ports 33 of the refrigerant passages S3 (see FIG. 4) face each 
other, the discharge port 33 being opened to each of facing side surfaces of the battery 
modules 1, 2 that face each other in the Y-direction. Accordingly, it is configured that 
the refrigerants that are discharged from the discharge ports 33 on the side surfaces of the 
first and second battery modules 1, 2 face each other in the gap 3 and hit (collide with) 
each other.

[0044] The dimension dl of the above gap 3 is set to such a degree that pressure 
loss (that is, flow passage resistance) is increased on an upstream side of the refrigerant 
supply passage S2, that is, on a side near the refrigerant supply duct 60 since the 
refrigerants that are discharged from the battery modules 1, 2 are spouted while facing 
each other. More specifically, the dimension dl of the above gap 3 is set to a few mm 
to 20 mm, for example. Usually, a relatively large amount of the refrigerant is 
distributed to the refrigerant passage S3, which is formed in the partitioning member 30 
of each of the battery modules 1, 2, on the upstream side (that is, the refrigerant supply 
duct 60 side) of the refrigerant supply passage S2. Meanwhile, an amount of the 
refrigerant that is distributed to the refrigerant passage S3 of the partitioning member 30 
located on a downstream side (that is, a closed end section side) of the refrigerant supply
passage S2 is relatively small. On the contrary, in this embodiment, a flow amount of the refrigerant that flows into the refrigerant passage S3 of the partitioning member 30 located on the upstream side of the refrigerant supply passage S2 is suppressed by an increase in the flow passage resistance that is generated in the above gap 3. Accordingly, the flow amount of the refrigerant in the refrigerant passage S3 of the partitioning member 30 that is located on the downstream side of the refrigerant supply passage S2 is increased by the suppressed flow amount. As a result, cooling performance for the single batteries 10 is equalized, and thus fluctuations in temperature among the single batteries 10 can be suppressed.

In the battery modules 1, 2, side surfaces on opposite sides of the gap 3 respectively face the side wall sections 58a, 58b of the case 50 via gaps 4. A dimension d2 of this gap 4 is preferably set to be smaller than the dimension d1 of the gap 3 between the battery modules 1, 2. Such setting can contribute to the reduction in the flow amount of the refrigerant on the upstream side of the refrigerant supply passage S2 and the increase in the flow amount of the refrigerant on the downstream side of the refrigerant supply passage S2 since the pressure loss (that is, the flow passage resistance) of the refrigerant that is discharged from each of the battery modules 1, 2 toward each of the side wall sections 58a, 58b of the case 50 is increased.

Referring again to FIG. 3, a space 80 is formed between the case 50 and each of the first and second battery modules 1, 2. More specifically, a space 80a that has a substantially I-shaped cross section and includes the gap 3 between the battery modules 1, 2 is formed in a central region in the Y-direction on the inside of the case 50. In addition, a space 80b that has a U-shaped cross section and includes the gap 4 is formed on both sides in the Y-direction on the inside of the case 50. Each of these spaces 80a, 80b is a space in which the refrigerant discharged from each of the battery modules 1, 2 can spread and be retained. In addition, each of the above spaces 80a, 80b is communicated with the discharge ports 59 that are provided in the side wall sections 56a, 56b on both of the sides of the case 50 in the X-direction. Accordingly, the refrigerant discharged from each of the battery modules 1, 2 is discharged to the outside
of the case 50 from each of the spaces 80a, 80b. In other words, the electric power supply device 100 of this embodiment adopts a configuration that is not provided with a duct or a discharge passage member for guiding the refrigerant discharged from each of the battery modules 1, 2 and discharging the refrigerant to the outside of the case.

Next, a description will be made on a cooling operation of each of the battery modules 1, 2 in the electric power supply device 100 that is configured as above with reference to FIG. 6. FIG. 6 is a view of a situation where the refrigerant flows in the electric power supply device 100 in FIG. 1.

As shown in FIG. 6, the refrigerant is supplied from the refrigerant supply source, which is not shown, to the refrigerant supply port 62 of the refrigerant supply duct 60. The refrigerant is introduced into the case 50 via the refrigerant supply duct 60, is branched into two, and then is supplied to the end of the refrigerant supply passage S2 of each of the battery modules 1, 2.

While flowing through the refrigerant supply passage S2 of each of the battery modules 1, 2 in the X-direction, the refrigerant is introduced into the refrigerant passages S3, which are formed by the partitioning member 30 between the single batteries 10, from the lower surface side of each of the battery modules 1, 2. Then, as described above with reference to FIG. 4, after flowing in the T shape, the refrigerant is discharged from the discharge ports 33 that are opened to the side surfaces on both sides in the Y-direction of each of the battery modules 1, 2. While flowing through the refrigerant passages S3 in the T shape, just as described, the refrigerant can draw heat from each of the single batteries 10 that constitute the battery modules 1, 2 and thereby cool each of the single batteries 10.

As shown in FIG. 6, the refrigerants that are discharged from the battery modules 1, 2 to the gap 3 between the battery modules 1, 2 face each other and hit each other (in a completely opposite direction). This causes the pressure loss in the flow of the refrigerant with respect to each of the battery modules 1, 2. At this time, the pressure loss (the flow passage resistance) during discharging of the refrigerant between the first and second battery modules 1, 2 is significant on the upstream side of the
refrigerant supply passage S2. Thus, the flow amount of the refrigerant that flows into
the refrigerant passage S3 between the single batteries 10 is suppressed. On the
contrary, the flow rate of the refrigerant is increased by the suppressed flow amount in
the refrigerant passage S3 that is located on the downstream side of the refrigerant supply
passage S2. As a result, the flow amount of the refrigerant that is distributed to the
refrigerant passages S3 between the single batteries 10 is equalized in the entire stacking
direction, and thus the cooling performance for the single batteries 10 is substantially
equalized. Thus, it is possible to suppress the fluctuations in the temperature of the
single batteries 10 that constitute each of the battery modules 1, 2 provided in the electric
power supply device 100.

[0051] In addition, in the electric power supply device 100 according to this
embodiment, after the refrigerant that is discharged from each of the first and second
battery modules 1, 2 spreads and is retained in the spaces 80a, 80b formed between the
case 50 and each of the battery modules 1, 2, the refrigerant is discharged from the
discharge port 59 (and 57) provided in the case 50. In this way, the spaces 80a, 80b, in
which the refrigerant discharged from the battery modules 1, 2 is retained, the smoke
discharge passage SI, and the refrigerant supply passage S2 each function as an air
heat-insulating layer provided around each of the battery modules 1, 2. Accordingly,
the fluctuations in the temperature among the single batteries 10 that constitute each of
the battery modules 1, 2 is unlikely to occur by a thermal influence from the outside of
the case 50.

[0052] Furthermore, in the electric power supply device 100 according to this
embodiment, it is configured that the refrigerant discharged from the first and second
battery modules 1, 2 spreads and is retained in the case 50 and is then discharged. Thus,
there is no need to provide the duct or the discharge passage member in the case 50, and
the electric power supply device 100 can be downsized by elimination of the duct or the
discharge passage member.

[0053] Next, a description will be made on an electric power supply device 102
as a second embodiment of the invention with reference to FIGs. 7 and 8. FIG. 7 is a
view of a situation where the refrigerant flows in the electric power supply device 102 of
the second embodiment. FIG. 8 is a view of a situation where the refrigerant flows in
the first battery module 1 that constitutes the electric power supply device 102 in FIG. 7.

[0054] Compared to the above-described electric power supply device 100 of
the first embodiment, the electric power supply device 102 of the second embodiment
only differs in a supply direction of the refrigerant to each of the battery modules 1, 2 and
shapes of the refrigerant passages S3 in the partitioning member. Accordingly, the
following description will be made primarily on these differences. The same
components are denoted by the same reference numerals, and the description thereof will
not be made.

[0055] As shown in FIG. 7 and FIG. 8, in the electric power supply device 102
of the second embodiment, the refrigerant passage S3 that is formed between the single
batteries 10 of each of the battery modules 1, 2 is formed along the Y-direction. More
specifically, a partitioning member 30a that is used in the electric power supply device
100 has plural ribs 32e that extend in the Y-direction, and the refrigerant passage S3 is
formed between the adjacent ribs 32e along the Y-direction.

[0056] In addition, in the electric power supply device 102, the refrigerant
supply passage S2 is provided on the outer side of each of the first and second battery
modules 1, 2 in the Y-direction (that is, on an opposite side of the side on which the
battery modules 1, 2 face each other). This refrigerant supply passage S2 is formed by a
supply passage forming member 82 that is arranged between each of the first and second
battery modules 1, 2 and each of the side wall sections 58a, 58b of the case 50. One end
of the refrigerant supply passage S2 in the X-direction, to which the refrigerant supply
duct 60 is connected; is opened, and another end thereof is closed.

[0057] In the electric power supply device 102 configured as described above,
the refrigerant that is supplied from the refrigerant supply duct 60 to the refrigerant
supply passage S2 is introduced into the refrigerant passage S3 that is formed by the
partitioning member 30a between the single batteries 10 from a side surface on the outer
side in the Y-direction of each of the battery modules 1, 2 while flowing through the
refrigerant supply passage S2 of each of the battery modules 1, 2 in the X-direction. After flowing in the battery modules 1, 2 in opposite directions from each other along the Y-direction, the refrigerant is discharged from the discharge port 33 that is opened to the side surface on the inner side in the Y-direction of each of the battery modules 1, 2.

While flowing through the refrigerant passage S3 along the Y-direction, just as described, the refrigerant draws heat from each of the single batteries 10 that constitute the battery modules 1, 2 and thereby cools each of the single batteries 10.

[0058] The refrigerants that are discharged from the battery modules 1, 2 to the gap 3 between the battery modules 1, 2 are spouted while facing each other (in the completely opposite direction) and thus hit each other. This causes the pressure loss in the flow of the refrigerant with respect to each of the battery modules 1, 2. At this time, the pressure loss (the flow passage resistance) during the discharging of the refrigerant between the first and second battery modules 1, 2 is significant on the upstream side of the refrigerant supply passage S2. Thus, the flow amount of the refrigerant that flows into the refrigerant passage S3 between the single batteries 10 is suppressed. On the contrary, the flow amount of the refrigerant is increased by the suppressed flow amount in the refrigerant passage S3 that is located on the downstream side of the refrigerant supply passage S2. As a result, the flow amount of the refrigerant that is distributed to the refrigerant passages S3 between the single batteries 10 is equalized in the entire stacking direction, and thus the cooling performance for the single batteries 10 is substantially equalized. Thus, it is possible to suppress the fluctuations in the temperature of the single batteries 10 that constitute each of the battery modules 1, 2 provided in the electric power supply device 102.

[0059] In addition, in the electric power supply device 102 according to this embodiment, after the refrigerant that is discharged from each of the first and second battery modules 1, 2 spreads and is retained in the space 80a formed between the case 50 and each of the battery modules 1, 2, the refrigerant is discharged from the discharge port 59 (and 57) provided in the case 50. In this way, the space 80a, in which the refrigerant discharged from each of the battery modules 1, 2 is retained, a space 80c that is defined
and formed by the two coupling sections 42 and the bottom wall section 54 of the case 50 on the lower side of each of the battery modules 1, 2, the smoke discharge passage SI, and the space 80b that is provided between the upper surface of each of the battery modules 1, 2 and the upper wall section 52 of the case 50 and between the lower surface of each of the battery modules 1, 2 and the bottom wall section 54 of the case 50 each function as the air heat-insulating layer provided around each of the battery modules 1, 2. Accordingly, the fluctuations in the temperature among the single batteries 10 that constitute each of the battery modules 1, 2 is unlikely to occur by the thermal influence from the outside of the case 50.

[0060] FIG. 9 is a view of one example of a state that the above electric power supply device 100 is mounted in the vehicle. Here, a description will be made on the electric power supply device 100 of the first embodiment as an example. However, the same can be said for the electric power supply device 102 of the second embodiment.

[0061] The electric power supply device 100 is mounted on a floor panel 90 of a vehicle C in a state that the bottom wall section 54 of the case 50 faces the floor panel 90. In the example shown in FIG. 9, the electric power supply device 100 is installed on a lower side of a rear seat 92 in the vehicle C. Electric power is supplied to a motor M that is mounted in a front section of the vehicle via an electric power cable 94 that extends from the electric power supply device 100. Accordingly, the motor is driven, and power for running the vehicle can be obtained.

[0062] In the case of a hybrid vehicle including an engine that is an internal combustion engine as a power source in addition to the motor, there is a case where the engine is mounted together with the motor M in the front section of the vehicle and where an exhaust pipe that extends from the engine to a rear section of the vehicle runs on a lower side of the floor panel 90 and is connected to a muffler in the rear section of the vehicle. In this case, if the electric power supply device 100 mounted on the floor panel 90 receives a thermal influence of the exhaust pipe that reaches a high temperature, the temperature may fluctuate among the single batteries 10 that constitute the first and second battery modules 1, 2 provided in the electric power supply device 100.
Meanwhile, according to the electric power supply device 100 of this embodiment, the spaces 80a, 80b, in which the refrigerant is retained, and the refrigerant supply passage S2 on the lower side of each of the first and second battery modules 1, 2 each function as the air heat-insulating layer. Thus, it is possible to reduce an influence of heat that is received from heat generating components such as the exhaust pipe provided under the floor panel 90.

Noted that the electric power supply device according to the invention is not limited to the above-described embodiments and modifications thereof, but various modifications and improvements can be made within the scope of matters described in the claims of the subject application and equivalents thereof.

The above description has been made on the example in which the refrigerant is distributed in the T shape or linearly in the Y-direction within each of the battery modules 1, 2. However, the invention is not limited thereto. For example, it may be configured that the refrigerant passage that is formed by the ribs of the partitioning member is formed in an L shape, that the refrigerant is introduced into the refrigerant passage from the lower surface side or the upper surface side of each of the battery modules 1, 2, and that the refrigerant is discharged from each of the side surfaces that face each other in each of the battery modules 1, 2 after being curved in the L shape and flowing.

In addition, the above description has been made on the example in which the electric power supply device is mounted on the floor panel under the rear seat of the vehicle. However, the invention is not limited thereto. For example, the electric power supply device may be installed in an engine compartment, a trunk room, or the like of the vehicle.

Furthermore, the refrigerant that is supplied to the electric power supply device installed in the vehicle is preferably suctioned from the inside of a vehicle cabin and supplied to the electric power supply device. It is because a temperature in the vehicle cabin tends to fall within a temperature range that is suitable for cooling of the
battery modules that constitute the electric power supply device due to air conditioning such as cooling or heating.
CLAIMS

1. An electric power supply device comprising:
   a first battery module;
   a second battery module, the first battery module and the second battery module being each constructed by stacking plural batteries;
   a case including a discharge port and housing the first battery module and the second battery module; and
   a cooling structure including a first passage and a second passage, the cooling structure being configured to distribute a refrigerant from the first passage to the second passage so as to cool the batteries, the refrigerant being supplied from outside of the case, the first passage extending in a stacking direction of the batteries, and the second passage being a passage formed between the stacked batteries,
   wherein
   the first battery module and the second battery module are arranged such that at least a portion of the refrigerant discharged from the second passage of the first battery module and at least a portion of the refrigerant discharged from the second passage of the second battery module face and hit each other, and
   the refrigerant discharged from the first battery module and the second battery module spreads and is retained in a space formed between each of the battery modules and the case, and is then discharged from the discharge port.

2. The electric power supply device according to claim 1 wherein the refrigerant is introduced into the second passage from a lower surface side of each of the first battery module and the second battery module in a state that the electric power supply device is installed, flows along the second passage in a curved shape, and is then discharged from each of side surfaces that face each other in the first battery module and the second battery module.
3. The electric power supply device according to claim 1 or 2 wherein the electric power supply device is mounted in a vehicle, and a bottom section of the case is installed on a floor panel of the vehicle.
# INTERNATIONAL SEARCH REPORT

**PCT/IB2015/000817**

## A. CLASSIFICATION OF SUBJECT MATTER

INV. H01M10/613 H01M10/617 H01M10/6565 H01M10/6566 H01M10/647 H01M2/10

## ADD.

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)

H01M

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

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

EPO-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Relevant to claim No.</th>
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<td>JP 2011 044275 A (SANYO ELECTRIC CO) 3 March 2011 (2011-03-03) cited in the application abstract; figures 1-12</td>
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[X] Further documents are listed in the continuation of Box C.  
[X] See patent family annex.

* Special categories of cited documents:

  * "A" document defining the general state of the art which is not considered to be of particular relevance
  * "E" earlier application or patent but published on or after the international filing date
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Date of the actual completion of the international search: 5 August 2015

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<td>US 5589290 A</td>
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<td>DE 4407156 CI</td>
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<td>WO 2014087234 AI</td>
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