LAMINATION-TYPE COOLER

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ABSTRACT

A lamination-type cooler comprises: a plurality of cooling pipes for interposing and cooling electronic parts; and a pair of refrigerant headers respectively engaged with both end portions of the plurality of cooling pipes, for laminating and fixing the plurality of cooling pipes. Both end portions of a refrigerant passage formed in each cooling pipe are respectively communicated with header passages formed in the refrigerant headers. The cooling pipes are composed so that a plurality of electronic parts can be interposed between the cooling pipes being arranged in a line in a direction perpendicular to the laminating direction of the cooling pipes and also perpendicular to the passage forming direction of the refrigerant passage.
LAMINATION-TYPE COOLER

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a lamination-type cooler for cooling electronic parts from both sides.

[0003] 2. Description of the Related Art

[0004] There is provided a conventional lamination-type cooler 9 as shown in FIG. 36 in which a plurality of cooling pipes 92 are arranged to hold electronic parts 4 so that the electronic parts 4 can be cooled from both sides by the cooling pipes. Concerning this lamination-type cooler 9, refer to the official gazette of JP-A-2002-26215.

[0005] This lamination-type cooler 9 includes: a supply side refrigerant header 93A for supplying a refrigerant 5 to each cooling pipe 92; and a discharge side refrigerant header 93B for discharging the refrigerant 5 from each cooling pipe 92. Concerning the refrigerant passages 92I in a plurality of cooling pipes 92 which are arranged being laminated, one end of the refrigerant passage 92I is communicated with a header passage 93I in the supply side refrigerant header 93A, and the other end of the refrigerant passage 92I is communicated with the header passage 93I in the discharge side refrigerant header 93B.

[0006] However, in the above conventional lamination-type cooler 9, each electronic part 4 is interposed between the cooling pipes 92. Therefore, in the lamination-type cooler 9, in order to hold a larger number of electronic parts 4 while the cooling performance is maintained, it is necessary to increase the number of laminations of the cooling pipes 92. Accordingly, there is a possibility that the size of the lamination-type cooler 9 is increased in the laminating direction D.

SUMMARY OF THE INVENTION

[0007] The present invention has been accomplished to solve the above conventional problems. An object of the present invention is to provide a lamination-type cooler capable of holding a large number of electronic parts while the sizes in the passage forming direction and the laminating direction are maintained small and the cooling performance is maintained high.

[0008] In order to accomplish the above object, according to a first aspect of the present invention, there is provided a lamination-type cooler comprising:

[0009] a plurality of cooling pipes for interposing and cooling electronic parts; and

[0010] a pair of refrigerant headers respectively engaged with both end portions of the plurality of cooling pipes, for laminating and fixing the plurality of cooling pipes, wherein

[0011] both end portions of a refrigerant passage formed in each cooling pipe are respectively communicated with header passages formed in the refrigerant headers, and

[0012] the cooling pipes are composed so that a plurality of electronic parts can be interposed between the cooling pipes being arranged in a line in a direction perpendicular to the laminating direction of the cooling pipes and also perpendicular to the passage forming direction of the refrigerant passage.

[0013] In the lamination-type cooler of the present invention, electronic parts are cooled from both sides, and a plurality of cooling pipes interpose the electronic parts in such a manner that the electronic parts are arranged in a line in the perpendicular direction.

[0014] The cooling pipe may have a space, in which one electronic part can be arranged, in the passage forming direction. Therefore, the sizes of the cooling pipe and the lamination-type cooler in the passage forming direction can be maintained small. Concerning the cooling pipe, a plurality of electronic parts can be arranged in the perpendicular direction. Therefore, in the lamination-type cooler, it is unnecessary to increase the number of laminations of the cooling pipes in order to hold a larger number of electronic parts, and it is possible to reduce the size of the lamination-type cooler in the laminating direction.

[0015] When a plurality of electronic parts are interposed between the cooling pipes being arranged in a line in the perpendicular direction, the distances between a plurality of electronic parts, which are interposed between the cooling pipes, from the refrigerant header can be made to be substantially equal to each other. Therefore, refrigerant supplied to the cooling pipes from the refrigerant header can substantially uniformly cool the electronic parts interposed between the cooling pipes.

[0016] Therefore, according to the lamination-type cooler of the present invention, it is possible to maintain the sizes in the passage forming direction and the laminating direction small, and it is possible hold a large number of electronic parts while the cooling performance is maintained high.

[0017] In this connection, electronic parts are cooled by the above lamination-type cooler as follows.

[0018] In the case where the lamination-type cooler is used, refrigerant is supplied from a header passage of one refrigerant header into the refrigerant passage of each cooling pipe. When this refrigerant flows in each refrigerant passage, heat is exchanged between the refrigerant and the electronic parts, so that the electronic parts can be cooled. After that, the refrigerant, the temperature of which is raised by the heat exchange, is discharged from each refrigerant passage into the header passage of the other refrigerant header.

[0019] A preferred embodiment of the present invention described above will be explained below.

[0020] In the present invention, for example, an inverter element can be incorporated into the above electronic part. Especially, the electronic part can be a semiconductor module into which IGBT (electric power switching element) and FWD (diode element) are incorporated.

[0021] The semiconductor module used for an inverter may be an inverter used for an automobile, an inverter used for driving a motor of industrial equipment or an inverter used for an air conditioner in a building.

[0022] The electronic part can be a battery used for a hybrid electric vehicle (HEV) or an electric vehicle (EV). The electronic part can be a semiconductor which has not
been made into a module yet. For example, the electronic part can be a thyristor, power transistor, power FET and IGBT.

[0023] The refrigerant (cooling medium) made to flow in the cooling pipe can be water, to which an antifreeze solution of ethylene glycol is mixed, a natural refrigerant such as water or ammonium, a refrigerant of carbon fluoride such as Fluorinert (trademark), a refrigerant of CFC such as HCFC123 or HFC134a, a refrigerant of an alcohol such as methanol or alcohol and a refrigerant of a ketone such as acetone.

[0024] At both end portions of the cooling pipe in the passage forming direction, protruding pipe portions are respectively formed which protrude in the laminating direction. The protruding pipe portions of each cooling pipe are connected to the protruding pipe portions of the adjoining cooling pipes. It is preferable that the refrigerant header is formed out of the protruding pipe portions which are connected as described above.

[0025] In this case, it is unnecessary to compose the refrigerant header of another member different from the cooling pipe. Therefore, it is possible to reduce the number of parts of the lamination-type cooler. Further, it becomes easy to manufacture the lamination-type cooler.

[0026] According to a second aspect of the present invention, it is preferred that an overall length of the cooling pipe in the passage forming direction is not more than 100 mm.

[0027] In this case, it is possible to appropriately ensure a space, in which one electronic part can be arranged, in the passage forming direction of the cooling pipe. Accordingly, the sizes of the cooling pipe and the lamination-type cooler in the passage forming direction can be appropriately reduced.

[0028] When consideration is given to the size of one electronic part, an entire length of the cooling pipe in the passage forming direction can be not less than 50 mm.

[0029] According to a third aspect of the present invention, it is preferred that an inner fin, the cross section perpendicular to the passage forming direction of which is formed into a wave-form shape, is arranged inside the cooling pipe.

[0030] In this case, due to the inner fin, the cooling efficiency of the cooling pipe can be enhanced.

[0031] According to a fourth aspect of the present invention, it is preferred that a pitch of the wave-form shape of the inner fin is different in each portion of the inner fin.

[0032] In this case, the heat transfer performance in the cooling pipe can be made to be different in each portion in the perpendicular direction. That is, in a portion of the cooling pipe in the perpendicular direction, the heat transfer performance of which is to be enhanced, it is possible to reduce a pitch of the wave-form shape of the inner fins.

[0033] Therefore, for example, when a pitch of the wave-form shape of the inner fin opposed to a portion of each electronic part, the amount of heat generation of which is the largest, is minimized, each electronic part can be effectively cooled.

[0034] According to a fifth aspect of the present invention, it is preferred that a pitch of the wave-form shape of the inner fin is the smallest at a position opposed to an electronic part, the amount of heat generation of which is the largest, in the plurality of electronic parts.

[0035] In this case, an electronic part, the amount of heat generation of which is the largest, can be effectively cooled by a portion of the inner fin, the heat transfer performance of which is the highest.

[0036] According to a sixth aspect of the present invention, it is preferred that the refrigerant passage includes a plurality of divided refrigerant passage portions which are formed by being divided in the perpendicular direction corresponding to an arrangement number of arranging the electronic parts.

[0037] In this case, in the cooling pipe, the electronic part can be opposed to a division refrigerant passage section in which refrigerant flows, and a space formed between the electronic parts can be opposed to a division section which divides the division refrigerant passage sections from each other. Due to the above structure in the refrigerant pipe, refrigerant can be made to flow only in a portion opposed to each electronic part. Therefore, each electronic part can be effectively cooled.

[0038] According to a seventh aspect of the present invention, it is preferred that, in the pair of refrigerant headers, a plurality of supply side refrigerant headers for supplying refrigerant to the cooling pipes are arranged corresponding to a division number of the divided refrigerant passage portions.

[0039] In this case, division refrigerant passage sections can be communicated with header passages of the supply side refrigerant headers, and refrigerant can be separately supplied to the division refrigerant passage sections via the supply side refrigerant headers. Due to the above structure, for example, flow velocities of the refrigerant in the supply side refrigerant headers are made to be different from each other, so that the cooling performance of the division refrigerant passage section can be made to be different.

[0040] In this connection, when a plurality of header passages are formed being divided corresponding to the division number of the division refrigerant passage sections, a plurality of the supply side refrigerant headers can be arranged in the lamination-type cooler. In this case, the same operational effect can be provided.

[0041] According to an eighth aspect of the present invention, it is preferred that cross-sectional areas of the passages of the plurality of supply side refrigerant headers are different from each other.

[0042] In this case, flow rates of the refrigerant flowing in the header passages of the supply side refrigerant headers can be made to be different from each other. Therefore, flow rates of the refrigerant in the header passages of the supply side refrigerant headers, which are communicated with the division refrigerant passage section, can be made to be different from each other. Therefore, the cooling performance in each division refrigerant passage section can be simply made to be different from each other.

[0043] According to a ninth aspect of the present invention, it is preferred that a header passage of a supply side
refrigerant header in the plurality of supply side refrigerant headers, the passage cross-sectional area of which is the largest, is communicated with the divided refrigerant passage portion which is opposed to an electronic part, the amount of heat generation of which is the largest.

[0044] In this case, an electronic part, the amount of heat generation of which is the largest, can be effectively cooled by a supply side refrigerant header, the sectional area of the passage of which is the largest so that the flow rate of the refrigerant can be the highest.

[0045] According to a tenth aspect of the present invention, it is preferred that the plurality of supply side refrigerant headers branch from one refrigerant introducing pipe.

[0046] In this case, the refrigerant can be made to flow from one refrigerant introducing pipe into a plurality of supply side refrigerant headers being branched. When one refrigerant introducing pipe is connected to a refrigerant supply source arranged outside the lamination-type cooler, the refrigerant can be supplied to the supply side refrigerant headers. Therefore, a plurality of supply side headers can be arranged in the lamination-type cooler without deteriorating the connection property (the property of mounting the lamination-type cooler) to the refrigerant supply source.

[0047] According to an eleventh aspect of the present invention, it is preferred that the passage forming direction is directed in the perpendicular direction, and a supply side refrigerant header, which is in the pair of refrigerant headers, for supplying refrigerant to the cooling pipes is arranged being directed upward in the perpendicular direction.

[0048] In this case, the refrigerant can be made to flow in the gravity direction (the perpendicular direction) in the cooling pipes. Therefore, it is possible to effectively prevent air except for the refrigerant from staying in the cooling pipes.

[0049] According to a twelfth aspect of the present invention, it is preferred that a lamination-type cooler comprises:

[0050] a plurality of cooling pipes for interposing and cooling electronic parts, wherein

[0051] the plurality of cooling pipes are laminated on and fixed to each other by a refrigerant supply header for supplying refrigerant to the plurality of cooling pipes and by a refrigerant discharge header for discharging the refrigerant from the plurality of cooling pipes,

[0052] one of the refrigerant supply header and the refrigerant discharge header is arranged at both end portions of the plurality of cooling pipes in the refrigerant flowing direction and the other is arranged in an intermediate portion between both end portions in the refrigerant flowing direction, and

[0053] the plurality of cooling pipes interpose the electronic parts at positions between the refrigerant supply header and the refrigerant discharge header in the refrigerant flowing direction.

[0054] In the lamination-type cooler of the present invention, electronic parts are cooled from both sides. In the case where electronic parts, which are arranged in the refrigerant flowing direction, are interposed between a plurality of cooling pipes, it is devised so that the electronic parts can be cooled as uniformly as possible.

[0055] That is, one of the refrigerant supply header and the refrigerant discharge header is arranged at both end portions in the refrigerant flowing direction, and the other is arranged in an intermediate portion between both end portions in the refrigerant flowing direction. The electronic parts to be interposed between the cooling pipes are interposed at positions between the refrigerant supply header and the refrigerant discharge header in the refrigerant flowing direction. Therefore, it is possible to hold a plurality of electronic parts in the refrigerant flowing direction between the cooling pipes in such a manner that the plurality of electronic parts are arranged in the refrigerant flowing direction.

[0056] Due to the foregoing, in the lamination-type cooler, it is unnecessary to increase the number of laminations of the cooling pipes in order to hold a large number of electronic parts. Accordingly, the size of the lamination-type cooler in the laminating direction (the direction of laminating a plurality of cooling pipes) can be maintained small.

[0057] Due to the above structure of the refrigerant supply header and the refrigerant discharge header, distances between the electronic parts from the refrigerant supply header and the refrigerant discharge header can be made to be the substantially same. Therefore, the refrigerant supplied from the refrigerant supply header to the cooling pipes can flow from the intermediate portion of the refrigerant flowing direction to both end portions. Alternatively, the refrigerant supplied from the refrigerant supply header to the cooling pipes can flow from both end portions of the refrigerant flowing direction to the intermediate portion. Due to the foregoing, the electronic parts interposed between the cooling pipes can be substantially uniformly cooled.

[0058] Therefore, according to the lamination-type cooler of the present invention, it is possible to maintain the size in the laminating direction small. Further, while the cooling performance is maintained high, a large number of electronic parts can be held.

[0059] In this connection, the electronic parts are cooled by the above lamination-type cooler as follows.

[0060] In the case of using the lamination-type cooler, the refrigerant is supplied from the refrigerant supply header into the cooling pipes. When this refrigerant flows in the cooling pipes, heat is exchanged between the refrigerant and the electronic parts, and the electronic parts are cooled. After that, the refrigerant, the temperature of which has been raised by the heat exchange, is discharged from the cooling pipes into the refrigerant discharge header.

[0061] A preferred embodiment of the present invention described above will be explained below.

[0062] In the present invention, for example, an inverter element can be incorporated into the above electronic part. Especially, the electronic part can be a semiconductor module into which IGBT (electric power switching element) and FWD (diode element) are incorporated.

[0063] The semiconductor module used for an inverter may be an inverter used for an automobile, an inverter used for driving a motor of industrial equipment or an inverter used for an air conditioner for used for a building.

[0064] The electronic part can be a battery used for a hybrid electric vehicle (HEV) or an electric vehicle (EV). The electronic part can be a semiconductor which has not
been made into a module yet. For example, the electronic part can be a thyristor, power transistor, power FET and IGBT.

[0065] The refrigerant (cooling medium) made to flow in the cooling pipe can be water, to which an antifreeze solution of ethylene glycol is mixed, natural refrigerant such as water or ammonium, a refrigerant of carbon fluoride such as Fluorinert (trademark), a refrigerant of CFC such as HCFC123 or HFC134a, a refrigerant of an alcohol such as methanol or alcohol and a refrigerant of a ketone such as acetone.

[0066] The cooling pipes have protruding pipe portions, which are protruded in the laminating direction of the cooling pipes, in both end portions and the intermediate portion in the refrigerant flowing direction. The protruding pipe portion of each cooling pipe is connected to the protruding pipe portion of the adjoining cooling pipe. It is preferable that the refrigerant supply header and the refrigerant discharge header are formed out of the protruding pipe portions which are connected to each other as described above.

[0067] In this case, it is unnecessary that the refrigerant supply header and the refrigerant discharge header are respectively made of materials different from each other. Therefore, it is possible to reduce the number of parts of the lamination-type cooler. Further, the lamination-type cooler can be easily manufactured.

[0068] According to a thirteenth aspect of the present invention, a cross-sectional area of the passage of the refrigerant supply header and a cross-sectional area of the passage of the refrigerant discharge header can be different from each other.

[0069] In this case, a sectional area of the passage of one of the refrigerant supply header and the refrigerant discharge header arranged at both end portions of the cooling pipe in the refrigerant flowing direction is made smaller than a sectional area of the passage of the other of the refrigerant supply header and the refrigerant discharge header arranged at the intermediate portion of the cooling pipe in the refrigerant flowing direction. In this way, the refrigerant can be made to flow smoothly in the cooling pipes.

[0070] According to a fourteenth aspect of the present invention, it is preferred that an overall cross-sectional area of the passage of the refrigerant supply header and an overall cross-sectional area of the passage of the refrigerant discharge header are equal to each other.

[0071] In this case, the flow rate of the refrigerant supplied to each cooling pipe and the flow rate of the refrigerant discharge from each cooling pipe can be made to be substantially equal to each other. Therefore, it is possible to reduce the resistance of the refrigerant flowing in each cooling pipe. Therefore, it is possible to make the refrigerant flow more smoothly in each cooling pipe.

[0072] According to a fifteenth aspect of the present invention, it is preferred that a lamination-type cooler further comprises: one refrigerant inlet portion which is an inlet of refrigerant to the refrigerant supply header; and one refrigerant outlet portion which is an outlet of refrigerant from the refrigerant discharge header, wherein one of the refrigerant supply header and the refrigerant discharge header respectively arranged at both end portions in the refrigerant flowing direction is communicated with all of the plurality of cooling pipes, the other of the refrigerant supply header and the refrigerant discharge header arranged in an intermediate portion between both end portions in the refrigerant flowing direction is communicated with the cooling pipes except for one side end portion cooling pipe laminated at the end on one side of the plurality of cooling pipes, and one of the refrigerant inlet portion and the refrigerant outlet portion is communicated with the refrigerant supply header or the refrigerant discharge header arranged in an intermediate portion between both end portions in the refrigerant flowing direction.

[0073] In this case, in the above lamination-type cooler, the refrigerant can be supplied and discharged by one refrigerant inlet portion and one refrigerant outlet portion. One refrigerant inlet portion is connected to the supply side pipe of the refrigerant supply source, and one refrigerant outlet portion is connected to the return side pipe of the refrigerant supply source, so that the lamination-type cooler can be arranged in an arrangement space in a vehicle. Therefore, the property of mounting the lamination-type cooler (the property of connecting the lamination-type cooler to the refrigerant supply source) can be enhanced.

[0074] According to a sixteenth aspect of the present invention, it is preferred that a passage width in the perpendicular direction perpendicular to the refrigerant flowing direction of the refrigerant supply header and the refrigerant discharge header is larger than a passage width in the refrigerant flowing direction, and the plurality of cooling pipes interpose a plurality of electronic parts so that the plurality of electronic parts can be arranged in line in the refrigerant flowing direction and the perpendicular direction.

[0075] In this case, not only a plurality of electronic parts are interposed between the cooling pipes described above being arranged in the refrigerant flowing direction but also the plurality of electronic parts are interposed between the cooling pipes being arranged in the perpendicular direction. Due to the above structure, in the lamination-type cooler of the present invention, it is possible to maintain the size in the lamination direction small. Further, while the cooling performance is maintained high, a large number of electronic parts can be held. Due to the foregoing, while the number of electronic parts and the cooling performance are maintained, the size of the lamination-type cooler in the laminating direction can be reduced.

[0076] The present invention may be more fully understood from the description of preferred embodiments of the invention set forth below, together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0077] In the drawings:

[0078] FIG. 1 is a front view showing a lamination-type cooler of Embodiment 1;

[0079] FIG. 2 is a schematic plan view showing an arrangement of electronic parts in a cooling pipe of the lamination-type cooler of Embodiment 1;

[0080] FIG. 3 is a schematic sectional view showing a cooling pipe and electronic parts of the lamination-type cooler of Embodiment 1;
FIG. 4 is a schematic sectional view showing a refrigerant header of the lamination-type cooler of Embodiment 1;

FIG. 5 is a schematic sectional view showing a refrigerant header of the lamination-type cooler of Embodiment 1;

FIG. 6 is a schematic sectional view showing a cooling pipe and electronic parts of the lamination-type cooler of Embodiment 2;

FIG. 7 is a schematic plan view showing an arrangement of electronic parts in a cooling pipe of the lamination-type cooler of Embodiment 2;

FIG. 8 is a schematic sectional view showing a cooling pipe and electronic parts of the lamination-type cooler of Embodiment 3;

FIG. 9 is a schematic sectional view showing a cooling pipe and electronic parts of the lamination-type cooler of Embodiment 4;

FIG. 10 is a schematic sectional view showing a refrigerant header of the lamination-type cooler of Embodiment 5;

FIG. 11 is a schematic sectional view showing a refrigerant header of the lamination-type cooler of Embodiment 6;

FIG. 12 is a schematic sectional view showing a refrigerant header of the lamination-type cooler of Embodiment 7;

FIG. 13 is a schematic sectional view showing a refrigerant header of the lamination-type cooler of Embodiment 8;

FIG. 14 is a schematic sectional view showing a refrigerant header of the lamination-type cooler of Embodiment 9;

FIG. 15 is a front view showing a lamination-type cooler of Embodiment 10;

FIG. 16 is a front view showing a lamination-type cooler of Comparative Example;

FIG. 17 is a schematic plan view showing an arrangement of electronic parts in a cooling pipe of the lamination-type cooler of Comparative Example;

FIG. 18 is a front view showing a lamination-type cooler of Embodiment 11;

FIG. 19 is a schematic plan view showing an arrangement of electronic parts in a cooling pipe of the lamination-type cooler of Embodiment 11;

FIG. 20 is a schematic sectional view showing a cooling pipe and electronic parts of the lamination-type cooler of Embodiment 11;

FIG. 21 is a schematic sectional view showing a refrigerant header of the lamination-type cooler of Embodiment 11;

FIG. 22 is a schematic sectional view showing a refrigerant supply header and refrigerant discharge header of the lamination-type cooler of Embodiment 11;

FIG. 23 is a front view showing another lamination-type cooler of Embodiment 11;

FIG. 24 is a front view showing still another lamination-type cooler of Embodiment 11;

FIG. 25 is a front view showing still another lamination-type cooler of Embodiment 11;

FIG. 26 is a front view showing a lamination-type cooler of Embodiment 12;

FIG. 27 is a schematic plan view showing an arrangement of electronic parts in a cooling pipe of the lamination-type cooler of Embodiment 12;

FIG. 28 is a front view showing another lamination-type cooler of Embodiment 12;

FIG. 29 is a front view showing a lamination-type cooler of Embodiment 13;

FIG. 30 is a schematic plan view showing an arrangement of electronic parts in a cooling pipe of the lamination-type cooler of Embodiment 13;

FIG. 31 is a front view showing a lamination-type cooler of Embodiment 14;

FIG. 32 is a schematic sectional view showing a refrigerant supply header and refrigerant discharge header of the lamination-type cooler of Embodiment 14;

FIG. 33 is a front view showing another lamination-type cooler of Embodiment 14;

FIG. 34 is a front view showing a lamination-type cooler of Comparative Example;

FIG. 35 is a schematic plan view showing an arrangement of electronic parts in a cooling pipe of the lamination-type cooler of Comparative Example; and

FIG. 36 is a front view showing a lamination-type cooler of a Conventional Example.

DESCRIPTION OF PREFERRED EMBODIMENTS

Embodiments of the lamination-type cooler of the present invention will be explained below by referring to the accompanying drawings.

First of all, Embodiment 1 will be explained as follows. As shown in FIGS. 1 to 5, a lamination-type cooler 1 of this embodiment includes: a plurality of cooling pipes 2 between which electronic parts 4 are interposed so that they can be cooled; and a pair of refrigerant headers 3 which are respectively engaged with both end portions of the plurality of cooling pipes 2 so that the plurality of cooling pipes 2 can be laminated and fixed. Both end portions of a refrigerant passage 21, which is formed in each cooling pipe 2, are respectively communicated with header passages 31 which are formed in the refrigerant headers 3.

A plurality of cooling pipes 2 are held in the perpendicular direction W, which is perpendicular to the laminating direction D of the cooling pipes 2 and also perpendicular to the passage forming direction L of the refrigerant passage 21, under the condition that the electronic parts 5 are interposed between the cooling pipes being arranged in a line.
Referring to FIGS. 1 to 5, the lamination-type cooler I of this embodiment will be described in detail as follows.

FIG. 2 is a schematic plan view showing an arrangement of electronic parts 4 in the cooling pipe 2 of the lamination-type cooler I. FIGS. 3 and 4 are schematic sectional views showing the cooling pipes 2 and the electronic parts 4 with respect to a section perpendicular to the passage forming direction L in the lamination-type cooler I. FIG. 5 is a schematic sectional view showing the cooling pipes 2 and the electronic parts 4 with respect to a section parallel with the passage forming direction L in the lamination-type cooler I.

As shown in FIGS. 2 and 3, the cooling pipes 2 have arrangement spaces 20 in which the electronic parts 4 are arranged in a line in the perpendicular direction W. In this embodiment, between the cooling pipes 2, two electronic parts 4 are interposed in such a manner that the electronic parts 4 are arranged in a line in the perpendicular direction W. When the electronic parts 4 are interposed between the cooling pipes 2, both sides of the electronic parts 4 come into contact with the cooling pipes 2.

The lamination-type cooler I of this embodiment is used for an automobile. The electronic parts 4 of this embodiment compose a portion of an inverter for automobile use, that is, the electronic parts 4 of this embodiment are semiconductor modules into which IGBTs (electric power switching elements) 41 and FWDs (diode elements) 42 are incorporated. A cross section of each electronic part 4 is formed into a flat shape, and an overall shape of the electronic part 4 is formed into a rectangle, along the long side of which IGBTs 41 and FWD 42 are arranged.

Each electronic part 4 is arranged in such a manner that an arrangement portion of IGBT 41 is located on the upstream side of the refrigerant 5 in the passage forming direction L, and an arrangement portion of FWD 42 is located on the downstream side.

The electronic part 4 of this embodiment is directly contacted with the cooling pipe 2. Except for the direct contact of the electronic part 4 with the cooling pipe 2, the electronic part 4 can be contacted with the cooling pipe 2 via insulating material such as a ceramic plate or heat conductive grease.

As shown in FIG. 3, the cooling pipe 2 has a flat cross section which is formed flat in the laminating direction D. This cooling pipe 2 is composed in such a manner that a pair of outside plates 24, which are formed bent, are joined to each other and compose an outer portion of the cooling pipe. An intermediate plate 25 is interposed between the pair of outside plates 24. Between each outside plate 24 and the intermediate plate 25, an inner fin 26 is arranged, wherein a cross section of the inner fin 26 is in a direction perpendicular to the passage forming direction of the cooling pipe 2 and is formed into a wave-form shape.

The refrigerant passage 21 in the cooling pipe 2 is formed in such a manner that the passage formed between the outside plates 24 and the intermediate plate 25 is partitioned into a plurality of passages by the wave-form shape portions of the inner fin 26.

As shown in FIGS. 4 and 5, the cooling pipe 2 has protruding pipe portions 23 which are formed in such a manner that portions of the outside plate 24 at both end portions of the cooling pipe 2 in the passage forming direction L are protruded and deformed in the laminating direction D. These protruding pipe portions 23 are formed toward both sides in the laminating direction D. Each protruding pipe portion 23 includes; an inside protruding pipe portion 23A formed on one side in the laminating direction D; and an outside protruding pipe portion 23B formed on the other side in the laminating direction D. The inside protruding pipe portion 23A is formed into a shape which can be engaged with an end portion of the outside protruding pipe portion 23B.

The refrigerant header 3 of this embodiment is formed when the inside protruding pipe portion 23A, which is formed in the cooling pipe 2, is engaged with the outside protruding pipe portion 23B which is formed in the cooling pipe 2 adjacent to the aforementioned cooling pipe 2.

The lamination-type cooler 1 of this embodiment includes a large number of cooling pipes 2 which are laminated on and fixed to each other. The inside protruding pipe portion 23A of each cooling pipe 2 is engaged with the outside protruding pipe portion 23B of the cooling pipe 2 adjacent to the aforementioned cooling pipe 2, so that the refrigerant header 3 can be composed.

As shown in FIG. 1, one of the pair of refrigerant header 3 is a supply side refrigerant header 3A for supplying the refrigerant 5 to the plurality of cooling pipes 2, and the other of the pair of refrigerant header 3 is a discharge side refrigerant header 3B for discharging the refrigerant 5 from the plurality of cooling pipes 2.

When the lamination-type cooler 1 is arranged in an automobile, the supply side refrigerant header 3A is connected to a supply side pipe of the refrigerant supply source, and the discharge side refrigerant header 3B is connected to a return side pipe of the refrigerant supply source.

In one side end portion cooling pipe 2X, which is laminated at the end on one side of the plurality of cooling pipes 2, the protruding pipe portions 23 compose a refrigerant inlet portion 32 in the supply side refrigerant header 3A and a refrigerant outlet portion 33 in the discharge side refrigerant header 3B. In the other side end portion cooling pipe 2Y laminated at the end on the other side of the plurality of cooling pipes 2, the protruding pipe portion 23 is formed at only one side in the laminating direction D.

The lamination-type cooler 1 of this embodiment is assembled as follows. First, a plurality of cooling pipes 2 are connected to each other by the protruding pipe portions 23 so as to compose a temporarily assembled body. Next, the electronic parts 4 are arranged between the cooling pipes 2 in the temporarily assembled body. Then, the cooling pipes 2, which are located at both end portions in the laminating direction D, are pressed, that is, all the cooling pipes 2 are pressed so that they can be compressed in the laminating direction D. At this time, a diaphragm portion 231 located at a root portion of the outside protruding pipe portion 23B of each cooling pipe 2 is deformed, and the inside protruding pipe portion 23A and the outside protruding pipe portion 23B are engaged with each other. In this way, surfaces (both faces of the heat generating body) of each electronic part 4 can be closely contacted with a surface of each cooling pipe...
2. In this way, the lamination-type cooler 1 can be formed in which a plurality of electronic parts 4 are interposed between the cooling pipe 2.

[0132] The electronic parts 4 are cooled by the above lamination-type cooler 1 as follows.

[0133] At the time of cooling, the refrigerant 5 is supplied from the supply side pipe of the refrigerant supply source to the supply side header 3A. Then, the refrigerant 5 flows from the header passage 31 of the supply side refrigerant header 3A into the refrigerant passage 21 of each cooling pipe 2. When this refrigerant 5 flows in each refrigerant passage 21, heat exchange is conducted between the refrigerant 5 and each electronic part 4 so that the electronic part 4 can be cooled. After that, the refrigerant 5, the temperature of which is raised by this heat exchange, flows from each refrigerant passage 21 into the header passage 31 of the discharge side refrigerant header 3B. The refrigerant 5 is returned from the discharge side refrigerant header 3B to the return side pipe of the refrigerant supply source.

[0134] As described above, the cooling pipe 2 in the lamination-type cooler 1 of this embodiment holds two electronic parts 4 in such a manner that the electronic parts 4 are arranged in a line in the perpendicular direction W. It is sufficient that the cooling pipe 2 has an arrangement space 20, in which one electronic part 4 is accommodated, in the passage forming direction L. Therefore, the sizes of the cooling pipe 2 and the lamination-type cooler 1 in the passage forming direction L can be maintained small. Concerning the cooling pipe 2, it is possible to arrange electronic parts 4 in the perpendicular direction W. Therefore, it is unnecessary that the number of lamination layers of the cooling pipe 2 is increased in order to hold a large number of electronic parts 4. Accordingly, the size of the lamination-type cooler 1 in the laminating direction D can be maintained small.

[0135] When two electronic parts 4 are interposed between the cooling pipes 2 being arranged in a line in the perpendicular direction W, distances between a plurality of electronic parts 4, which are interposed between the cooling pipes 2, from the refrigerant header 3A can be made to be substantially equal to each other. Therefore, the refrigerant 5 is supplied to the cooling pipes 2 from the supply side refrigerant header 3A can substantially uniformly cool the electronic parts 4 interposed between the cooling pipes 2.

[0136] Therefore, according to the lamination-type cooler 1 of this embodiment, it is possible to maintain the sizes in the passage forming direction L and the laminating direction D small, and it is possible to hold a large number of electronic parts 4 while the cooling performance is maintained high.

[0137] In this connection, in the cooling pipe 2, the refrigerant 5, the temperature of which is low, flows at a high flow velocity in a portion close to the center of the cross section of the cooling pipe 2 perpendicular to the passage forming direction L, and the refrigerant 5, the temperature of which is high because the refrigerant 5 has received heat from the electronic part 4, flows at a low flow velocity. On the downstream side of the cooling pipe 2, the refrigerant 5 of high temperature flows in a wide range. Therefore, when a length of the cooling pipe 2 in the passage forming direction L is extended, there is a possibility that the electronic parts 4 can not be sufficiently cooled in a portion on the downstream side of the cooling pipe 2.

[0138] On the other hand, in the case of the cooling pipe 2 of this embodiment, only one electronic part 4 is arranged in the passage forming direction L. Further, the total length L0 shown in FIG. 2 in the passage forming direction L of the cooling pipe 2 of this embodiment is 100 mm which is small. Therefore, it is possible to extend a range, in which the refrigerant 5 of low temperature flows, on a cross section perpendicular to the passage forming direction L of the cooling pipe 2. Accordingly, the cooling effect of cooling the refrigerant by the lamination-type cooler 1 can be maintained high.

[0139] As the size of each cooling pipe 2 in the passage forming direction L is small, it is possible to reduce a distance between a pair of refrigerant headers 3. Therefore, a mechanical strength of the lamination-type cooler 1 can be enhanced.

[0140] Embodiment 2 will be explained below. In this embodiment, the pitch P of the wave-form shape of the inner fin 26 of the cooling pipe 2 is made to be different in each portion as shown in FIG. 6.

[0141] In this embodiment, as shown in FIG. 7, concerning the two electronic parts 4 interposed between the cooling pipes 2, two IGBT 41 are incorporated into one electronic part and two FWD 42 are incorporated into the other electronic part. A quantity of heat generation of the first electronic part 4A, into which IGBT 41 is incorporated, is larger than that of the second electronic part 4B, into which FWD 42 is incorporated.

[0142] As shown in FIG. 6, in the cooling pipe 2, the inner fin 26 is formed while the pitch P of the wave-form shape is changing stepwise. That is, the pitch P of the wave-form shape of the inner fin 26 of this embodiment changes substantially stepwise from one end to the other end in the perpendicular direction W.

[0143] In the inner fin 26, from an end portion on the arrangement space 20 side in which the first electronic part 4A having IGBT 41 is arranged, a small pitch wave-form portion 261, the wave-form shape pitch P of which is the smallest, a middle pitch wave-form portion 262 and a large pitch wave-form portion, the wave-form shape pitch P of which is the largest, are formed in order in the perpendicular direction W. In the inner fin 26, a heat transfer area of the small pitch wave-form portion 261 is the largest, a heat transfer area of the large pitch wave-form portion 263 is the smallest, and a heat transfer area of the middle pitch wave-form portion 262 is intermediate between them.

[0144] In this embodiment, when the pitch P of the wave-form shape of the inner fin 26 is made to be different in each portion, the heat transfer performance of the cooling pipe 2 can be made to be different in each portion in the perpendicular direction W.

[0145] When the small pitch wave-form portion 261 and the middle pitch wave-form portion 262 are opposed to the first electronic part 4A, the amount of heat generation of which is large, the first electronic part 4A can be effectively cooled. Therefore, the cooling efficiency of the entire electronic parts 4 can be enhanced.
Other points of this embodiment are the same as those of Embodiment 1 described before, and this embodiment can provide the same operational effect as that of Embodiment 1 described before.

Next, Embodiment 3 will be explained below. In this embodiment, as shown in FIG. 8, the refrigerant passage 21 of the cooling pipe 2 includes a plurality of divided refrigerant passage sections 22 which are formed by dividing the refrigerant passage 21 in the perpendicular direction corresponding to the number of arrangements of the electronic parts 4.

In this embodiment, two electronic parts 4 are interposed between the cooling pipes 2. IGBTs 41 and FWDs 42 are incorporated into these two electronic parts 4.

In this embodiment, the refrigerant passage 21 is divided into two. Between the two divided refrigerant passage sections 22, a division section 221 for dividing the two divided refrigerant passage sections 22 is formed.

In this embodiment, in the cooling pipe 2, each electronic part 4 can be opposed to the divided refrigerant passage 22 in which the refrigerant flows, and a space formed between the electronic parts 4 can be opposed to the division section 221. Therefore, in the cooling pipe 2 of this embodiment, the refrigerant 5 can be made to flow only in the portion opposed to each electronic part 4. Therefore, each electronic part 4 can be effectively cooled.

Other points of this embodiment are the same as those of Embodiment 1 described before, and this embodiment can provide the same operational effect as that of Embodiment 1 described before.

Next, Embodiment 4 will be explained below. In this embodiment, as shown in FIG. 9, in the two divided refrigerant passage sections 22 shown in Embodiment 3, the pitch P of the wave-form shape of the inner fin 26 of the second divided refrigerant passage section 22B is larger than the pitch P of the wave-form shape of the inner fin 26 of the first divided refrigerant passage section 22A.

That is, the first divided refrigerant passage section 22A includes the first inner fin 26A having a short pitch wave portion 261, and the second divided refrigerant passage section 22B includes the second inner fin 26B having a long pitch wave portion 263. A heat transfer area in the first divided refrigerant passage section 22A is larger then a heat transfer area in the second divided refrigerant passage section 22B.

Concerning the two electronic parts 4 in this embodiment, one of the two electronic parts 4 has two IGBTs 41, and the other has two FWDs 42. A quantity of heat generation of the first electronic part 4A, into which IGBT 41 is incorporated, is larger than the amount of heat generation of the second electronic part 4B, into which FWD 42 is incorporated.

In this embodiment, the first divided refrigerant passage section 22A is opposed to the first electronic part 4A, the amount of heat generation of which is larger, and the second divided refrigerant passage section 22B is opposed to the second electronic part 4B. Therefore, the first electronic part 4A can be effectively cooled, and the cooling efficiency of the entire electronic parts 4 can be enhanced.

Other points of this embodiment are the same as those of Embodiment 3 described before, and this embodiment can provide the same operational effect as that of Embodiment 3 described before.

Next, Embodiment 5 will be explained below. In this embodiment, as shown in FIG. 10, in the lamination-type cooler 1, two supply side refrigerant headers 3A, which are in the pair of refrigerant headers 3 described before, are arranged corresponding to the two divided refrigerant passage sections 22 shown in Embodiment 3 described above.

In this embodiment, in the lamination-type cooler 1, two discharge side refrigerant headers 3B are also arranged corresponding to the two divided refrigerant passage sections 22.

In this embodiment, the header passage 31 of one supply side refrigerant header 3A is communicated with one divided refrigerant passage section 22, and the header passage 31 of the other supply side refrigerant header 3A is communicated with the other divided refrigerant passage section 22. Due to this structure, the divided refrigerant passage sections 22 can be separately supplied with the refrigerant 5 via the supply side refrigerant headers 3A. Therefore, flow velocities of the refrigerant 5 in the header passages 31 in the supply side refrigerant headers 3A can be made different from each other, and the cooling performance of the divided refrigerant passage sections 22 can be made different from each other.

In this connection, concerning the supply side refrigerant header 3A and the discharge side refrigerant header 3B, a plurality of headers can be arranged in the lamination-type cooler 1 when the header passage 31 is formed being divided according to the division number of the divided refrigerant passages sections 22.

Other points of this embodiment are the same as those of Embodiment 3 described before, and this embodiment can provide the same operational effect as that of Embodiment 3 described before.

Next, Embodiment 6 will be explained below. In this embodiment, as shown in FIG. 11, the supply side refrigerant header 3A and the discharge side refrigerant header 3B are respectively separately communicated with the two divided refrigerant passage sections 22 (the two divided refrigerant passage sections 22, the wave-form shape pitches P in the inner fins 26 of which are different from each other) shown in Embodiment 4 described before.

Concerning the two electronic parts 4 in this embodiment, two IGBTs 41 are incorporated into the first electronic part 4A, and two FWDs 42 are incorporated into the second electronic part 4B. The first divided refrigerant passage section 22A, in which the first inner fin 26A having the small pitch wave-form section 261 is arranged, is opposed to the first electronic part 4A, the amount of heat generation of which is large, and the second divided refrigerant passage section 22B, in which the second inner fin 26B having the large pitch wave-form section 263 is arranged, is opposed to the second electronic part 4B, the amount of heat generation of which is small.

In this embodiment flow rates of the refrigerant 5 to be supplied to the supply side refrigerant headers 3A can be easily made to be different from each other. Therefore,
when the flow rate of the refrigerant 5 supplied to the first divided refrigerant passage sections 22A, the heat transfer area of which is large, is made to be higher than the flow rate of the refrigerant 5 supplied to the second divided refrigerant passage sections 22B, the heat transfer area of which is small, so that the first electronic part 4A arranged in the first divided refrigerant passage section 22A can be effectively cooled.

[0165] Other points of this embodiment are the same as those of Embodiment 4 described before, and this embodiment can provide the same operational effect as that of Embodiment 4 described before.

[0166] Next, Embodiment 7 will be explained below. In this embodiment, as shown in FIG. 12, sectional passage areas of the two supply side refrigerant headers 3A shown in Embodiment 5 described before are made to be different from each other.

[0167] In this embodiment, sectional passage areas of the two discharge side refrigerant headers 3B are made to be different from each other. In the two divided refrigerant passage sections 22, the inner fins 26, the pitches P of the wave-form shapes of which are the same, are respectively arranged.

[0168] Concerning the two electronic parts 4 in this embodiment, two IGBT 41 are incorporated into the first electronic part 4A, and two FWD 42 are incorporated into the second electronic part 4B.

[0169] A header passage 31 of the first supply side refrigerant header 3A, the sectional passage area of which is large, and a header passage 31 of the first discharge side refrigerant header 3B, are communicated with one divided refrigerant passage section 22 which is opposed to the first electronic part 4A, the amount of heat generation of which is large. A header passage 31 of the second discharge side refrigerant header 3B, the sectional passage area of which is small, and a header passage 31 of the second discharge side refrigerant header 3B, are communicated with the other divided refrigerant passage section 22 which is opposed to the second electronic part 4B, the amount of heat generation of which is small.

[0170] In this embodiment, flow rates of the refrigerant 5 to be supplied to the supply side refrigerant headers 3A can be easily made to be different from each other. Therefore, the flow rate of the refrigerant 5 supplied to one divided refrigerant passage section 22 opposed to the first electronic part 4A, the amount of heat generation of which is large, is made larger than the flow rate of the refrigerant 5 supplied to the other divided refrigerant passage section 22 opposed to the second electronic part 4B, the amount of heat generation of which is small, so that the first electronic part 4A can be effectively cooled.

[0171] Other points of this embodiment are the same as those of Embodiment 5 described before, and this embodiment can provide the same operational effect as that of Embodiment 5 described before.

[0172] Next, Embodiment 8 will be explained below. In this embodiment, as shown in FIG. 13, the header passages 31 to the first supply side refrigerant header 3A, and the second supply side refrigerant header 3A, respectively shown in Embodiment 7 (the two supply side refrigerant headers 3A, 3B, the sectional passage areas of which are different from each other) are communicated with the first divided refrigerant passage section 22A and the second divided refrigerant passage section 22B (the two divided refrigerant passage sections 22, the wave-form shape pitches P in the inner fins 26 of which are different from each other) shown in Embodiment 4 described before.

[0173] In this embodiment, the refrigerant 5 is supplied from the first supply side refrigerant header 3A to the first divided refrigerant passage section 22A opposed to the first electronic part 4A into which two IGBT 41 are incorporated, and the refrigerant 5 is supplied from the second supply side refrigerant header 3A to the second divided refrigerant passage section 22B opposed to the second electronic part 4B into which two FWD 42 are incorporated. Therefore, the first electronic part 4A, the amount of heat generation of which is large, can be effectively cooled by the first supply side refrigerant header 3A, the sectional passage area of the header passage 31 of which is large.

[0174] Other points of this embodiment are the same as those of Embodiments 4 and 7 described before, and this embodiment can provide the same operational effect as that of Embodiments 4 and 7 described before.

[0175] Next, Embodiment 9 will be explained below. As shown in FIG. 14, in this embodiment, one refrigerant introducing pipe 34 is branched into two supply side refrigerant headers 3A.

[0176] In this embodiment, one refrigerant discharge pipe 35 is branched into two discharge side refrigerant headers 3B. The cooling pipe 2 of this embodiment includes two divided refrigerant passage section 22. The supply side refrigerant header 3A and the discharge side refrigerant header 3B are respectively communicated with the divided refrigerant passage sections 22.

[0177] The refrigerant introducing pipe 34 and the refrigerant discharge pipe 35 of this embodiment are formed out of the protruding pipe portion 23 protruded from one side end portion cooling pipe 2 laminated at the end on side in the plurality of cooling pipes 2.

[0178] The refrigerant 5 supplied to the divided refrigerant passage section 22 in the plurality of cooling pipes 2 can flow from one refrigerant introducing pipe 34 to two supply side refrigerant headers 3A. The refrigerant 5, which has flowed in the divided refrigerant passage section 22 in the plurality of cooling pipes 2, can flow from the two discharge side refrigerant header 3B to one refrigerant discharge pipe 35 joined to each other.

[0179] In this embodiment, when one refrigerant introducing pipe 34 is connected to a supply side pipe of the refrigerant supply source which is arranged outside the lamination-type cooler 1, the refrigerant 5 can be supplied to the supply side refrigerant headers 3A. When one refrigerant discharge pipe 35 is connected to a return side pipe of the refrigerant supply source which is arranged outside the lamination-type cooler 1, the refrigerant 5 can be returned from the discharge side refrigerant header 3B to the refrigerant supply source.

[0180] Therefore, the plurality of supply side refrigerant headers 3A and discharge side refrigerant headers 3B can be arranged in the lamination-type cooler 1 without deteriorat-
ing the connection property (the mounting property of mounting the lamination-type cooler 1) to the refrigerant supply source.

[0181] Other points of this embodiment are the same as those of Embodiment 1 described before, and this embodiment can provide the same operational effect as that of Embodiment 1 described before.

[0182] Next, Embodiment 10 will be explained below. As shown in FIG. 15, in this embodiment, a direction of the lamination-type cooler 1 is devised at the time of arranging the lamination-type cooler 1 in an automobile.

[0183] The lamination-type cooler 1 of this embodiment is arranged in an automobile as follows. The passage forming direction L is directed to the gravity direction (the perpendicular direction), and the supply side refrigerant header 3A, which is in a pair of refrigerant headers 3, is directed upward in the perpendicular direction.

[0184] In this embodiment, the refrigerant 5 can be made to flow in the direction of gravity in each cooling pipe 2. Therefore, it is possible to effectively prevent air from staying in each cooling pipe 2.

[0185] Other points of this embodiment are the same as those of Embodiment 1 described before, and this embodiment can provide the same operational effect as that of Embodiment 1 described before.

[0186] In this connection, although not shown in the drawing, the first electronic part 4A, into which two IGBTs 41 shown in Embodiments 2, 4, 6, 7 and 8 are incorporated, and the second electronic part 4B, into which two FWDs 42 are incorporated, can be integrated with each other into one body by various semiconductor package materials. Two electronic parts 4 shown in Embodiments 1, 3 and 5, into which IGBTs 41 and FWDs 42 are incorporated, can be also integrated with each other into one body by various semiconductor package materials.

[0187] Next, a Comparative Example will be explained below. This Comparative Example is shown for reference. As shown in FIGS. 16 and 17, in the lamination-type cooler 1Z, a plurality of electronic parts 4 (two electronic parts in this example) are interposed between the cooling pipes in the passage forming direction L of the cooling pipes 2Z.

[0188] In this Comparative Example, distances between the two electronic parts 4, which are interposed between the cooling pipes 2Z, from the supply side header 3A are different from each other. Therefore, when the refrigerant 5 is supplied from the supply side header 3A to the cooling pipes 2Z, the first electronic part 4A, which is located on the upstream side in the passage forming direction L of the cooling pipe 2Z, can be effectively cooled by the refrigerant 5 of low temperature. On the other hand, the second electronic part 4B, which is located on the downstream side in the passage forming direction L of the cooling pipe 2Z, is cooled by the refrigerant 5, the temperature of which has been raised. Therefore, it is difficult to sufficiently cool the second electronic part 4B. Therefore, in this Comparative Example, it is difficult for the refrigerant 5, which has been supplied from the supply side header 93A into the cooling pipes 2, to uniformly cool the electronic parts interposed between the cooling pipes 2.

[0189] It is possible to consider an arrangement in which a plurality of electronic parts 4 are arranged in the passage forming direction L so as to increase the number of the electronic parts 4 to be held in the lamination-type cooler 1Z as described above. However, it should be understood that it is difficult to uniformly cool the electronic parts 4 by this structure.

[0190] Therefore, as shown in Embodiments 1 to 10, when a plurality of electronic parts 4 are interposed between the cooling pipes 2 being formed into a line in the perpendicular direction, it is possible to hold a large number of electronic parts 4 while the cooling performance is maintained high.

[0191] Next, Embodiment 11 will be explained below. As shown in FIGS. 18 to 22, in the lamination-type cooler 1 of this embodiment, the electronic parts 4 are cooled from both sides. Therefore, the lamination-type cooler 1 includes a plurality of cooling pipes 2 for holding and cooling the electronic parts 4. The plurality of cooling pipes 2 are laminated and fixed by the refrigerant supply header 3A for supplying the refrigerant 5 to the plurality of cooling pipes 2 and by the refrigerant discharge header 3B for discharging the refrigerant 5 from the plurality of cooling pipes 2.

[0192] The refrigerant discharge headers 3B are respectively arranged at both end portions of the plurality of cooling pipes 2 in the refrigerant flowing direction L. The refrigerant supply header 3A is arranged in a central portion which is an intermediate portion located between both end portions of the plurality of cooling pipes 2 in the refrigerant flowing direction L. The plurality of cooling pipes 2 are arranged so that the electronic parts 4 can be interposed between the plurality of cooling pipes 2 at positions between the refrigerant supply header 3A and the refrigerant discharge header 3B in the refrigerant flowing direction L.

[0193] Referring to FIGS. 18 to 11, the lamination-type cooler 1 of this embodiment will be explained in detail below.

[0194] In this case, FIG. 19 is a schematic plan view showing an arrangement of electronic parts 4 in a cooling pipe 2 of the lamination-type cooler 1. FIGS. 20 and 21 are sectional schematic illustrations showing a cross section perpendicular to the refrigerant flowing direction L in the lamination-type cooler 1 with respect to some of the cooling pipe 2 and the electronic parts 4. FIG. 22 is a sectional schematic illustration showing a cross section parallel with the refrigerant flowing direction L in the lamination-type cooler 1 with respect to some of the cooling pipe 2 and the electronic parts 4.

[0195] As shown in FIGS. 19 and 20, the cooling pipe 2 has a space 20 in which a plurality of electronic parts 4 are arranged in the refrigerant flowing direction L. In this embodiment, between the cooling pipes 2, two electronic parts 4 are interposed being arranged in the refrigerant flowing direction L. Two electronic parts 4 are arranged in the arrangement space 20 of the cooling pipe 2 in the direction L being arranged in a line. When the electronic parts 4 are interposed between the cooling pipes 2, both sides of the electronic parts 4 come into contact with the cooling pipes 2.

[0196] In each cooling pipe 2 of this embodiment, the refrigerant supply header 3A is arranged in the central portion in the refrigerant flowing direction L. One electronic
part 4 is held on each side of the refrigerant supply header 3A in the refrigerant flowing direction L. Due to this structure, distances between the electronic parts 4, which are interposed between the cooling pipes 2, from the refrigerant supply header 3A in the refrigerant flowing direction L can be the same. Further, distances between the electronic parts 4, which are interposed between the cooling pipes 2, from the refrigerant discharge header 3B in the refrigerant flowing direction L can be the same.

[0197] The lamination-type cooler 1 of this embodiment is used for an automobile. The electronic part 4 of this embodiment composes a portion of the inverter for automobile use. The electronic part 4 of this embodiment is a semiconductor module into which IGBTs (electric power switching elements) 41 and FWDs (diode elements) 42 are incorporated. This electronic part 4 has a flat cross section. This electronic part 4 is formed into a rectangle, along the long side of which IGBT 41 and FWD 42 are arranged.

[0198] In the arrangement space 20 of each cooling pipe 2, each electronic part 4 is arranged so that which IGBTs 41 and FWDs 42 can be arranged.

[0199] In this connection, as shown in FIG. 19, each electronic part 4 can be arranged in each cooling pipe 2 as follows. IGBT 41 is located on the upstream side (the side close to the refrigerant supply header 3A) of the flow of the refrigerant 5 in the refrigerant flowing direction L, and FWD 42 is located on the downstream side (the side close to the refrigerant discharge header 3B) of the flow of the refrigerant 5 in the refrigerant flowing direction L.

[0200] In this embodiment, each electronic part 4 is directly contacted with the cooling pipe 2. Except for that, the electronic part 4 can be contacted with the cooling pipe 2 via insulating material (ceramic plate) or heat conductive grease.

[0201] As shown in FIG. 20, the cooling pipe 2 has a flat cross section which is formed flat in the laminating direction D of a plurality of cooling pipes 2. In the cooling pipe 2, the refrigerant passage 21, in which the refrigerant 5 flows, is formed in the refrigerant flowing direction L. An outline portion of the pipe is formed in such a manner that a pair of outside plates 24, which are bent, are joined to each other. An intermediate plate 25 is interposed between the pair of outside plates 24. Between the outside plate 24 and the intermediate plate 25, an inner fin 26 is arranged, the cross section perpendicular to the refrigerant flowing direction L of which is formed into a wave-form shape.

[0202] The refrigerant passage 21 in the cooling pipe 2 is formed outside the plate 24 and the intermediate plate 25 being partitioned into a plurality of portions by the wave-form shape portion of the inner fin.

[0203] As shown in FIGS. 21 and 22, at both end portions and the central portion of the cooling pipe 2 in the refrigerant flowing direction L, the protruding pipe portions 23 are provided which are formed in such a manner that a portion of the outside plate 24 is protruded and deformed in the laminating direction D. These protruding pipe portions 23 are formed being directed to both sides of the laminating direction D. These protruding pipe portions 23 include: an inside protruding pipe portion 23A formed on one side of the laminating direction D; and an outside protruding pipe portion 23B formed on the other side of the laminating direction D. The inside protruding pipe portion 23A is formed into a shape which can be engaged into an end portion of the outside protruding pipe portion 23B.

[0204] The refrigerant supply header 3A and the refrigerant discharge header 3B of this embodiment are formed when the inside protruding pipe portion 23A formed in any cooling pipe 2 and the outside protruding pipe portion 23B formed in the cooling pipe 2 adjacent to any cooling pipe 2 are engaged with each other.

[0205] In the lamination-type cooler 1 of this embodiment, a large number of cooling pipes 2 are laminated on and fixed to each other. The inside protruding pipe portion 23A of each cooling pipe 2 is engaged with the outside protruding pipe portion 23B of the cooling pipe 2 adjacent to it, so that the refrigerant supply header 3A and the refrigerant discharge header 3B can be composed.

[0206] When the lamination-type cooler 1 is arranged in an automobile, the refrigerant supply header 3A is connected to a supply side pipe of the refrigerant supply source, and the refrigerant discharge header 3B is connected to a return side pipe of the refrigerant supply source.

[0207] As shown in FIG. 18, in one side end portion cooling pipe 2X which is laminated at the end portion on one side, the refrigerant inlet portion 32, which is an inlet of the refrigerant 5 to the refrigerant supply header 3A, and the refrigerant outlet portion 33, which is an outlet of the refrigerant 5 from the refrigerant discharge header 3B, are formed out of the protruding pipe portions 23. The lamination-type cooler 1 of this embodiment includes: one refrigerant inlet portion 32; and two refrigerant outlet portions 33. In the other side end portion cooling pipe 2Y in the plurality of cooling pipes 2 laminated at the end portion on the other side, the protruding pipe portion 23 is formed only onto one side of the laminating direction D.

[0208] As shown in FIG. 22, in the refrigerant supply header 3A and the refrigerant discharge header 3B, the header passages 31, in which the refrigerant 5 flows, are formed. The header passages 31 in the refrigerant supply header 3A and the refrigerant discharge header 3B are communicated with the refrigerant passages 21 in all the cooling pipes 2.

[0209] The lamination-type cooler 1 of this embodiment is assembled as follows. First of all, a plurality of cooling pipes 2 are connected to each other by the protruding pipe portions 23 so as to form a temporarily assembled body. Next, the electronic parts 4 are arranged between the cooling pipes 2 of the temporarily assembled body. Then, the temporarily assembled body is pressed from one side end portion cooling pipe 2X and the other side end portion cooling pipe 2Y which are respectively located at both end portions in the laminating direction D, and all the cooling pipes 2 are compressed in the laminating direction D. At this time, a diaphragm portion 231 located at the root portion of the outside protruding pipe portion 23B of each cooling pipe 2 is deformed, and the inside protruding pipe portion 23A and the outside protruding pipe portion 23B are engaged with each other. In this way, surfaces (both sides of the heat generating face) of the electronic parts 4 can be closely contacted with the surfaces of the cooling pipes 2, and the lamination-type cooler 1 can be composed, between the cooling pipes 2 of which a plurality of electronic parts 4 are interposed.
In the lamination-type cooler 1, the electronic parts 4 are cooled as follows.

At the time of cooling, the refrigerant 5 is supplied from the supply side pipe of the refrigerant supply source to the refrigerant supply header 3A via the refrigerant inlet portion 32. The refrigerant 5 flows into the refrigerant passage 21 of each cooling pipe 2 from the header passage 31 of the refrigerant supply header 3A. When this refrigerant 5 flows in each refrigerant passage 21, heat exchange is conducted between the refrigerant 5 and each electronic part 4, so that the electronic part 4 can be cooled. After that, the refrigerant 5, the temperature of which has been raised by the heat exchange, flows from each refrigerant passage 21 to the header passage 31 of the refrigerant discharge header 3B. The refrigerant 5 is returned from this refrigerant discharge header 3B to the return side pipe of the refrigerant supply source via the refrigerant outlet portion 33.

As described above, in the lamination-type cooler 1 of this embodiment, the refrigerant discharge headers 3B are respectively arranged at both end portions in the refrigerant flowing direction L, and the refrigerant supply header 3A is arranged at the central portion in the refrigerant flowing direction. The electronic parts 4 interposed between the cooling pipes 2 are interposed between the refrigerant supply header 3A and the refrigerant discharge header 3B in the refrigerant flowing direction L. Therefore, two electronic parts 4 can be interposed between the cooling pipes 2 being arranged in the refrigerant flowing direction L.

Due to the above structure, in the lamination-type cooler 1, it is unnecessary to increase the number of laminations of the cooling pipes 2 so as to hold a large number of electronic parts 4. Accordingly, it is possible to reduce the size of the lamination-type cooler 1 in the laminating direction D.

Due to the above structure of the refrigerant supply header 3A and the refrigerant discharge header 3B, the distances between the electronic parts 4, which are interposed between the cooling pipes 2, and the refrigerant supply header 3A and the refrigerant discharge header 3B, can be made substantially the same. Therefore, the refrigerant 5, which has been supplied from the refrigerant supply header 3A to the cooling pipes 2, can flow from the intermediate portion of the refrigerant flowing direction L to both end portions being branched. Due to the foregoing, the electronic parts interposed between the cooling pipes 2 can be substantially uniformly cooled.

Therefore, according to the lamination-type cooler 1 of this embodiment, it is possible to maintain the size of the laminating direction D small. Further, while the cooling performance is maintained high, a large number of electronic parts 4 can be held.

In this connection, in the cooling pipe 2, the refrigerant 5, the temperature of which is low, flows at a high flow velocity in a portion close to the center of the cross section of the cooling pipe 2 perpendicular to the refrigerant flowing direction L, and the refrigerant 5, the temperature of which is high because the refrigerant 5 has received heat from the electronic part 4, flows at a low flow velocity. On the downstream side of the cooling pipe 2, the refrigerant 5 of high temperature flows in a wide range. Therefore, when a length of the cooling pipe 2 in the refrigerant flowing direction L is extended, there is a possibility that the electronic parts 4 can not be sufficiently cooled in a portion on the downstream side of the cooling pipe 2.

In the cooling pipe 2 of this embodiment, the refrigerant supply header 3A is arranged in the central portion in the refrigerant flowing direction, so that a distance from the refrigerant supply header 3A to each electronic part 4 can be reduced. Therefore, on a cross section perpendicular to the refrigerant flowing direction L of the cooling pipe 2, it is possible to extend a range in which the refrigerant 5 of low temperature flows. Accordingly, the cooling effect obtained by the lamination-type cooler 1 can be maintained high.

As the refrigerant supply header 3A is arranged in the central portion in the refrigerant flowing direction L, it is possible to reduce a distance between the refrigerant supply header 3A, by which the cooling pipes 2 are laminated and fixed, and the refrigerant discharge header 3B. Therefore, it is possible to enhance a mechanical strength of the lamination-type cooler 1.

As described above, in the lamination-type cooler 1 of this embodiment, the refrigerant discharge headers 3B are arranged at both end portions of the cooling pipes 2 in the refrigerant flowing direction L, and the refrigerant supply header 3A is arranged in the central portion of the cooling pipes 2 in the refrigerant flowing direction L. Further, in one end portion cooling pipe 2X, the refrigerant inlet portion 32 in the refrigerant supply header 3A and the refrigerant outlet portion 33 in the refrigerant discharge header 3B are formed. Except for that, the lamination-type cooler 1 can be variously composed and the same operational effect as that Embodiment 1 described before can be provided.

That is, the lamination-type cooler 1 can be composed as follows. As shown in FIG. 23, the refrigerant supply headers 3A are arranged at both end portions of the cooling pipes 2 in the refrigerant flowing direction L, and the refrigerant discharge header 3B is arranged in the central portion of the cooling pipes 2 in the refrigerant flowing direction L. In one end portion cooling pipe 2X, the refrigerant inlet portion 32 in the refrigerant supply header 3A and the refrigerant outlet portion 33 in the refrigerant discharge header 3B can be formed.

Further, the lamination-type cooler 1 can be composed as follows. As shown in FIG. 24, the refrigerant discharge headers 3B are arranged at both end portions of the cooling pipes 2 in the refrigerant flowing direction L, and the refrigerant supply header 3A is arranged in the central portion of the cooling pipes 2 in the refrigerant flowing direction L. In one end portion cooling pipe 2X, the refrigerant outlet portion 33 in the refrigerant discharge header 3B can be formed, and in the other end portion cooling pipe 2Y, the refrigerant inlet portion 32 in the refrigerant supply header 3A can be formed.

Further, the lamination-type cooler 1 can be composed as follows. As shown in FIG. 25, the refrigerant supply headers 3A are arranged at both end portions of the cooling pipes 2 in the refrigerant flowing direction L, and the refrigerant discharge header 3B is arranged in the central portion of the cooling pipes 2 in the refrigerant flowing direction L. In one end portion cooling pipe 2X, the
refrigerant inlet portion 32 in the refrigerant supply header 3A is formed, and in the other side end portion cooling pipe 2Y, the refrigerant outlet portion 33 in the refrigerant discharge header 3B can be formed.

[0223] Next, Embodiment 12 will be explained below. In this embodiment, as shown in FIGS. 26 and 27, the overall passage sectional area of the refrigerant supply header 3A and the overall passage sectional area of the refrigerant discharge headers 3B are made to be equal to each other in the laminating-type cooler 1.

[0224] The laminating-type cooler 1 of this embodiment includes: refrigerant discharge headers 3B arranged at both end portions of the cooling pipes 2 in the refrigerant flowing direction L; and a refrigerant supply header 3A arranged in the central portion of the cooling pipe 2 in the refrigerant flowing direction L.

[0225] The passage sectional area S1 of the header passage 31 of the refrigerant supply header 3A and the passage sectional area S2 of the header passage 31 of the refrigerant discharge header 3B are different from each other. The passage sectional area S2 of the refrigerant discharge header 3B is half of the passage sectional area S1 of the refrigerant supply header 3A. The overall passage sectional area of the header passage 31 of one refrigerant supply header 3A and the overall passage sectional area (the total passage sectional area) of the header passage 31 of two refrigerant discharge headers 3B are the same (S1 = S2 x 2).

[0226] The electric parts 4 arranged between the cooling pipes 2 are the same. The passage sectional area S2 of the header passage 31 of one refrigerant discharge header 3B is the same as the passage sectional area S2 of the header passage 31 of the other refrigerant discharge header 3B.

[0227] In this embodiment, the flow rate of the refrigerant 5 supplied to each cooling pipe 2 can be made to be substantially the same as the flow rate of the refrigerant 5 discharged from each cooling pipe 2. Therefore, it is possible to reduce the resistance of the refrigerant 5 flowing in each cooling pipe 2, and it is possible to smooth the flow of the refrigerant 5 in each cooling pipe 2.

[0228] In this embodiment, in the above one side end portion cooling pipe 2X, the refrigerant inlet portion 32 in the refrigerant supply header 3A and the refrigerant outlet portions 33 in the refrigerant discharge header 3B are formed. On the other hand, in the same manner as that of Embodiment 11 described above, the refrigerant outlet portion 33 in the refrigerant discharge header 3B is formed in one side end portion cooling pipe 2X, and the refrigerant inlet portion 32 in the refrigerant supply header 3A is formed in the other side end portion cooling pipe 2Y.

[0229] In this embodiment, as shown in FIG. 28, the following structure can be adopted in the same manner as that of Embodiment 11. At both end portions of the cooling pipes 2 in the refrigerant flowing direction L, the refrigerant supply headers 3A are arranged, and the refrigerant discharge headers 3B are arranged in the central portion of the cooling pipes 2 in the refrigerant flowing direction L.

[0230] It is possible to make the passage sectional area S3 of the header passage 31 of the other refrigerant discharge header 3B smaller than the passage sectional area S2 of the header passage 31 of one refrigerant discharge header 3B. In this case, the first electronic part 4, the amount of heat generation of which is large, can be arranged between the refrigerant discharge header 3B, the passage cross sectional area S2 of which are large, and the refrigerant supply header 3A. Further, the second electronic part 4, the amount of heat generation of which is smaller than that of the first electronic part 4, can be arranged between the refrigerant discharge header 3B, the passage cross sectional area S1 of which are large, and the refrigerant supply header 3A. In this connection, the overall passage sectional area of the header passage 31 in one refrigerant supply header 3A can be made to be the same as the overall passage sectional area (the total passage sectional area) of the header passages 31 of two refrigerant discharge headers 3B (S1=S2+S3).

[0231] Other points of this embodiment are the same as those of Embodiment 11 described before, and this embodiment can provide the same operational effect as that of Embodiment 11 described before.

[0232] Next, Embodiment 13 will be explained below. The laminating-type cooler 1 of this embodiment is composed as follows. As shown in FIGS. 29 and 30, concerning the refrigerant supply header 3A and the refrigerant discharge header 3B, the passage width W1 in the perpendicular direction W, which is perpendicular to the refrigerant flowing direction L, is made larger than the passage width L1 in the refrigerant flowing direction L.

[0233] Two electronic parts 4 are arranged in the refrigerant flowing direction L, being interposed between a plurality of cooling pipes 2, and the two electronic parts 4 are arranged in the perpendicular direction W being interposed.

[0234] In this embodiment, between the cooling pipes 2, not only a plurality of electronic parts 4 can be arranged in the refrigerant flowing direction, and be interposed, but also a plurality of electronic parts 4 can be arranged in the perpendicular direction W, and be interposed. Due to this structure, it is possible to reduce the number of laminations of the cooling pipes 2 as shown in FIG. 29. The number of laminations of the cooling pipes 2 of this embodiment can be reduced to a half of the number of laminations of the cooling pipes 2 of the laminating-type cooler 1 of Embodiment 11. While the number of the electronic parts 4 to be held and the cooling performance are maintained as they are, the size in the laminating direction D can be reduced.

[0235] Other points of this embodiment are the same as those of Embodiment 11 described before, and this embodiment can provide the same operational effect as that of Embodiment 11 described before.

[0236] Next, Embodiment 14 will be explained below. As shown in FIGS. 31 and 32, the laminating-type cooler 1 of this embodiment includes: one refrigerant inlet portion 32 in the refrigerant supply header 3A; and one refrigerant outlet portion 33 in the refrigerant discharge header 3B.

[0237] In the laminating-type cooler 1 of this embodiment, the refrigerant header supply 3A is arranged in the central portion of each cooling pipe 2 in the refrigerant flowing direction L, and the refrigerant discharge headers 3B are arranged at both end portions of each cooling pipe 2 in the refrigerant flowing direction L as shown in Embodiments 11 to 13 described before.

[0238] The header passages 31 of the refrigerant discharge headers 3B, which are respectively arranged at both end
portions of the cooling pipes 2 in the refrigerant flowing direction, are communicated with all the refrigerant passages 21 of a plurality of cooling pipes 2. The header passage 31 in the refrigerant supply header 3A, which is arranged in the central portion of the cooling pipes 2 in the refrigerant flowing direction L, is communicated with the refrigerant passages 21 of the cooling pipes 2 except for one side end portion cooling pipe 2X which is laminated at the end of the plurality of cooling pipes 2 on one side.

[0239] In the accumulation type cooler 1, the refrigerant inlet portion 32 and the refrigerant outlet portion 33 are formed being protruded from one side of the plurality of cooling pipes 2 in the laminating direction D.

[0240] The header passage 31 of the refrigerant outlet portion 33 of the refrigerant discharge header 3B is communicated with (open to) the refrigerant passage 21 of one portion side end portion cooling pipe 2X. The refrigerant inlet portion 32 of the refrigerant supply header 3A is extended from the refrigerant supply header 3A communicated with the refrigerant passage 21 of the cooling pipe 2Z adjacent to one side end portion cooling pipe 2X.

[0241] The refrigerant outlet portion 33 is arranged at a position adjacent to the refrigerant inlet portion 32 of one side end portion cooling pipe 2X in the refrigerant flowing direction L.

[0242] In the lamination-type cooler 1 of this embodiment, the refrigerant 5 can be supplied and discharged by one refrigerant inlet portion 32 and one refrigerant outlet portion 33. One refrigerant inlet portion 32 is connected to a supply side pipe of the refrigerant supply source, and one refrigerant outlet portion 33 is connected to a return side pipe of the refrigerant supply source. In this way, the lamination-type cooler 1 can be arranged in an arrangement space provided in a vehicle. Therefore, the mounting property of mounting the lamination-type cooler 1 on the vehicle (the connecting property of connecting the lamination-type cooler 1 to the refrigerant supply source) can be enhanced.

[0243] In this connection, although not shown in the drawing, in the lamination-type cooler 1 in which the refrigerant discharge header 3B is arranged in the central portion of each cooling pipe 2 in the refrigerant flowing direction L and the refrigerant supply headers 3A are arranged at both end portions of each cooling pipe 2 in the refrigerant flowing direction L, the header passages 31 of the refrigerant supply headers 3A, which are respectively arranged at both end portions of the cooling pipe in the refrigerant flowing direction L, can be communicated with all the refrigerant passages 21 in the plurality of cooling pipes 2, and the header passage 31 of the refrigerant discharge header 3B, which is arranged at the central portion of the cooling pipe 2 in the refrigerant flowing direction L, can be communicated with the refrigerant passages 21 of the cooling pipes 2 except for one side end portion cooling pipe 2X.

[0244] In this connection, as shown in FIG. 33, in the lamination-type cooler 1 of this embodiment, the refrigerant inlet portion 32 can be formed being protruded from one side of the lamination-type cooler 1 in the laminating direction D, and the refrigerant outlet portion 33 can be formed being protruded from the other side of the lamination-type cooler 1 in the laminating direction D. In this case, the header passage 31 of the refrigerant outlet portion 33 of the refrigerant discharge header 3B can be communicated with (open to) the refrigerant passage 21 of one side end portion cooling pipe 2X, and the header passage 31 of the refrigerant inlet portion 32 of the refrigerant supply header 3A can be communicated with (open to) the refrigerant passage 21 of the other side end portion cooling pipe 2Y in the plurality of cooling pipes 2 laminated at the end portion on the other side.

[0245] Finally, Comparative Example will be explained below. This Comparative Example is shown for reference. This lamination-type cooler 1Z is composed as follows. As shown in FIGS. 34 and 35, between the refrigerant supply header 3A and the refrigerant discharge header 3B which are arranged between both end portions of the cooling pipes 2Z in the refrigerant flowing direction L, a plurality of electronic parts 4 (two electronic parts in this example) are interposed being arranged in the refrigerant flowing direction L. In this Comparative Example, the refrigerant supply header 3A and the refrigerant discharge header 3B are not arranged in an intermediate portion of the cooling pipe 2Z in the refrigerant flowing direction L.

[0246] In this Comparative Example, the distances between the two electronic parts 4, which are interposed between the cooling pipes 2Z, from the refrigerant supply header 3A, are different from each other. Therefore, when the refrigerant 5 is supplied from the refrigerant supply header 3A to each cooling pipe 2Z, the first electronic part 4A, which is located on the upstream side of the cooling pipe 2Z in the refrigerant flowing direction L, can be effectively cooled by the refrigerant 5 of low temperature. On the other hand, the second electronic part 4B, which is located on the downstream side of the cooling pipe 2Z in the refrigerant flowing direction L, is cooled by the refrigerant 5 of high temperature. Accordingly, there is a possibility that the second electronic part 4B cannot be sufficiently cooled. Therefore, in this Comparative Example, the refrigerant 5 supplied from the refrigerant supply header 93A to each cooling pipe 2Z cannot uniformly cool the electronic parts 4 interposed between the cooling pipes 2Z.

[0247] As described above, in the lamination-type cooler 1Z in which the refrigerant supply header 3A or the refrigerant discharge header 3B is not arranged in the intermediate portion of the cooling pipe 2Z in the refrigerant flowing direction L., it is difficult for the electronic parts 4 to be uniformly cooled.

[0248] Therefore, as shown in Embodiments 11 to 14, in the lamination-type cooler 1 in which the refrigerant supply header 3A or the refrigerant discharge header 3B is arranged in the intermediate portion of the cooling pipe 2 in the refrigerant flowing direction L., a large number of electronic parts 4 can be held while the cooling performance is held high.

[0249] While the invention has been described by reference to specific embodiments chosen for purposes of illustration, it should be apparent that numerous modifications could be made thereto, by those skilled in the art, without departing from the basic concept and scope of the invention.

1. A lamination-type cooler comprising:
   a plurality of cooling pipes for interposing and cooling electronic parts; and
a pair of refrigerant headers respectively engaged with both end portions of the plurality of cooling pipes, for laminating and fixing the plurality of cooling pipes, wherein

both end portions of a refrigerant passage formed in each cooling pipe are respectively communicated with header passages formed in the refrigerant headers, and

the cooling pipes are composed so that a plurality of electronic parts can be interposed between the cooling pipes being arranged in a line in a direction perpendicular to the laminating direction of the cooling pipes and also perpendicular to the passage forming direction of the refrigerant passage.

2. A lamination-type cooler according to claim 1, wherein an overall length of the cooling pipe in the passage forming direction is not more than 100 mm.

3. A lamination-type cooler according to claim 1, wherein an inner fin, the cross section perpendicular to the passage forming direction of which is formed into a wave-form shape, is arranged inside the cooling pipe.

4. A lamination-type cooler according to claim 3, wherein a pitch of the wave-form shape of the inner fin is different in each portion of the inner fin.

5. A lamination-type cooler according to claim 4, wherein a pitch of the wave-form shape of the inner fin is the smallest at a position opposed to an electronic part, the amount of heat generation of which is the largest, in the plurality of electronic parts.

6. A lamination-type cooler according to one of claims 1, wherein the refrigerant passage includes a plurality of divided refrigerant passage portions which are formed by being divided in the perpendicular direction corresponding to an arrangement number of arranging the electronic parts.

7. A lamination-type cooler according to claim 6, wherein, in the pair of refrigerant headers, a plurality of supply side refrigerant headers for supplying refrigerant to the cooling pipes are arranged corresponding to a division number of the divided refrigerant passage portions.

8. A lamination-type cooler according to claim 7, wherein cross-sectional areas of the passages of the plurality of supply side refrigerant headers are different from each other.

9. A lamination-type cooler according to claim 8, wherein a header passage of a supply side refrigerant header in the plurality of supply side refrigerant headers, the passage cross-sectional area of which is the largest, is communicated with the divided refrigerant passage portion which is opposed to an electronic part, the amount of heat generation of which the largest.

10. A lamination-type cooler according to one of claims 7, wherein the plurality of supply side refrigerant headers branch from one refrigerant introducing pipe.

11. A lamination-type cooler according to one of claims 1, wherein the passage forming direction is directed in the perpendicular direction, and a supply side refrigerant header, which is in the pair of refrigerant headers, for supplying refrigerant to the cooling pipe is arranged being directed upward in the perpendicular direction.

12. A lamination-type cooler comprising:

- a plurality of cooling pipes for interposing and cooling electronic parts, wherein

the plurality of cooling pipes are laminated on and fixed to each other by a refrigerant supply header for supplying refrigerant to the plurality of cooling pipes and by a refrigerant discharge header for discharging the refrigerant from the plurality of cooling pipes,

one of the refrigerant supply header and the refrigerant discharge header is arranged at both end portions of the plurality of cooling pipes in the refrigerant flowing direction and the other is arranged in an intermediate portion between both end portions in the refrigerant flowing direction, and

the plurality of cooling pipes interpose the electronic parts at positions between the refrigerant supply header and the refrigerant discharge header in the refrigerant flowing direction.

13. A lamination-type cooler according to claim 12, wherein a cross-sectional area of the passage of the refrigerant supply header and a cross-sectional area of the passage of the refrigerant discharge header are different from each other.

14. A lamination-type cooler according to claim 12, wherein an overall cross-sectional area of the passage of the refrigerant supply header and an overall cross-sectional area of the passage of the refrigerant discharge header are equal to each other.

15. A lamination-type cooler according to one of claims 12, further comprising: one refrigerant inlet portion which is an inlet of refrigerant to the refrigerant supply header; and one refrigerant outlet portion which is an outlet of refrigerant from the refrigerant discharge header, wherein

one of the refrigerant supply header and the refrigerant discharge header respectively arranged at both end portions in the refrigerant flowing direction is communicated with all of the plurality of cooling pipes,

the other of the refrigerant supply header and the refrigerant discharge header arranged in an intermediate portion between both end portions in the refrigerant flowing direction is communicated with the cooling pipes except for one side end portion cooling pipe laminated at the end on one side of the plurality of cooling pipes, and

one of the refrigerant inlet portion and the refrigerant outlet portion is communicated with one side end portion cooling pipe and the other is communicated with the refrigerant supply header or the refrigerant discharge header arranged in an intermediate portion between both end portions in the refrigerant flowing direction.

16. A lamination-type cooler according to one of claims 12, wherein a passage width in the perpendicular direction perpendicular to the refrigerant flowing direction of the refrigerant supply header and the refrigerant discharge header is larger than a passage width in the refrigerant flowing direction, and

the plurality of cooling pipes interpose a plurality of electronic parts so that the plurality of electronic parts can be arranged in line in the refrigerant flowing direction and the perpendicular direction.