



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
18.03.2009 Bulletin 2009/12

(51) Int Cl.:
F28D 1/04 (2006.01)

(21) Application number: **08252901.7**

(22) Date of filing: **01.09.2008**

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

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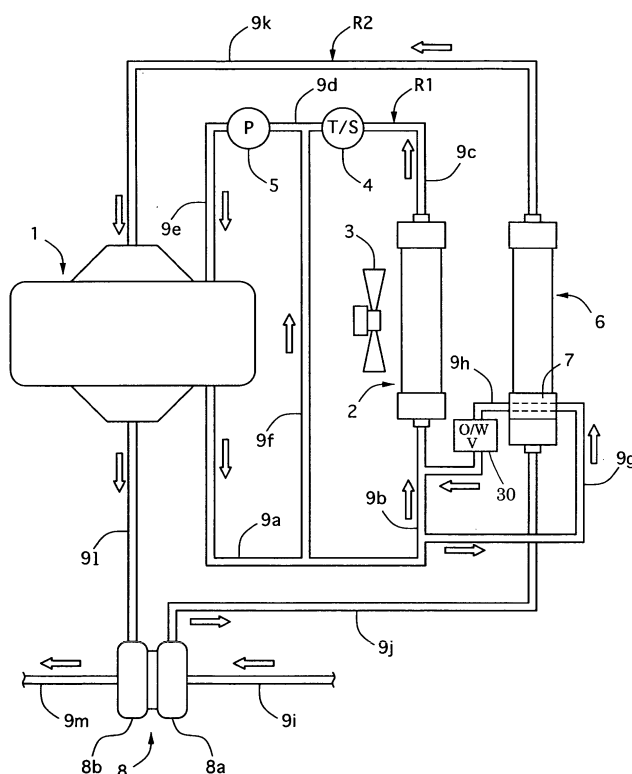
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(54) **Composite heat exchanger**

(57) A composite heat exchanger includes a first heat exchanger (6) and a case (7). The first heat exchanger (6) has a pair of tanks (10a, 10b) being apart from each other and a plurality of tubes (11; 11a, 11b) both end portions of which are connected with the tanks (10a, 10b), respectively so that a fluid is cooled by airflow when the

fluid is passing through the tubes (11; 11a, 11b). The case (7) surrounds portions of the tubes (11; 11a, 11b) and is provided with an inlet port (P3) and an outlet port (P4) which flow a cooling medium whose temperature is lower than a temperature of the fluid to enter the tubes (11; 11a, 11b).

FIG. 1



Description

[0001] The present invention relates to a composite heat exchanger that can cool a cooling medium in two stages.

[0002] Some of motor vehicles carry an engine with a turbocharger to force an additional amount of air or air-fuel mixture into the engine for increasing combustion pressure and engine output power. The turbocharger compresses the air, which decreases the engine output power due to the hot air. In order to cool the hot air and increase its density, the turbocharger is provided with an air-cooled intercooler, which is disclosed in Japanese Patent Applications Laid-Open Publication NO. 11 - 280479 and 2006 - 336890. Such an intercooler uses a heat exchanger disclosed in Japanese Patent Applications Laid-Open Publication NO. 2006 - 189181. The conventional heat exchanger of the intercooler has a pair of tanks located apart from each other and a core part having a plurality of tubes whose both end portions are respectively connected with the tanks, where a coolant in the tubes are cooled by ram airflow generated when a motor vehicle is running and/or airflow generated by a motor fan.

[0003] However, in the above known conventional heat exchanger, there are problems in that the heat exchanger becomes larger in dimensions because it needs to improve its coolability according to the increase in output power of recent engines and that the number of additional parts increases especially in a coolant system for engines with a turbo-charger. On the other hand, engine compartments have decreased in space because passenger compartment spaces are set to be enlarged.

[0004] The present invention seeks to provide a composite heat exchanger which overcomes the foregoing drawbacks and can improve its coolability, suppressing its dimensions and the number of additional parts.

[0005] According to an aspect of the present invention there is provided a composite heat exchanger including a first heat exchanger and a case. The first heat exchanger has a pair of tanks being apart from each other and a plurality of tubes both end portions of which are connected with the tanks, respectively so that a fluid is cooled by airflow when the fluid is passing through the tubes. The case surrounds portions of the tubes and is provided with an inlet port and an outlet port which flow a cooling medium whose temperature is lower than a temperature of the fluid to enter the tubes.

[0006] Therefore, the first heat exchanger of the present invention can improve its coolability by using the case and the first heat exchanger, suppressing its dimensions and the number of additional parts.

[0007] Preferably, the portions of the tubes which are surrounded by the case are upstream side portions of the tubes.

[0008] Therefore, the upstream side portions, where the hottest intake air flows in the tubes, are cooled by the cooling medium flowing through the case, so that thermal

stress in connecting portions of the upstream side portions and the case can be decreased.

[0009] Preferably, the case and the tank are integrally formed with each other.

5 **[0010]** Therefore, the number of parts of the composite heat exchanger can be decreased.

[0011] Preferably, the tubes have fins between portions thereof except portions inserted into the tanks.

10 **[0012]** Therefore, the fins, the tubes and the case can be easily assembled with one another, reducing a material cost.

[0013] Preferably, the case has a partition plate for preventing the cooling medium from unevenly flowing between the tubes in the case.

15 **[0014]** Therefore, the hot intake air can be efficiently cooled by the cooling medium.

[0015] Preferably, the cooling medium flows through a second heat exchanger, having a tank, where the cooling medium flows in the lateral direction in a core part thereof. The composite heat exchanger is mounted on a motor vehicle so that the pair of tanks is arranged in a lateral direction of the motor vehicle, and the case and the tank of the second heat exchanger are overlapped with each other in the lateral direction.

25 **[0016]** This arrangement can make efficient utilization of a dead space in front of the tank of the second heat exchanger.

30 **[0017]** Preferably, the first heat exchanger is an intercooler, the fluid is an intake air supplied to the intercooler, the second heat exchanger is a radiator, and the cooling medium is a coolant circulating in an engine cooling circuit.

35 **[0018]** The composite heat exchanger is suitable for motor vehicles with an intercooler because of its compact size and high coolability.

[0019] The objects, features and advantages of the present invention will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

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FIG. 1 is a schematic diagram showing an internal combustion engine and a cooling system consisting of an engine cooling system and a turbocharger gas cooling system, where the turbocharger gas cooling system has a composite heat exchanger of a first embodiment according to the present invention;

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FIG. 2 is a rear view showing the composite heat exchanger of the first embodiment;

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FIG. 3 is a plain view showing the composite heat exchanger of the first embodiment and a radiator which is used for the engine cooling system;

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FIG. 4 is an enlarged cross sectional view showing a part of the composite heat exchanger of the first embodiment;

FIG. 5 is an enlarged cross sectional view showing the composite heat exchanger of the first embodiment, taken along a line S5 - S5 in FIG. 4;

FIG. 6 is a perspective view explaining a first manufacturing process of the composite heat exchanger of the first embodiment, and showing parts, although some of the parts are omitted, of the composite heat exchanger of the first embodiment;

FIG. 7 is a perspective view explaining a second manufacturing process of the heat exchanger of the first embodiment, and showing the parts, showing parts, although some of the parts are omitted, of the heat exchanger of the first embodiment;

FIG. 8 is a perspective view explaining a third manufacturing process of the composite heat exchanger of the first embodiment, and showing the parts, showing parts, although some of the parts are omitted, of the composite heat exchanger of the first embodiment;

FIG. 9 is a perspective view explaining a fourth manufacturing process of the composite heat exchanger of the first embodiment, and showing the parts, showing parts, although some of the parts are omitted, of the heat composite exchanger of the first embodiment ;and

FIG. 10 is a perspective view showing a core part and a main case body of a composite heat exchanger of a second embodiment according to the present invention.

[0020] Throughout the following detailed description, similar reference characters and numbers refer to similar elements in all figures of the drawings, and their descriptions are omitted for eliminating duplication.

[0021] In the accompanying drawings, "FW" indicates a forward direction and "RW" indicates a rearward direction when a composite heat exchanger is mounted on a motor vehicle.

[0022] Referring to FIG. 1 of the drawings, there is shown an internal combustion engine 1 and a cooling system consisting of an engine cooling system and a turbocharger gas cooling system. The turbocharger gas cooling system has an intercooler 6 functioning as a first heat exchanger of a first preferred embodiment according to the present invention.

[0023] The cooling system is mounted on the motor vehicle equipped with the internal combustion engine 1 with a turbocharger 8.

[0024] The engine cooling system includes a radiator 2 and an engine cooling circuit R1. The engine cooling circuit R1 is fluidically connecting with a not-shown water jacket formed in the engine 1 and the radiator 2. Note that the radiator 2 functions as a second heat exchanger.

[0025] The radiator 2 is a conventional one, and, as shown in FIG. 3, it has a core part 2a and a pair of tanks 2b and 2c, where the core part 2a includes a plurality of tubes and fins. The radiator 2 is arranged behind the intercooler 6, and the tank 2b (an upstream side tank) is overlapped with a case 7 attached to the intercooler 6 in a lateral direction of the motor vehicle when they are mounted thereon.

[0026] The case 7 and the intercooler 6 correspond to a composite heat exchanger of the first embodiment of the present invention.

[0027] The engine cooling circuit 2 has first to sixth tubes 9a to 9f, where the first and second tubes 9a and 9b fluidically connect the water jacket of the engine 1 and an inlet port of the radiator 2 with each other, the third tube 9c fluidically connects an outlet port of the radiator 2 and a thermostat 4 with each other, the fourth tube 9d fluidically connects the thermostat 4 and an inlet port of a water pump 5 with each other, the fifth tube 9e fluidically connects an outlet port of the water pump and the water jacket of the engine with each other, and the sixth tube 9f fluidically connects (i.e. is in fluid connection with) an intermediate portion of the fourth tube 9d and a connection portion of the first and second tubes 9a and 9b.

[0028] A coolant, which is discharged from the water jacket of the engine 1 at a temperature of approximately 80 °C, is introduced through the first and second tubes 9a and 9b to the inlet port of the radiator 2. The radiator 2 cools the coolant to a temperature of approximately 60 °C by using a ram airflow generated when the motor vehicle is running and/or an airflow generated by a motor fan 3. The cooled coolant is discharged from the radiator 2, and then is absorbed by the water pump 5 through the third tube 9c, the thermostat 4 and the fourth tube 9d. The water pump 5 pressures the coolant to be supplied to the water jacket of engine 1 through the fifth tube 9e, thus circulating the coolant in the engine cooling circuit R1.

[0029] The thermostat 4 closes its not-shown valve when the temperature of the coolant is low, so that the coolant is prevented from passing through the radiator 2, thereby circulating only between the engine 1 and the water pump 5 through the first tube 9a, the sixth tube 9f, a downstream portion of the fourth tube 5d, the water pump 5 and the fifth tube 9e. When the temperature thereof is high, the thermostat 4 opens the valve, so that the coolant circulates mainly between the engine 1 and the radiator 2 through the first to fifth tubes 9a to 9e, and also between the engine 1 and the water pump 5 through the first, sixth, fourth and fifth tubes 9a, 9f, 9d and 9e.

[0030] A part of the coolant in the second tube 9b is separated from that flowing in the second tube 9b, being introduced to an inlet port P3, shown in FIG. 2, of the case 7 attached with the intercooler 6 through a seventh tube 9g. Then the coolant in the case 7 is discharged from an outlet port P4, shown in FIGS. 2 and 3, of the intercooler 6 to the second tube 9b through an eighth tube 9h, where the eighth tube 9h is fluidically connected

with the second tube 9b at its downstream side portion of a connected portion of the second tube 9b and the seventh tube 9g.

[0031] The eighth tube 9h is provided at its intermediate portion with a one-way valve 30 for preventing the coolant from flowing back from a second-tube side of the eighth tube 9h toward the case side thereof. The seventh and eighth tubes 9g and 9h are used for cooling an intake air passing through the intercooler 6, and accordingly they also belong to the turbocharger gas cooling circuit R2, although they also belong to the engine cooling circuit R1 because of the fluid connection with the tubes of the engine cooling circuit R1.

[0032] The coolant corresponds to a cooling medium of the first embodiment of the present invention, and the intake air corresponds to a fluid of the first embodiment of the present invention.

[0033] The turbocharger gas cooling system includes the intercooler 6 and a turbocharger gas cooling circuit R2.

[0034] The turbocharger 8 has a compressor 8a and a turbine receiving exhaust gas discharged from the engine 1 and driving the compressor 8a. The compressor 8a pressurizes the intake air entered through a ninth tube 9i connected with a not-shown air cleaner. The turbine 8b is connected with the compressor 8a, connecting with an exhaust manifold of the engine 1 through a twelfth tube 9l to receive by the exhaust gas and with a thirteenth tube 9m to discharge the exhaust gas to the atmosphere.

[0035] The turbocharger gas cooling circuit R2 has a tenth tube 9i and an eleventh tube 9k, where the tenth tube 9i fluidically connects the compressor 8a of the turbocharger 8 and an inlet port P1 of the case 7 attached to the intercooler 6 with each other, and the eleventh tube 9k fluidically connects an outlet port P2 of the intercooler 6 and an intake manifold of the engine 1 with each other.

[0036] The intake air introduced through the air cleaner and the ninth tube 9i is pressurized by the compressor 8a, thus increasing a temperature up to approximately 180 °C. This pressurized high-temperature intake air flows into the case 7, where it is cooled due to heat transfer between the intake air and the coolant flowing through the seventh and eighth tubes 9g and 9h to circulate in the engine cooling circuit R1. Then the air passes through a core part of the intercooler 6. The air cooled in the case 7 is further cooled down to a temperature of approximately 60 °C due to heat transfer between the intake air and the outside air flow which is generated to run through the core part when the motor vehicle is running and/or when the motor fan 3 works. This two-stage cooled air is introduced to the intake manifold of the engine 1 with a fuel, where the fuel is burned to produce a driving torque. Thus two-stage cooling, by using the case 7 and the intercooler 6, improves a charging ratio and an output of the engine 1.

[0037] The exhaust gas is discharged from the exhaust manifold of the engine 1 to the turbine 8b through the twelfth tube 9l, thereby driving the turbine 8b. Then it is discharged to the atmosphere through the thirteenth tube

9n, a not shown catalytic converter for purifying the exhaust gas, a not-shown muffler for reducing exhaust noise and an exhaust pipe.

[0038] Next, a construction of the intercooler 6 with the case 7 will be described in detail.

[0039] As shown in FIGS. 2 to 5, the intercooler 6 includes a pair of tanks 10a and 10b and the core part including a plurality of tubes 11, and is attached with the case 7. The first tank 10a and the second tank 10b are located apart from each other in a lateral direction, when they are mounted on the motor vehicle. The both end portions of tubes 11 connects the first and second tanks 10a and 10b, respectively. The case 7 is fixed to the first tank 10a to surround upstream side portions of tubes 11.

[0040] The first tank 10a and the second tank 10b are made of plastic material and are shaped like a box with an opening at its one side. As shown in FIGS. 4 and 5, the opening of the first tank 10a is covered by a first tube plate 12, while the opening of the second tank 10b is covered by a second tube plate 13 as shown in FIG. 3. The first and second tube plates 12 and 13 have a plurality of holding portions 14 projecting from outer circumferences thereof so that the holding portions 14 caulk flange portions of the tanks 10a and 10b with sealing members S1, respectively. The first and second tube plates 12 and 13 are formed symmetrically, although only the cross section of the first tube plate 12 is illustrated.

[0041] The inlet port P1 is provided on a rear surface of the first tank 10a to be fluidically connected with the tenth tube 9j, and the outlet port P2 is provided on a rear surface of the second tank 10b to be fluidically connected with eleventh tube 9k. As shown in FIG. 3, pipes with the inlet port P1 and the outlet port P2 are projected rearward from the rear surfaces of the first and second tanks 10a and 10b, respectively.

[0042] On the other hand, the case 9 includes a case main body 15, the first tube plate 12 and a blocking plate 16, as shown in FIG. 4.

[0043] The case main body 15 is formed as a parallelepiped, and its one of openings of the case main body 15 is closed by the first tube plate 12 and the other of the openings is closed by the blocking plate 16, thus forming a liquid-tight space therein. The first tube plate 12 closes the both openings of the first tank 10a and the case main body 15, which can decrease the number of parts of the composite heat exchanger.

[0044] The first tube plate 12 is formed thereon with a plurality of burring portion 12a with a through-hole, and the blocking plate 16 is also formed thereon with a plurality of burring portions 16a with a through-hole.

[0045] The tubes 11 are flat tubes, and each tube 11 contains an inner fin 11c. The tubes 11 are fixed to the first and second tanks 10a and 10b so that their one end portions are inserted through the burring portions 16a of the blocking plate 16 and the burring portions 12a of the first tube plate 12 and their other end portions are inserted through not-shown burring portions formed on the second tube plate 13. The tubes 11 fluidically communicate

an inner space of the first tank 10a and an inner space of the second tank 10b with each other.

[0046] The case main body 15 is provided on its bottom surface with the inlet port P3 fluidically connected with the seventh tube 9g, while it is provided on its top surface with the outlet port P4 fluidically connected with the eighth tube 9h. Pipes with the inlet port P3 and the outlet port P4 are vertically projecting from the bottom and top surfaces, respectively.

[0047] As shown in FIG. 5, a lower partition plate 17a is provided near and at a rear side of the inlet port P3 so as to divide a bottom space, which is formed by a lowest tube 11a and an inner surface of a bottom portion of the case main body 15, into a front side space and a rear side space. Similarly, an upper partition plate 17b is provided near and at a front side of the outlet port P4 so as to divide a top space, which is formed by a most-upper tube 11b and a top inner surface of a top portion of the case main body 15, into a front space and a rear space. Accordingly, the coolant inputted through the inlet port P3 changes its flow direction forward, and then goes up in a front side space of the case main body 15 to flow rearward between the lowest tube 11a and the most-upper tube 11b along the tubes 11, cooling the compressed hot intake air passing through the tubes 11.

[0048] On the other hand, outer corrugated fins 18 are disposed between the blocking plate 16 and the second tube plate 13 and also between the adjacent tubes 11 so as to further promote heat transfer between the intake air flowing in the tubes 11 and the outside air (a ram airflow generated when the motor vehicle is running and/or an airflow generated by the motor fan 3) through the tubes 11 and the outer fins 18.

[0049] All parts, except the first tanks 10a and 10b and the sealing members S1, of the intercooler 7 with the case 7 are made of aluminum material. After one side surfaces of connecting portions of the parts are placed with clad material, such as brazing sheets, the connecting portions are brazed with each other.

[0050] The intercooler 6 is manufactured as follows.

[0051] The tubes 11 and the outer fins 18 are arranged at predetermined positions, being piled alternately, and the one end portions (upstream side end portions) of the tubes 11 are inserted into the burring portions 16a of the blocking plate 16 as shown in FIG. 6. The burring portions 16a are formed to project toward the first tube plate 12, so that the tubes 11 can be easily inserted therethrough.

[0052] In advance of this inserting process, the lower upper partition plate 17a, the upper partition plate 17b, the pipe with the inlet port P3 and the pipe with the outlet port P4 are welded or brazed to the case main body 15 in another manufacturing process. Incidentally, the welding or brazing may be executed after a contemporary assembly of the intercooler 6.

[0053] Then, the outer circumference of the blocking plate 16 is fitted and fixed in the one opening of the case main body 15, as shown in FIG. 7.

[0054] The one end portions of the tubes 11 are insert-

ed in the burring portions 12a of the first tube plate 12 as shown in FIG. 8, and the first tube plate 12 is inserted and fixed into the case main body 15 as shown in FIG. 5.

[0055] The other end portions (downstream side portions) of the tubes 12 are inserted in and fixed to the burring portions of the second tube plate 13, although they are not illustrated. The burring portions are projected towards the second tank 10b, so that the other end portions can be easily inserted into the burring portions.

[0056] A temporary assembly of the tubes 11, the outer fins 18, the blocking plate 16, the case main body 15, the first tube plate 12 and the second tube plate 13 is conveyed in a not-shown heat furnace to be treated with heat, so that the connecting portions thereof are connected by brazing with one another as one unit.

[0057] As described above, the tubes 11, the outer fins 18, the blocking plate 16, the case main body 15, the first tube plate 12 and the second tube plate 13 are assembled along a longitudinal direction of the intercooler 6, so that they can be continuously conveyed in the longitudinal direction, being easily and successively assembled.

[0058] In the following process, the sealing members S1 are placed between the first tube plate 12 and the first tank 10a and between the second tube tank 13 and the second tank 10b, respectively. The holding portions 14 of the first tube plate 12 are bent to caulk the outer circumference of the first tank 10a with the sealing member S1 as shown in FIG. 4. Similarly, the holding portions of the second tube plate 13 are bent to caulk the outer circumference of the second tank 10b with the sealing member S1.

[0059] Incidentally, when the first and second tanks 10a and 10b are made of metal material, they may be brazed or welded with the first and second tube plates 12 and 13, respectively.

[0060] The operation of the intercooler 6 will be described.

[0061] Behind the intercooler 6, the radiator 2 is arranged, as shown in FIG. 3, in a state where the upstream side tank 2b and the case 7 are overlapped in the lateral direction. Therefore, the case 7 can be located at a dead space, in front of the upstream side tank 2b, where no airflow generated when the motor vehicle is running and/or generated by the motor fan 3. This enables the case 7 to be arranged, making efficient use of the dead space.

[0062] In addition, the case 7 and the upstream side tank 2b are arranged near to each other, which enables the seventh tube 9g and the eighth tube 9h to be connected with the second tube 9b by shorter tubes.

[0063] As shown in FIG. 4, the coolant entering the case 7 through the seventh tube 9g and the inlet port P3 passes between the tubes 11 as indicated by alternate long and two short dashes lined arrows, and then it is discharged through the outlet port P4 to the eighth tube 9h. Specifically, as shown in FIG. 5, the coolant enters the case 7 through the inlet port 3 and flows upward in the front side space, then flowing between the tubes 11

toward the rear side space to be discharged through the outlet port P4 as also indicated by the alternate long and two short dashes lined arrows. Therefore, the coolant is delivered substantially evenly between the tubes 11, preventing from unevenly flowing toward one side space in the case 7. This can improve the coolability of the intercooler 6.

[0064] The coolant passing through the case 7 is cooled by the ram airflow generated when the motor vehicle running and/or the air flow generated by the motor fan 3.

[0065] The fins 18 are removed in the case 7, which results in reduction in flow resistance of the coolant passing between the tubes 11. This save a material cost of the fins 18 and improve coolability of the case 7.

[0066] On the other hand, the intake air entering the first tank 10a through the tenth tube 10j is cooled down due to the heat transfer between the intake air and the coolant when the intake air flows through an upstream portion of the tubes 11 inside the case 7. This cooling-down is enhanced by the fact in that the coolant evenly flows between the tubes 11 in the case 7 and that the case 7 is cooled down by the airflow hit the case 7.

[0067] The cooled intake air is further cooled down when it flows through the tubes 11 between which the outside air flows, and it is supplied to the engine through the outlet port P2 and the eleventh tube 9k.

[0068] Incidentally, a demanded temperature of the intake air is approximately at the outlet port P2. This temperature cannot be obtained only by using the coolant in the engine cooling circuit R1. If an independent cooling system is used to obtain the demanded temperature, it requires a sub radiator, a pump and water-cooled intercooler. This increases the number of parts, thus it is impossible to arrange the new independent system in an engine room of motor vehicles with a turbocharger. In addition, increase in the parts results in high manufacturing costs.

[0069] In the above-described operation of the composite heat exchanger of the first embodiment, the pipes 11 thermally expand and contract notably in a longitudinal direction of the tubes 11 due to the hot intake air. This causes thermal stress in connecting portions of the tubes 11 and the plates 12, 13 and 16, especially in the first tube plate 12 because it is positioned at the most-upstream side of the hot intake air. In the first embodiment, the case 7 is provided at the upstream side of the hot air to cool the upstream side portions of the tubes 11, thereby decreasing the thermal stress in the connections of the tubes 11 and the first tube 12 and the blocking plate 16.

[0070] The composite heat exchanger of the first embodiment has the following advantages.

[0071] The composite heat exchanger of the first embodiment can improve the coolability of the intake air in the two stages, first by the case 7 using the coolant in the engine cooling circuit 7 and second by the core part of the intercooler 6 using the outside airflow.

[0072] The case 7 and the first tank 10a are integrally

combined with each other, which can increase their rigidity, suppress its dimensions and the number of additional parts. In addition, the case 7 cools the upstream side portions of the tubes 11 to decrease the thermal stress in the connections of the tubes 11 and the first tube plate 12 and the blocking plate 16.

[0073] Removal of the fins 18 in the case 7 can decrease the flow resistance of the coolant in the engine cooling circuit R1, ensuring a coolability of the tubes 11 between the case 7 and the second tank 10b, and the tubes 11 and the case 7 are easily assembled with each other.

[0074] The lower and upper partition plates 17a and 7b enable the coolant to evenly flow between the tubes 11, thus improving the coolability of the case 7.

[0075] The case 7 and the upstream side tank 2 of the radiator 2 behind the case 7 are overlapped with each other in the lateral direction, which can provide a efficient utilization of the dead space of the upstream tank 2b.

[0076] A close arrangement of the case and the upstream tank 10b enables the seventh tube 9g and the eighth tube 9h to be shorten, thus decreasing the manufacturing cost.

[0077] The composite heat exchanger of the present invention is applied to the intercooler 6, which satisfies motor vehicles with a turbocharger and an intercooler in a high performance and a compact size.

[0078] Utilization of the coolant can decrease the manufacturing cost relative to a motor vehicle further provided with a new cooling system.

[0079] Next a composite heat exchanger of a second embodiment will be described.

[0080] As shown in FIG. 10, an intercooler 6 with a case 7, corresponding to the composite heat exchanger of the second embodiment of the present invention, of the second embodiment includes a case main body 20 formed as a parallelepiped and a blocking plate portion formed with the parallelepiped at its one side as one unit. The blocking plate portion is formed with a plurality of burring portions 16a through which end portions 19 of tubes 11 are inserted. One opening of the case main body 20 is provided at a side thereof opposite to the blocking plate portion and is closed by a first tube plate with burring portions for receiving the end portions 19 of the tubes 11, although the first tube plate and a first tank are not illustrated in FIG. 10.

[0081] The other parts of the second embodiment are constructed similarly to those of the first embodiment.

[0082] The composite heat exchanger of the second embodiment can decrease the number of the parts in addition to the advantages of the first embodiment.

[0083] While there have been particularly shown and described with reference to preferred embodiments thereof, it will be understood that various modifications may be made therein.

[0084] For example, the part of the coolant in the engine cooling circuit R1 is introduced into the case 7 in the first and second embodiment, while all of the coolant in

the engine cooling circuit R1 may be designed to pass through the case 7. A variable flow rate valve may be provided in the seventh tube 9g so that a flow rate of the coolant to pass the case 7 can be adjusted according to load of the radiator 2. Positions of a connecting portion of the second tube 9b and the seventh tube 9g and a connecting portion of the second tube 9b and the eighth tube 9h may be set appropriately.

[0085] Cross-sectional shapes of the tubes 11 may be formed appropriately, not limited to the flat tubes.

[0086] The intercooler 6 is employed as the first heat exchanger in the first and second embodiments, while the first heat exchanger of the present invention can be used for radiators, condensers, oil coolers, evaporators and the like. In this case, kinds of cooling mediums introduced into the case 7 may be determined, allowing for temperature conditions thereof.

[0087] The composite heat exchanger of embodiments of the present invention is applicable not only to motor vehicles with an intercooler, but also to motor vehicles without a turbocharger, hybrid electric vehicles, fuel-cell electric vehicles and others.

from unevenly flowing between the tubes (11; 11a, 11b) in the case (7).

6. The composite heat exchanger according to any one of claims 1 to 5, wherein the cooling medium flows through a second heat exchanger (2) where the cooling medium flows in the lateral direction in a core part (2a) thereof, the second heat exchanger (2) having a tank (2b), and wherein the composite heat exchanger (6, 7) is mounted on a motor vehicle so that the pair of tanks (10a, 10b) is arranged in a lateral direction of the motor vehicle, and the case (7) and the tank (2b) of the second heat exchanger (2) are overlapped with each other in the lateral direction.
7. The composite heat exchanger according to any one of claims 1 to 6, wherein the first heat exchanger is an intercooler(6), the fluid is an intake air supplied to the intercooler (6), the second heat exchanger is a radiator (2) and the cooling medium is a coolant circulating in an engine cooling circuit (R1).

Claims

1. A composite heat exchanger comprising:

a first heat exchanger (6) having a pair of tanks (10a, 10b) being apart from each other and a plurality of tubes (11; 11a, 11b) both end portions of which are connected with the tanks (10a, 10b), respectively so that a fluid is cooled by airflow when the fluid is passing through the tubes (11; 11 a, 11b); and a case (7) surrounding portions of the tubes (11; 11a, 11b) and provided with an inlet port (P3) and an outlet port (P4) which flow a cooling medium whose temperature is lower than a temperature of the fluid to enter the tubes (11; 11a, 11b).

2. The composite heat exchanger according to claim 1, wherein the portions of the tubes (11; 11a, 11b) which are surrounded by the case (7) are upstream side portions of the tubes (11; 11a, 11b).

3. The composite heat exchanger according to claim 1 or claim 2, wherein the case (7) and the tank (10a) are integrally formed with each other.

4. The composite heat exchanger according to any one of claims 1 to 3, wherein the tubes (11; 11a, 11b) have fins between portions thereof except portions inserted into the tanks (10a, 10b).

5. The composite heat exchanger according to any one of claims 1 to 4, wherein the case (7) has a partition plate (17a, 17b) for preventing the cooling medium

FIG. 1

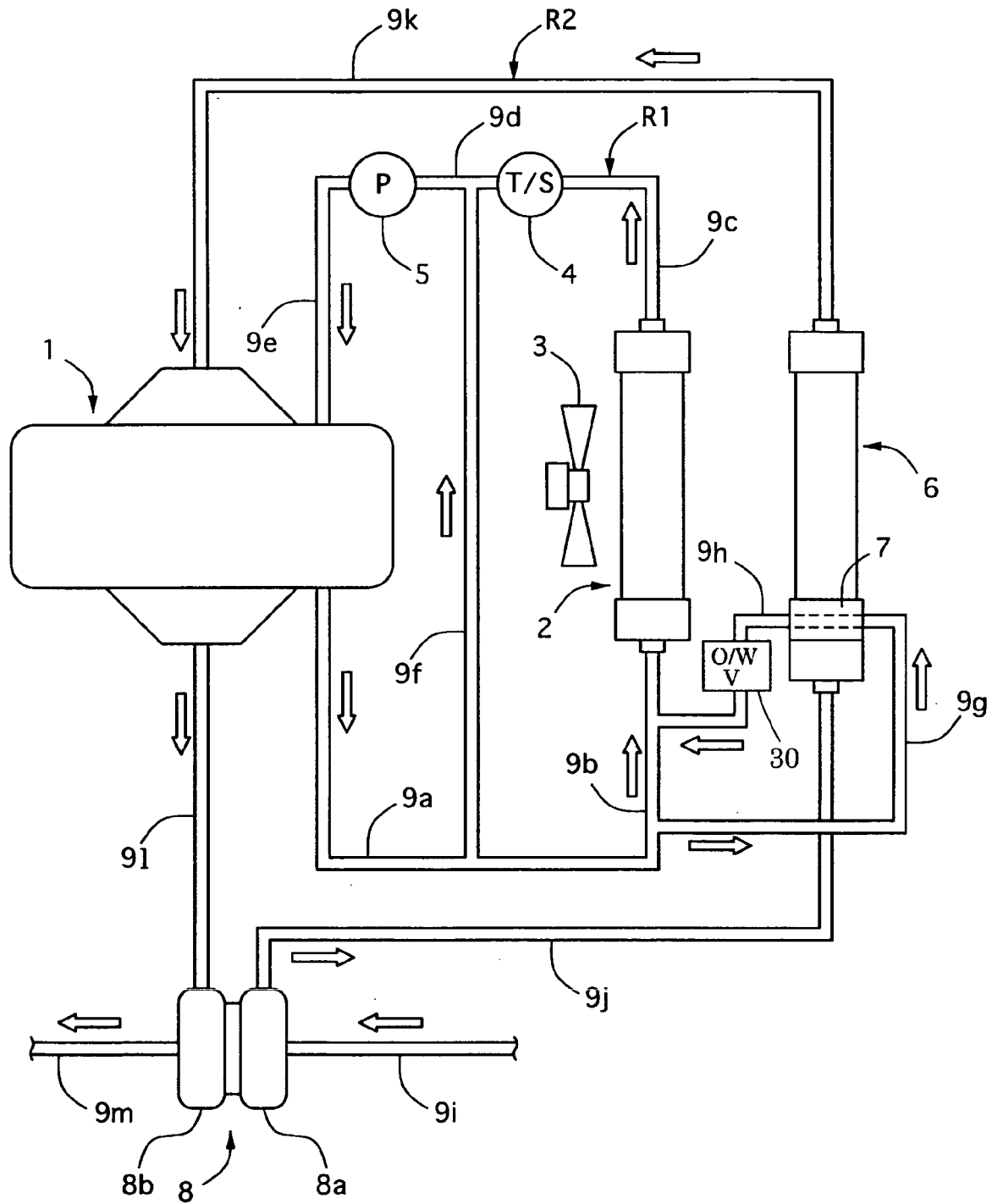


FIG. 2

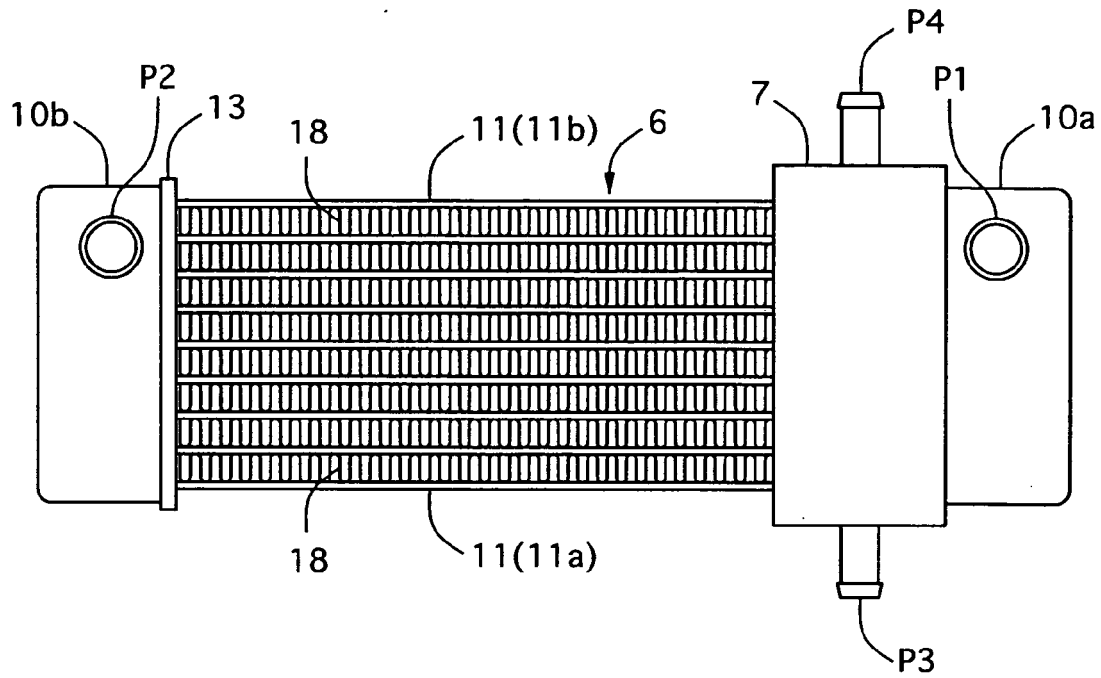


FIG. 3

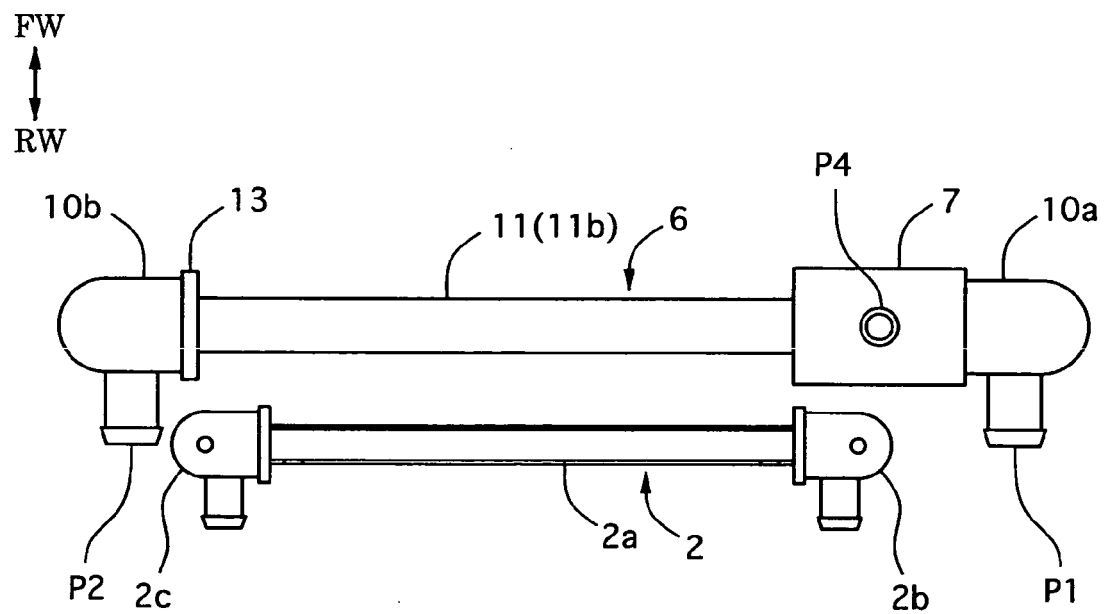


FIG. 4

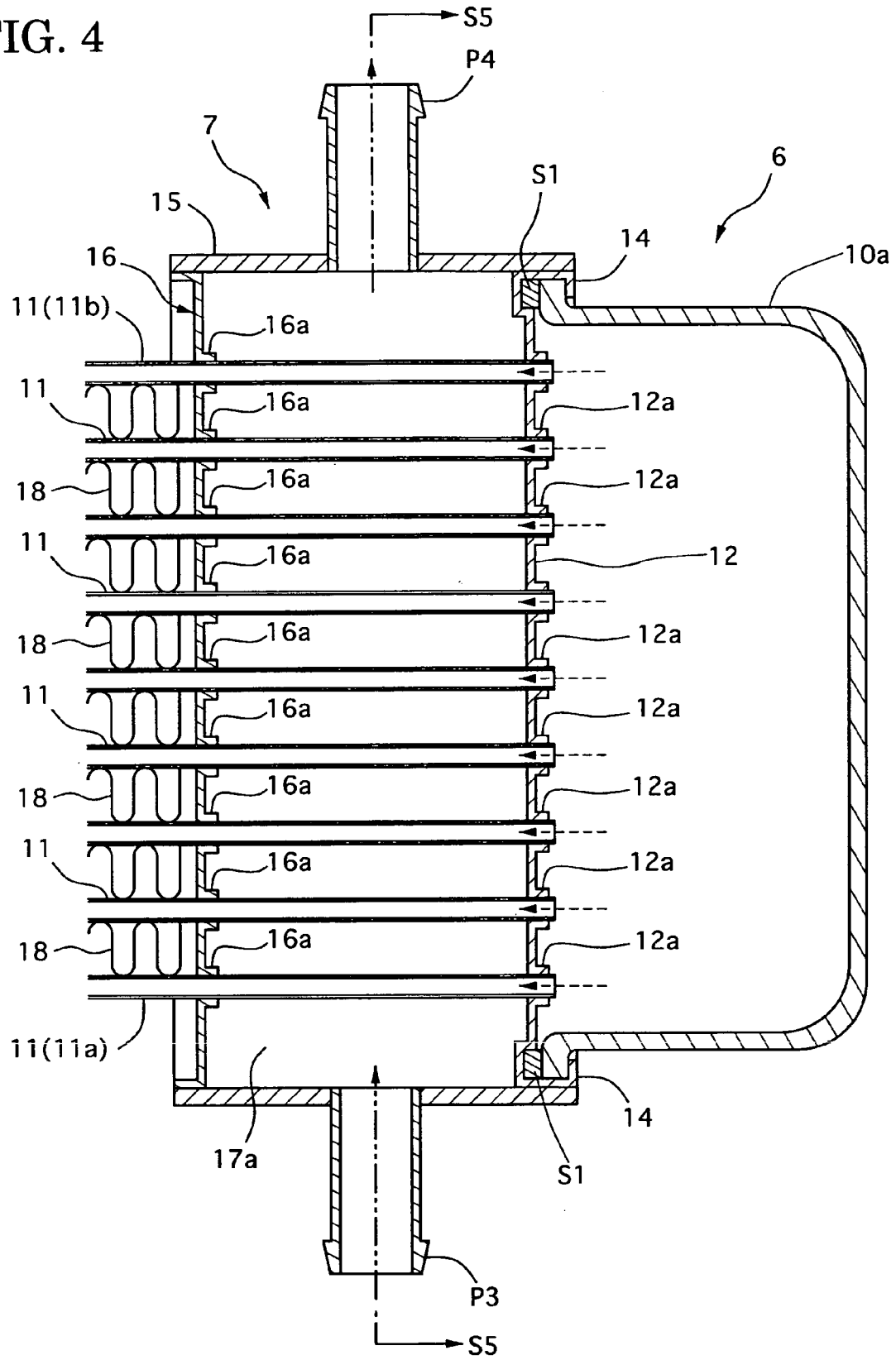


FIG. 5

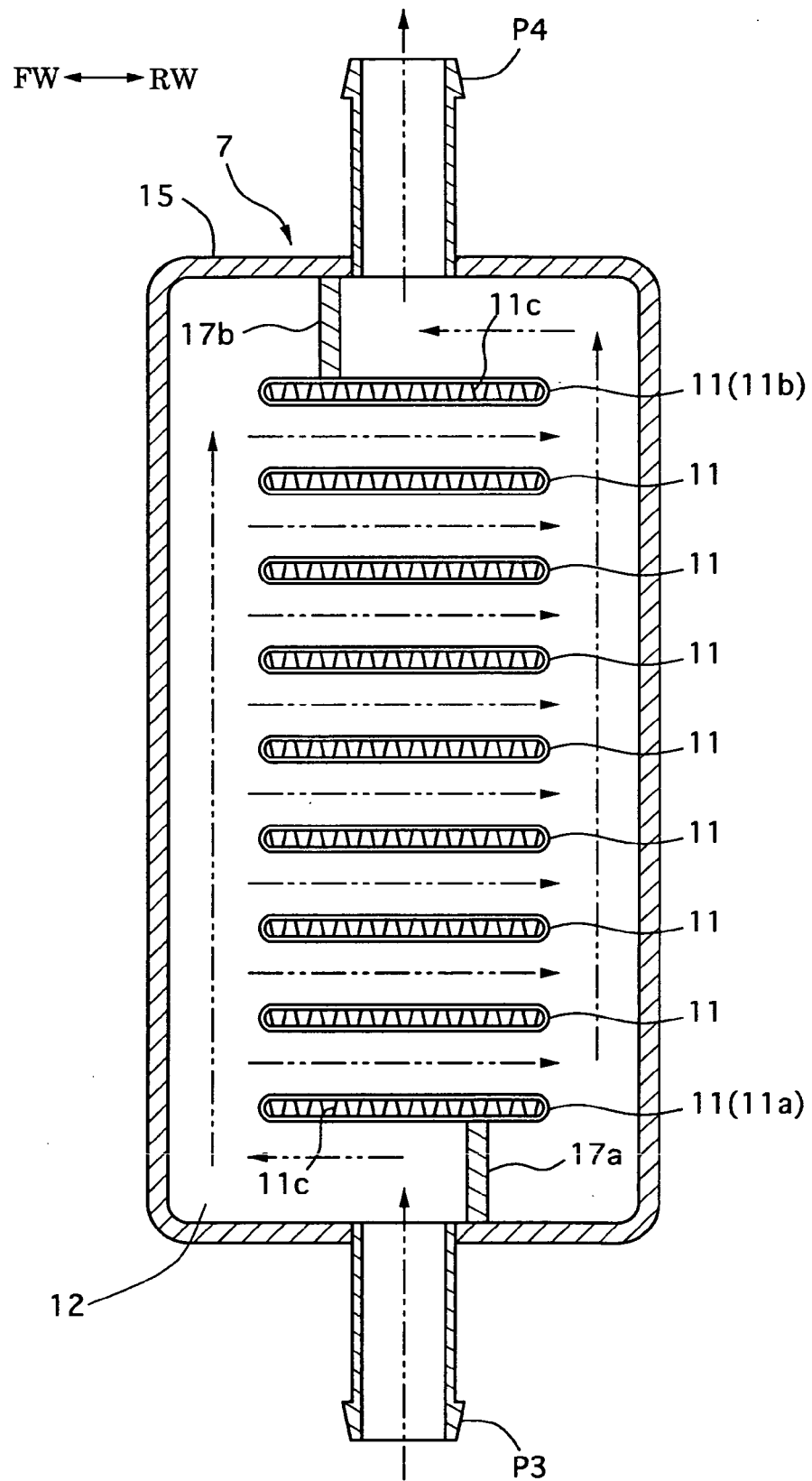


FIG. 6

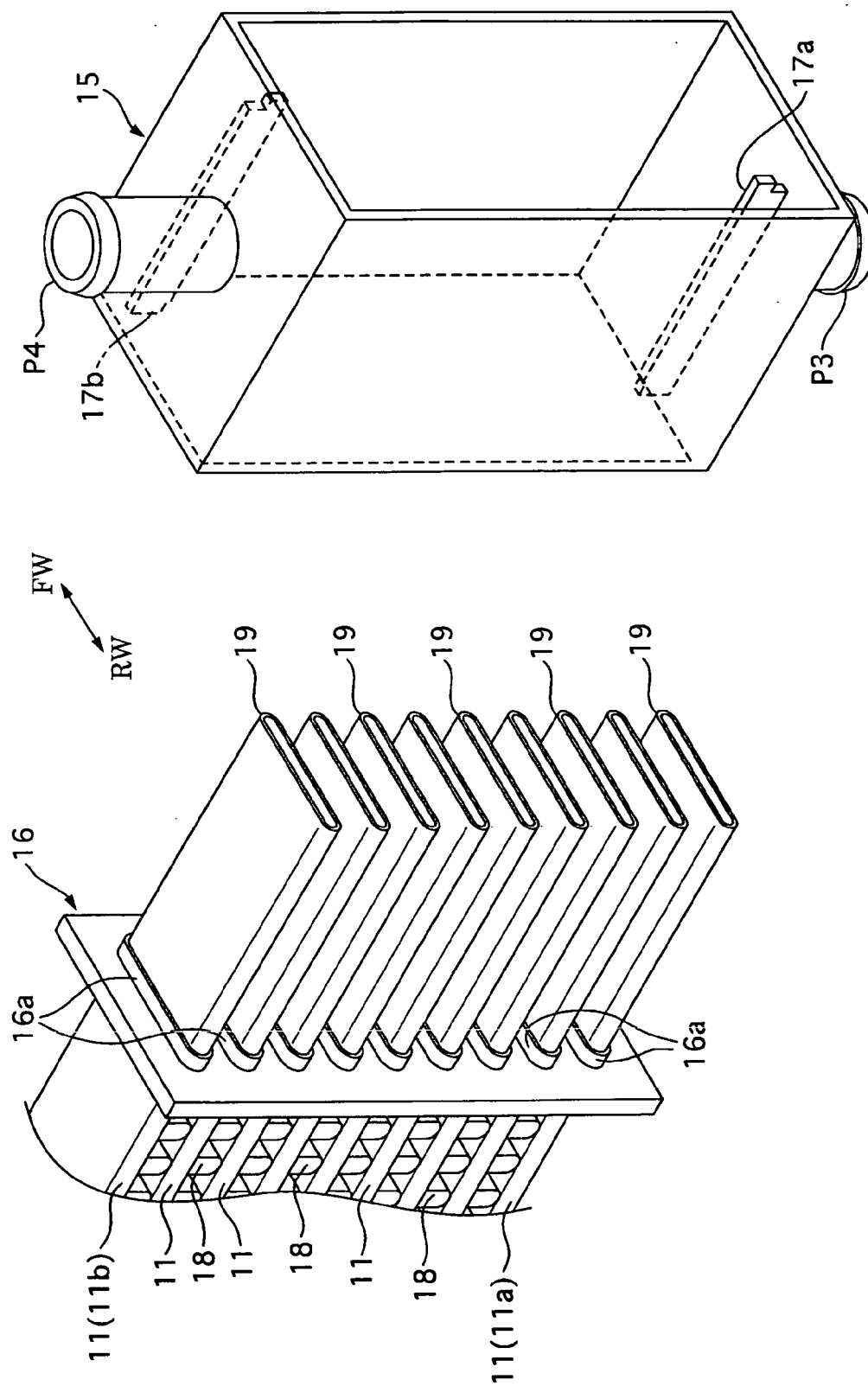
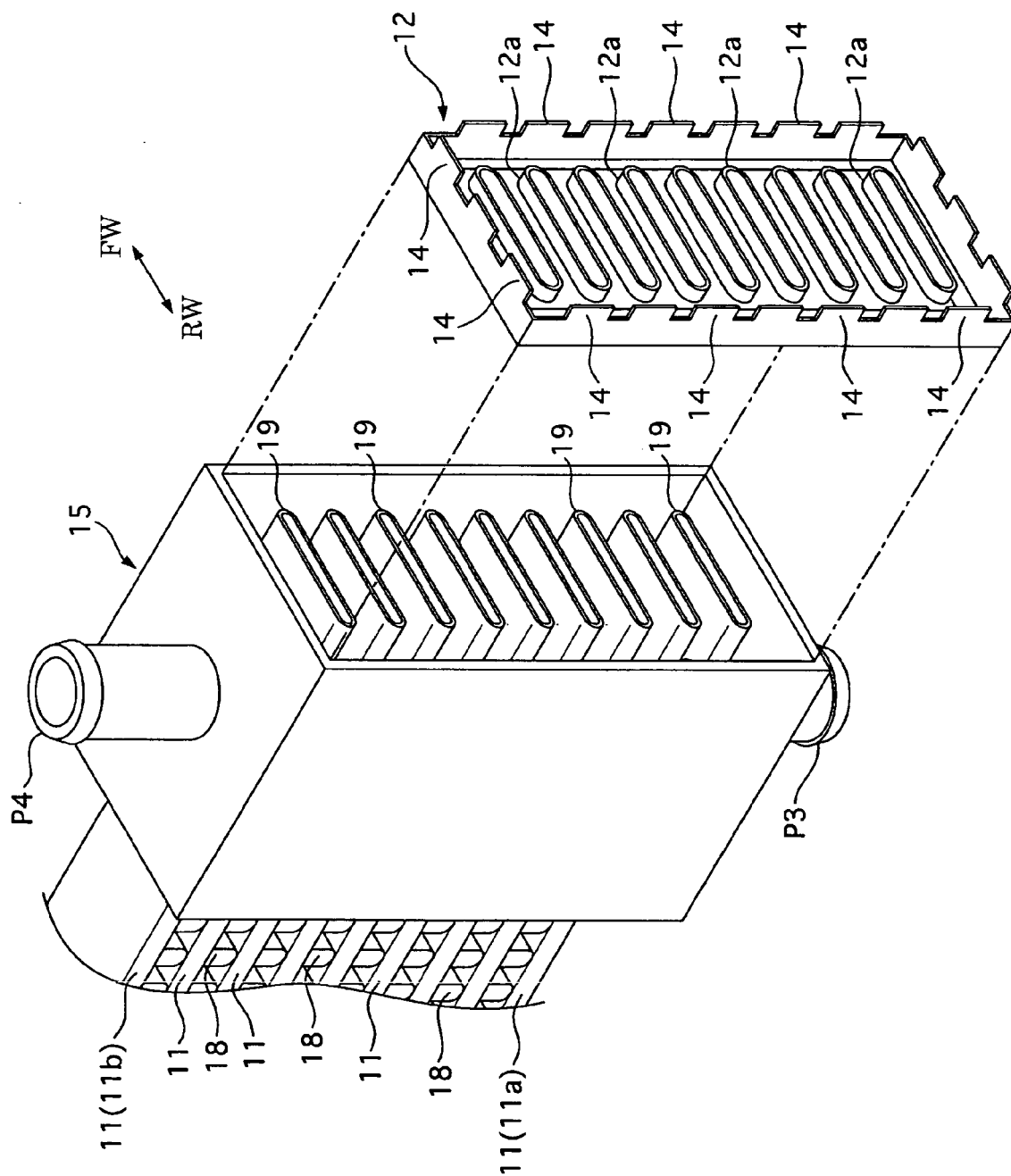


FIG. 7



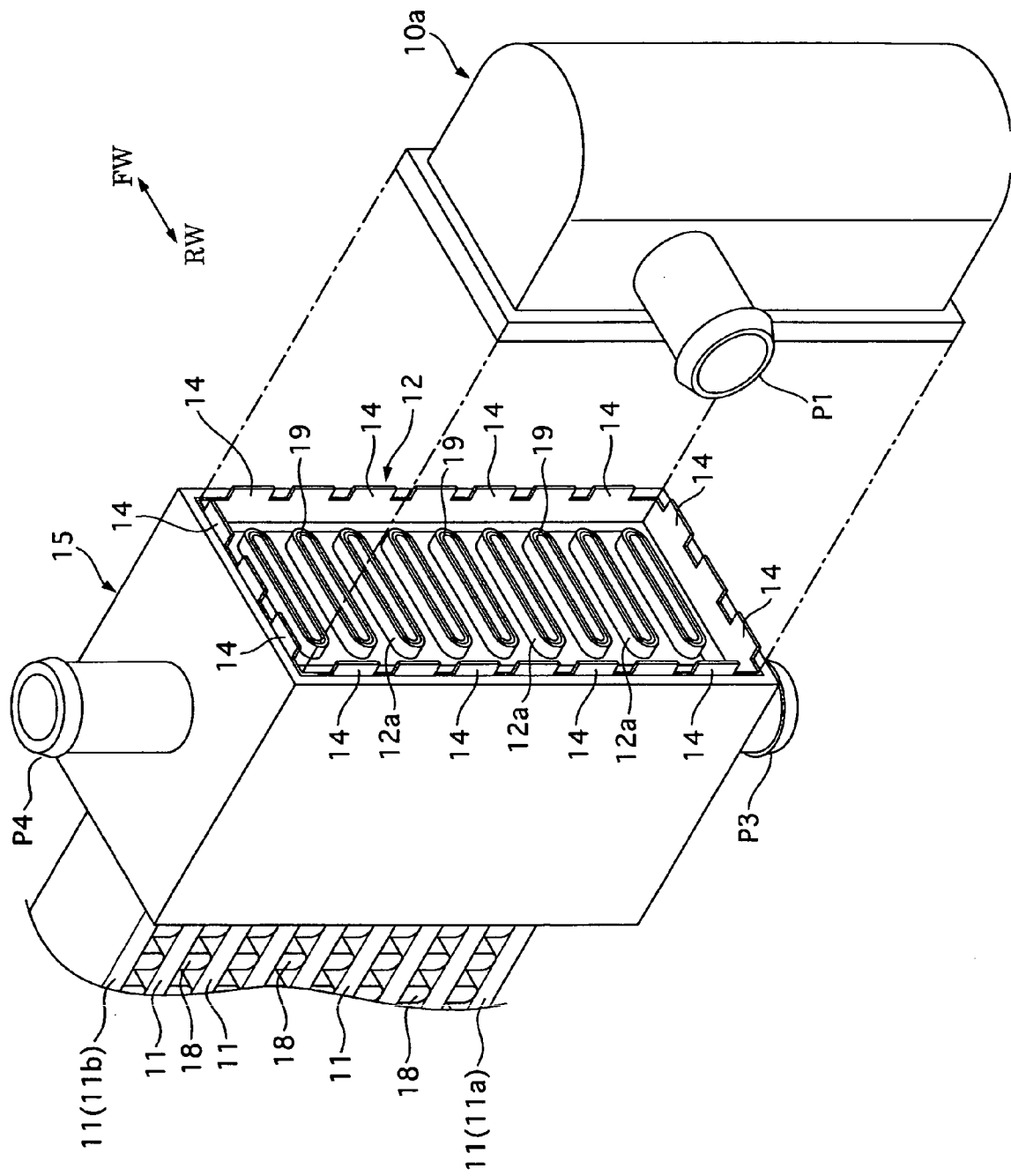


FIG. 8

FIG. 9

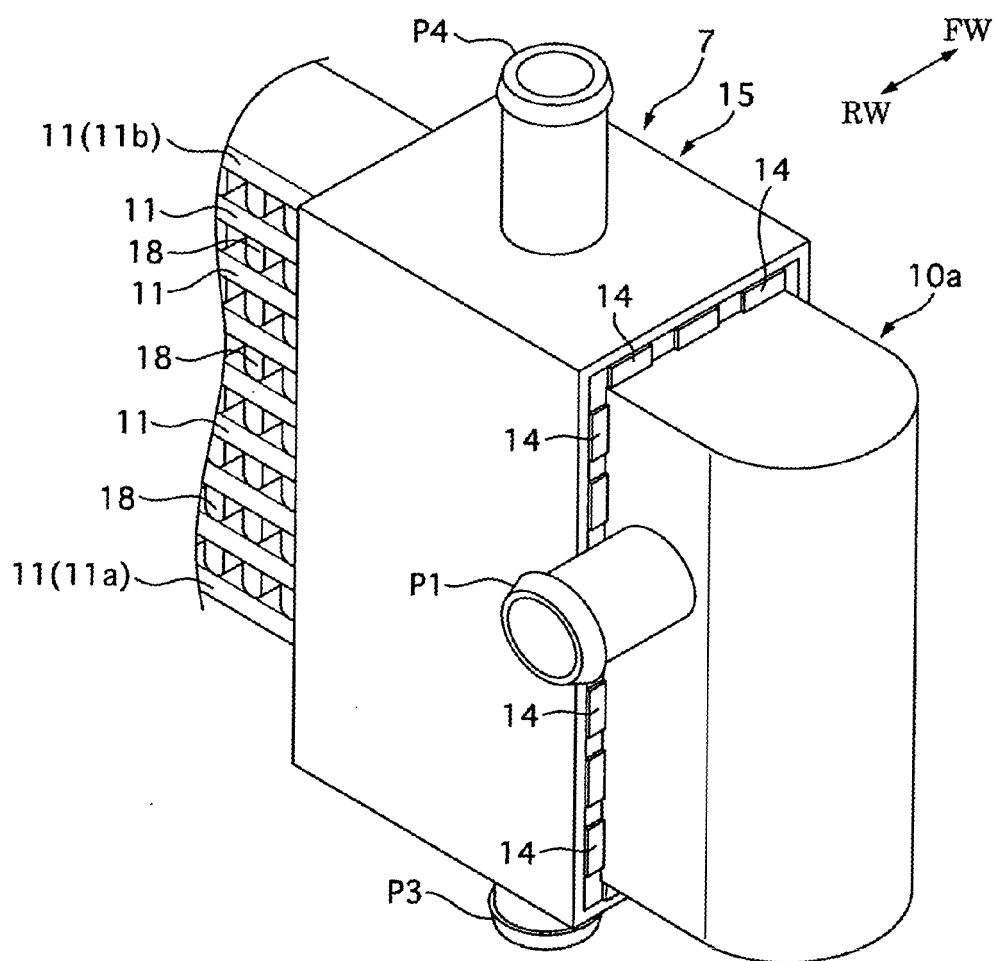
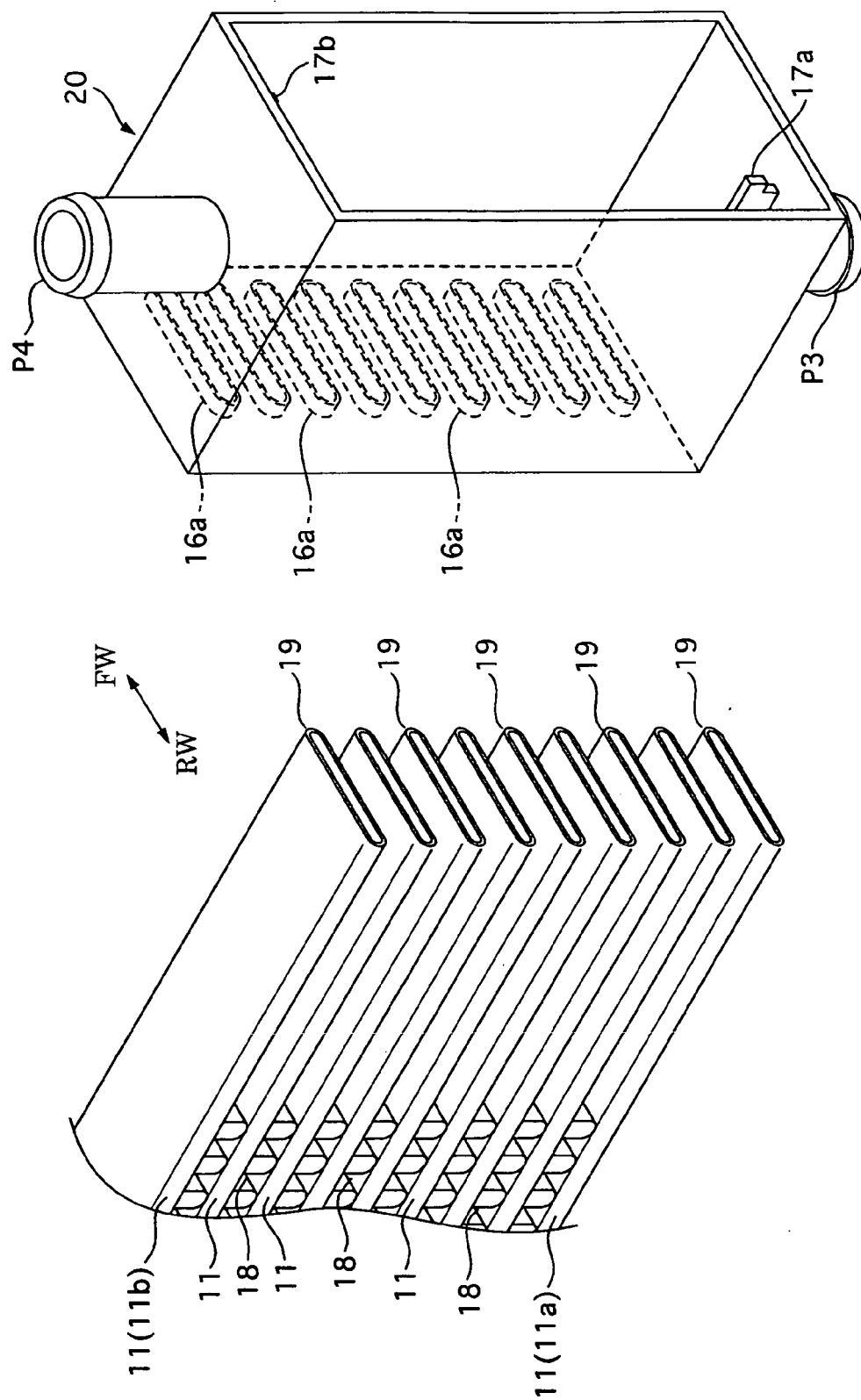


FIG. 10



REFERENCES CITED IN THE DESCRIPTION

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