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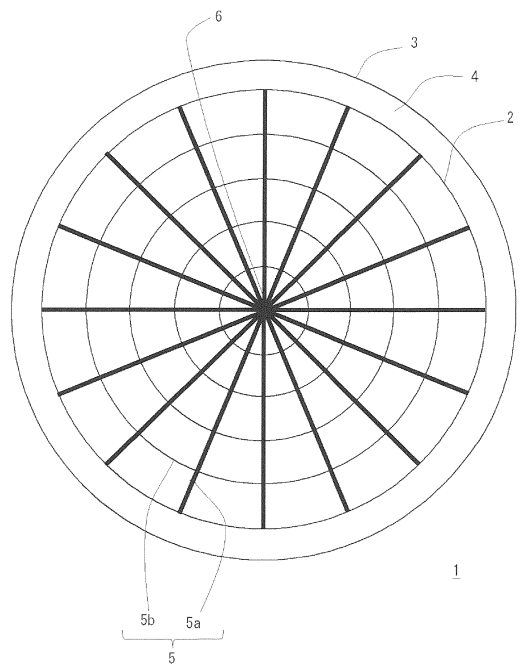
(54) ## HEAT EXCHANGER

(57) A heat exchanger includes: a heat exchange body through which a fluid serving as a cooled object passes; and a coolant passage which is provided in at least one of a central portion and an outer circumferential portion of the heat exchange body, and through which a coolant exchanging heat with the heat exchange body flows, wherein the heat exchange body includes: a first heat transfer means which extends from a central portion to an outer circumferential portion; and a second heat transfer means which extends in a circumferential direction, and which intersects the first heat transfer means, a heat transfer efficiency of the first heat transfer means is greater than that of the second heat transfer means. It is thus possible to effectively transfer heat to the coolant passage provided in the outer circumferential portion or the central portion, and the good heat conductive property is ensured in the heat exchanger, which enables the improvement of the cool efficiency.

FIG. 2



EP 2 913 616 A1

Description

TECHNICAL FIELD

[0001] The present invention is related to a heat exchanger.

BACKGROUND ART

[0002] Conventionally, various heat exchangers are known. For example, Patent Document 1 discloses a heat exchanger having: a first fluid flow portion formed by a honeycomb structure having plural cells through which a heated element of a first fluid flows; and a second fluid flow portion provided in the outer circumferential portion of the first fluid flow portion. Coolant flows through the second fluid flow portion, so that heat is taken from the heated element flowing through the first fluid flow portion, which cools the heated element. Also, Patent Document 2 discloses an air-cooling semiconductor heat sink having: cooling surfaces having a radial shape; and cooling surfaces having a concentric shape about an axis and integrated with the cooling surfaces having a radial shape. Conceivably, the cooling surfaces having a radial shape and the cooling surfaces having a concentric shape disclosed in Patent Document 2 easily ensure a heat radiation area, and they are effectively used in combination with the heat exchanger disclosed in Patent Document 1.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0003]

[Patent Document 1] International Publication No. WO 2011/071161
[Patent Docuemnt 2] Japanese Unexamined Patent Application Publication No. 2003-100974

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004] However, as for the combination of the above cooling surfaces having a radial shape and the cooling surfaces having a concentric shape, there is room for further improvement in heat transfer efficiency (heat conductive property) in consideration of the arrangements of the coolant and the heated element serving as a cooled object.

[0005] It is thus an object to ensure a good heat conductive property in a heat exchanger disclosed in the present specification.

MEANS FOR SOLVING THE PROBLEMS

[0006] To solve the problem, a heat exchanger described in the present specification includes: a heat exchange body through which a fluid serving as a cooled object passes; and a coolant passage which is provided in at least one of a central portion and an outer circumferential portion of the heat exchange body, and through which a coolant exchanging heat with the heat exchange body flows, wherein the heat exchange body includes: a first heat transfer means which extends from a central portion to an outer circumferential portion; and a second heat transfer means which extends in a circumferential direction, and which intersects the first heat transfer means. Further, a heat transfer efficiency of the first heat transfer means is greater than that of the second heat transfer means. Here, the heat transfer efficiency is understood as a value obtained by multiplying a heat conductivity, which is a physical property value of a material of which the heat exchange body is made, by a thickness of one partition wall.

[0007] The heat transfer efficiency, of the heat flow in the radial direction, namely, a heat transfer path extending to the coolant passage provided in the central portion or the outer circumferential portion of the heat exchange body, is set high, thereby improving the heat conductive property. Accordingly, the good heat conductive property is ensured in the heat exchanger, which can effectively cool the cooled object.

[0008] The first heat transfer means may be first partition walls extending radially from a central portion to an outer circumferential portion of the heat exchange body, the second heat transfer means may be second partition walls having a concentric shape, and a thickness of the first partition wall may be larger than that of the second partition wall. The walls having a concentric shape, that is, the second partition walls can increase the contact area with the fluid serving as the cooled object. On the other hand, each heat transfer efficiency of such partition walls having a concentric shape has to be smaller than that of partition walls extending radially, that is, the first partition walls. Therefore, the thickness of the first partition wall is set larger than that of the second partition wall, so that the heat transfer efficiency of the first partition walls serving as the first heat transfer means is made greater than that of second partition walls.

[0009] The first heat transfer means may be first partition walls extending radially from a central portion to an outer circumferential portion of the heat exchange body, the second heat transfer means may be second partition walls having a concentric shape, and a heat conductive property of a material of the first partition wall may be greater than that of a material of the second partition wall. As mentioned above, the walls having a concentric shape, that is, the second partition walls can increase the contact area with the fluid serving as the cooled object. On the other hand, each heat transfer efficiency of such partition walls having a concentric shape has to be smaller than that of partition walls extending radially, that is, the first partition walls. Therefore, the first partition wall is made of the material having a heat conductive property greater than that of the material of which the second partition wall is made, so that the heat transfer efficiency of the first partition walls serving as the first heat transfer means is made greater than that of second partition walls. In order to have different heat conductive properties, there can be difference in the heat conductivity between the material of which the first partition wall is made and that of which the second partition wall. That is, the first partition wall can be made of the material having a heat conductivity greater than that of the material of which the second partition wall is made.

[0010] The first heat transfer means may be a first partition wall extending from an inlet side to an outlet side of a fluid serving as a cooled object in the heat exchange body, the second heat transfer means may be a second partition wall extending from an inlet side to an outlet side of a fluid serving as a cooled object in the heat exchange body, at least one of a thickness of the first partition wall and the second partition wall may include a portion having a thickness becoming smaller from the inlet side to an outlet side. The temperature of the fluid serving as the cooled object becomes higher as it comes closer to the inlet of the heat exchange body. Thus, the first partition wall or the second partition wall is made thicker as it is closer to the inlet, so that the heat is easily transferred to the coolant passage side, which improves the temperature efficiency.

[0011] The first heat transfer means may be a first partition wall extending from an inlet side to an outlet side of a fluid serving as a cooled object in the heat exchange body, the second heat transfer means may be a second partition wall extending from an inlet side to an outlet side of a fluid serving as a cooled object in the heat exchange body, and at least one of a thickness of the first partition wall and the second partition wall may include a portion having a thickness becoming larger from the inlet side to an outlet side. It is an embodiment to preferentially reduce the pressure loss. In the vicinity of the inlet of the heat exchange body, the temperature of the fluid is high, the volume thereof is large. For this reason, the narrow flow passage area greatly influences on the pressure loss, which increases the pressure loss. Therefore, the first partition wall or the second partition wall is made thinner as it is closer to the inlet, thereby reducing the pressure loss, and it is made thicker as it is closer to the outlet, thereby preventing a decrease in the temperature efficiency.

EFFECTS OF THE INVENTION

[0012] According to a heat exchanger disclosed in the present specification, it is possible to ensure a good heat conductive property.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

FIG. 1 is an explanatory view schematically illustrating a heat exchanger according to a first embodiment;
FIG. 2 is a sectional view taken along line A-A of FIG. 1;
FIG. 3 is an explanatory view illustrating thicknesses of first partition walls and second partition walls;
FIG. 4 is an explanatory view illustrating a variation changing density of the second partition walls;
FIG. 5 is an explanatory view illustrating arrangements of second partition walls in the variation illustrated in FIG. 4;
FIG. 6 is an explanatory view illustrating a heat exchanger according to a second embodiment;
FIGs. 7(A) to (C) are explanatory views illustrating a heat exchanger according to a third embodiment;
FIGs. 8(A) to (C) are explanatory views illustrating a heat exchanger according to a fourth embodiment;
FIG. 9 is an explanatory view illustrating a variation in which a cross section of a second partition wall has a rectangular shape;
FIG. 10 is an explanatory view illustrating a variation in which a cross section of a second partition wall has a spiral shape;
FIG. 11 is an explanatory view illustrating a variation in which a cross section of a second partition wall has an elliptic shape; and
FIG. 12 is an explanatory view illustrating a variation in which coolant passages are provided in a central portion and an outer circumferential portion of a heat exchange body.

MODES FOR CARRYING OUT THE INVENTION

[0014] Hereinafter, embodiments according to the present invention will be described with reference to the accompanying drawings. However, a dimension and a ratio of each component illustrated in the drawings may not correspond to the reality. Also, details may be omitted in some drawings.

(First Embodiment)

[0015] First, a heat exchanger 1 according to the first embodiment will be described with reference to FIGs. 1 to 3. The heat exchanger 1, which can employ various types of fluids serving as cooled objects, is incorporated into an exhaust gas recirculation device equipped with an internal combustion engine in the first embodiment, and is used as an EGR cooler for cooling the EGR (Exhaust Gas Recirculation) gas. FIG. 1 is an explanatory view schematically illustrating the heat exchanger 1 according to the first embodiment. FIG. 2 is a sectional view taken along line A-A of FIG. 1. FIG. 3 is an explanatory view illustrating thicknesses of partition walls provided in the heat exchanger 1.

[0016] The heat exchanger 1 includes an EGR pipe 2 through which the EGR gas flows. The EGR pipe is a tube material made from stainless steel (SUS). The EGR pipe 2 can also be made from another material such as aluminum. The heat exchanger 1 includes a housing member 3, an end portion 3a of which is joined to an end portion 2a of the EGR pipe 2, and which forms a coolant passage 4 in the outer circumferential portion of the EGR pipe 2. The housing member 3 is also made from stainless steel (SUS). The housing member 3 includes a coolant inlet 3b1 for introducing the coolant into the coolant passage 4 and a coolant outlet 3b2 for discharging the coolant from the coolant passage 4. The coolant may be any fluid, but it is cooling water in the present embodiment. An outer wall of the housing member 3 is provided with stays 3c.

[0017] A heat exchange body 5 arranged to abut with the inner circumferential wall surface 2b of the EGR pipe 2 is accommodated within the EGR pipe 2. The fluid serving as a cooled object, that is, the EGR gas passes through the heat exchange body 5 in the present embodiment. The heat exchange body 5 is made of a silicon carbide ceramic (SiC). The ceramic material has an efficient heat conductivity and can exert a high corrosion resistance. Therefore, the ceramic material having a high heat conductivity is preferably suitable for materials of the heat exchange body arranged within the EGR pipe and a covering member. The heat exchange body 5 is formed into a cylindrical shape, and a passage through which the gas can pass is formed. The heat exchange body 5 can exchange heat from the coolant flowing into the coolant passage 4 through the EGR pipe 2. That is, when the EGR gas passes through the heat exchange body 5, heat is exchanged between the EGR gas and the coolant through the heat exchange body 5 and the EGR pipe 2, so the EGR gas is cooled.

[0018] Referring to FIG. 2, the heat exchange body 5 has first partition walls 5a, which radially extends from a central portion 6 toward the outer circumferential portion, and which serves as a first heat transfer means extending from the central portion 6 toward the outer circumferential portion. Further, the heat exchange body 5 has second partition walls 5b, which have concentric shapes, and which serve as a second heat transfer means extending in the circumferential direction and intersecting the first partition walls 5a. Herein, the central portion 6 is not required to be positioned perfectly at the center of the heat exchange body 5. The first partition wall 5a has only to form a heat transfer path from the inside to the outside. That is, it has only to extend in the radial direction, and it may be partly wave-shaped or may be curved. On the other hand, the second partition wall 5b has only to be shaped with a portion continuous in the circumferential direction. As for the second partition wall 5b, its cross section perpendicular to the flowing direction of the fluid may have a circular shape, an ellipse shape, or a rectangular shape. Further, it is not required to have a full ring shape, and it may have an open ring shape. Such a second partition wall 5b intersects the first partition wall 5a, so that the strength of the heat exchange body 5 can be improved. Further, the provision of the second partition wall 5b can increase the contact area with the fluid, thereby improving the temperature efficiency.

[0019] Referring now to FIGs. 2 and 3, the thickness T1 of the first partition wall 5a is larger than the thickness T2 of the second partition wall 5b. Thus, in the first embodiment, a change in the thickness between the first partition wall 5a and the second partition wall 5b makes the heat transfer efficiency of the first heat transfer means, that is, the first partition wall 5a greater than that of the second heat transfer means, that is, the second partition wall 5b. Thus, the first partition wall 5a is thickened and the heat transfer path extending toward the coolant passage 4 is thickened, so the heat transfer efficiency can increase. Supposing the second partition wall 5b is thickened, the pressure loss increases correspondingly. However, in the first embodiment, the second partition wall 5b is so thin as to reduce the pressure loss, thereby contributing to the improvement in the heat efficiency. Herein, the second partition walls 5b can be thinned one by one and the number thereof can be increased. The increase in the number of the second partition walls 5b can further increase the contact area with the fluid. As a result, the temperature efficiency is further improved. Even in a case of increasing the number of the second partition walls 5b, the increase in the pressure loss can be suppressed by thinning the second partition walls 5b. In such a way, thinning the second partition walls 5b one by one in association with the increase in the number of the second partition walls 5b is also convenient for satisfaction of the relationship between the thickness of the first partition wall 5a and the thickness of the second partition wall 5b. Also, thinning the second partition wall 5b provides an advantage in ensuring the flow passage area for the EGR gas.

[0020] Herein, a description will be given of comparison between the thickness of the first partition wall 5a and the thickness of the second partition wall 5b in more detail. Even if the first partition wall 5a is partly thinned and its thickness is smaller than that of an arbitrary position of the second partition wall 5b, the average thickness in the first partition wall 5a has only to be larger than that in the second partition wall 5b.

[0021] Further, if the EGR pipe having a cylindrical shape accommodates a heat exchange body having square cells, it might be difficult to maintain the square shape of the cell or the cell size might be reduced in the vicinity of the EGR pipe. This results in clogging easily, and there is a possibility to reduce the amount of the EGR gas flowing into the cells located at the outermost circumferential portion and to reduce the cooling efficiency. The combination of the first partition walls 5a extending radially and the second partition walls 5b having a concentric shape can overcome the disadvantages, which are concerned in a case of employing the square cells.

[0022] Such a heat exchanger 1 includes cone members 8 in the upstream side and the downstream side of the EGR pipe 2. The cone member 8 in the upstream side is a member serving as an introduction portion for introducing the EGR gas into the EGR pipe 2. The cone member 8 in the downstream side is a member serving as a discharging portion for the EGR gas in the EGR pipe 2. The cone member 8 is joined to the housing member 3 by brazing such that a large diameter side covers the end portion 3a of the housing member 3. The front end portion of the cone member 8 is joined with a flange 9 member by brazing. The upstream side of the heat exchanger 1 is connected to an exhaust manifold of the engine by the flange 9. Also, the downstream side of the heat exchanger 1 is connected to an intake pipe. Additionally, the heat exchanger 1 is attached to the engine body by the stays 3c provided on the outer wall of the housing member 3.

[0023] A description will now be given of a variation according to the first embodiment with reference to FIGs. 4 and 5. FIG. 4 is an explanatory view illustrating the variation changing the density of the second partition walls. FIG. 5 is an explanatory view illustrating the arrangements of the second partition walls in the variation illustrated in FIG. 4.

[0024] Plural second partition walls 5b are arranged concentrically. Herein, Ln indicates the distance between the adjacent second partition walls 5b. n is a natural number becoming larger from the central portion 6 to the outer circumferential portion. The distance Ln becomes larger toward the outer circumferential portion. That is, the second partition walls 5b are arranged more densely as they are closer to the central portion 6. Accordingly, the fluid, that is, the EGR gas flows more easily as it is closer to the outer circumferential portion side. In the first embodiment, the coolant passage 4 is provided in the outer circumferential portion. Therefore, in order to efficiently cool the EGR gas, it is desired that a large amount of the EGR gas flows into the outer circumference portion close to the coolant passage 4. For this reason, the second partition walls 5b are densely arranged near the central portion 6 side, so that the amount of the EGR gas flowing into the outer circumferential portion is larger than that of the EGR gas flowing into the central portion, which can improve the temperature efficiency.

[0025] Additionally, as for the arrangements of the distance Ln in the whole, $Ln-1<Ln$ may not be satisfied. In short, the portion where the second partition walls 5b are arranged densely has only to be formed in a region close to the central portion 6.

(Second Embodiment)

[0026] Next, a second embodiment will be described with reference to FIG. 6. FIG. 6 is an explanatory view illustrating a heat exchanger 20 according to the second embodiment. FIG. 6 corresponds to FIG. 2 describing the first embodiment. There are following differences between the heat exchanger 20 according to the second embodiment and the heat exchanger 1 according to the first embodiment. That is, the heat conductive property of the material of a first partition wall 25a is greater than that of the material of the second partition wall 5b. Moreover, the thickness of a second partition wall 25b is the same as that of the first partition wall 25a. Other components are the same, so common components are designated with the same reference numerals in the drawings and descriptions of those components will be omitted.

[0027] The first partition wall 25a is made of a ceramic with a high heat conductivity. On the other hand, the second partition wall 25b is made of a typical ceramic, that is, a ceramic with a heat conductivity (heat conductive property) inferior to that of the material of the first partition wall 25a. Thus, heat taken from the fluid by the first partition walls 25a and the second partition walls 25b is easily transferred through the first partition walls 25a to the coolant passage 4. Unlike the first embodiment, in the heat exchanger 20 according to the second embodiment, the thickness of the first partition wall 25a can be the same as that of the second partition wall 25b. It is therefore possible to reduce the pressure loss.

(Third Embodiment)

[0028] Next, a description will be given of a heat exchanger 30 according to the third embodiment with reference to FIGs. 7(A) to (C). FIG. 7(A) is an explanatory view of the heat exchanger 30 according to the third embodiment when viewed from an inlet side. FIG. 7(B) is a sectional view taken along line B-B of FIG. 7(A). FIG. 7(C) is an explanatory view of the heat exchanger 30 according to the third embodiment when viewed from an outlet side.

[0029] A first partition wall 35a corresponding to the first heat transfer means extends from the inlet side to the outlet side of the EGR gas in a heat exchange body 35. The thickness becomes smaller from the inlet side to the outlet side. That is, the thickness Tin in the inlet side > the thickness Tout in the outlet side. The EGR gas flowing into the heat exchange body 35 becomes higher as it comes closer to the inlet side. Therefore, in order to transfer heat toward the coolant passage 4 in the inlet side, the thickness Tin in the inlet side is larger than the thickness Tout in the outlet side. This can effectively cool the EGR gas. Additionally, in the example illustrated in FIGs. 7(A) to (C), the thickness of the first partition wall 35a is changed. Herein, instead of the first partition wall 35a or in conjunction therewith, a second partition wall 35b extending from the inlet side to the outlet side of the EGR gas in the heat exchange body 35 can become thinner from the inlet side to the outlet side.

(Fourth Embodiment)

[0030] Next, a description will be given of a heat exchanger 40 according to the fourth embodiment with reference to FIGs. 8(A) to (C). FIG. 8(A) is an explanatory view of the heat exchanger 40 according to the fourth embodiment when viewed from an inlet side. FIG. 8(B) is a sectional view taken along line C-C of FIG. 8(A). FIG. 8(C) is an explanatory view of the heat exchanger 40 according to the fourth embodiment when viewed from an outlet side.

[0031] A first partition wall 45a corresponding to the first heat transfer means extends from the inlet side to the outlet side of the EGR gas in a heat exchange body 45. The thickness becomes lager from the inlet side to the outlet side. That is, the thickness Tin in the inlet side < the thickness Tout in the outlet side. This makes it possible to reduce the pressure loss in the inlet. The temperature of the EGR gas is high and the volume of the EGR gas is large in the vicinity of the inlet side, so the narrow flow passage area greatly influences on the pressure loss, which increases the pressure loss. For this reason, the thickness Tin in the inlet side is smaller than the thickness Tout in the outlet side. This can effectively cool the fluid. Further, the outlet side is made thick, so the deterioration in the temperature efficiency is suppressed. Additionally, in the example illustrated in FIGs. 8(A) to (C), the thickness of the first partition wall 45a is changed. Herein, instead of the first partition wall 45a or in conjunction therewith, a second partition wall 45b extending from the inlet side to the outlet side of the EGR gas in the heat exchange body 45 can become thicker from the inlet side to the outlet side.

[0032] In addition, the fourth embodiment is incompatible with the third embodiment, and any one can be selected depending on which is considered as important.

(Variation)

[0033] Next, various variations will be described.

[0034] FIG. 9 illustrates a heat exchanger 50 in which a cross section of a second partition wall 55b has a rectangular shape. Like the first embodiment, the heat exchanger 50 includes an EGR pipe 52, a housing 53, and a coolant passage 54, and each cross section thereof has a rectangular shape. Further, a heat exchange body 55 having first partition walls 55a and the second partition walls 55b is included. Even in such a case of providing rectangular cross-sections, the same arrangements as the first embodiment to the fourth embodiment can be employed.

[0035] Next, FIG. 10 illustrates a heat exchanger 60 in which a cross section of a second shape partition wall has a spiral shape. Like the first embodiment, the heat exchanger 60 includes the EGR pipe 2, the housing 3, and the coolant passage 4. Further, a heat exchange body 65 having first partition walls 65a intersecting second partition walls 65b having a spiral shape is included. Even in such a case where the cross section of the second partition wall 65b has a spiral shape, the same arrangements as the first embodiment to the third embodiment can be employed.

[0036] Next, FIG. 11 illustrates a heat exchanger 70 in which a cross section of a second partition wall has an elliptic shape. Like the first embodiment, the heat exchanger 70 includes an EGR pipe 72, a housing 73, and a coolant passage 74, and each cross section thereof has an elliptic shape. Further, a heat exchange body 75 having first partition walls 75a and second partition walls 75b is included. Even in such a case of providing elliptic cross-sections, the same arrangements as the first embodiment to the third embodiment can be employed.

[0037] Next, FIG. 12 illustrates a heat exchanger 80 in which coolant passages are provided in the central portion and the outer circumferential portion of the heat exchange body. The heat exchanger 80 includes a coolant passage 11 at the central portion, and in addition to the coolant passage 4 located at the outer circumferential portion. Even in such a case, the same arrangements as the first embodiment to the third embodiment can be employed. It is thus possible to effectively transfer heat to the coolant passage 4 and the coolant passage 11, thereby cooling the EGR gas.

[0038] While the exemplary embodiments of the present invention have been illustrated in detail, the present invention is not limited to the above-mentioned embodiments, and other embodiments, variations and modifications may be made without departing from the scope of the present invention. For example, it can be used for applications other than the

EGR cooler.

[DESCRIPTION OF LETTERS OR NUMERALS]

[0039]

1, 20, 30, 40, 50, 60, and 70	heat exchanger
2	EGR pipe
3, 53, 73	housing
4, 54, 74	coolant passage
5, 25, 55, 65, 75	heat exchange body
5a, 25a, 55a, 65a, 75a	first partition wall
5b, 25b, 55b, 65b, 75b	second partition wall

Claims

1. A heat exchanger comprising:

a heat exchange body through which a fluid serving as a cooled object passes; and
a coolant passage which is provided in at least one of a central portion and an outer circumferential portion of the heat exchange body, and through which a coolant exchanging heat with the heat exchange body flows, wherein
the heat exchange body includes:

a first heat transfer means which extends from a central portion to an outer circumferential portion; and
a second heat transfer means which extends in a circumferential direction, and which intersects the first heat transfer means,

a heat transfer efficiency of the first heat transfer means is greater than that of the second heat transfer means.

2. The heat exchanger of claim 1, wherein
the first heat transfer means is first partition walls extending radially from a central portion to an outer circumferential portion of the heat exchange body,
the second heat transfer means is second partition walls having a concentric shape,
a thickness of the first partition wall is larger than that of the second partition wall.

3. The heat exchanger of claim 1 or 2, wherein
the first heat transfer means is first partition walls extending radially from a central portion to an outer circumferential portion of the heat exchange body,
the second heat transfer means is second partition walls having a concentric shape,
a heat conductive property of a material of the first partition wall is greater than that of a material of the second partition wall.

4. The heat exchanger of any one of claims 1 to 3, wherein
the first heat transfer means is a first partition wall extending from an inlet side to an outlet side of a fluid serving as a cooled object in the heat exchange body,
the second heat transfer means is a second partition wall extending from an inlet side to an outlet side of a fluid serving as a cooled object in the heat exchange body,
at least one of a thickness of the first partition wall and the second partition wall includes a portion having a thickness becoming smaller from the inlet side to an outlet side.

5. The heat exchanger of any one of claims 1 to 3, wherein
the first heat transfer means is a first partition wall extending from an inlet side to an outlet side of a fluid serving as a cooled object in the heat exchange body,
the second heat transfer means is a second partition wall extending from an inlet side to an outlet side of a fluid serving as a cooled object in the heat exchange body,
at least one of a thickness of the first partition wall and the second partition wall includes a portion having a thickness

becoming larger from the inlet side to an outlet side.

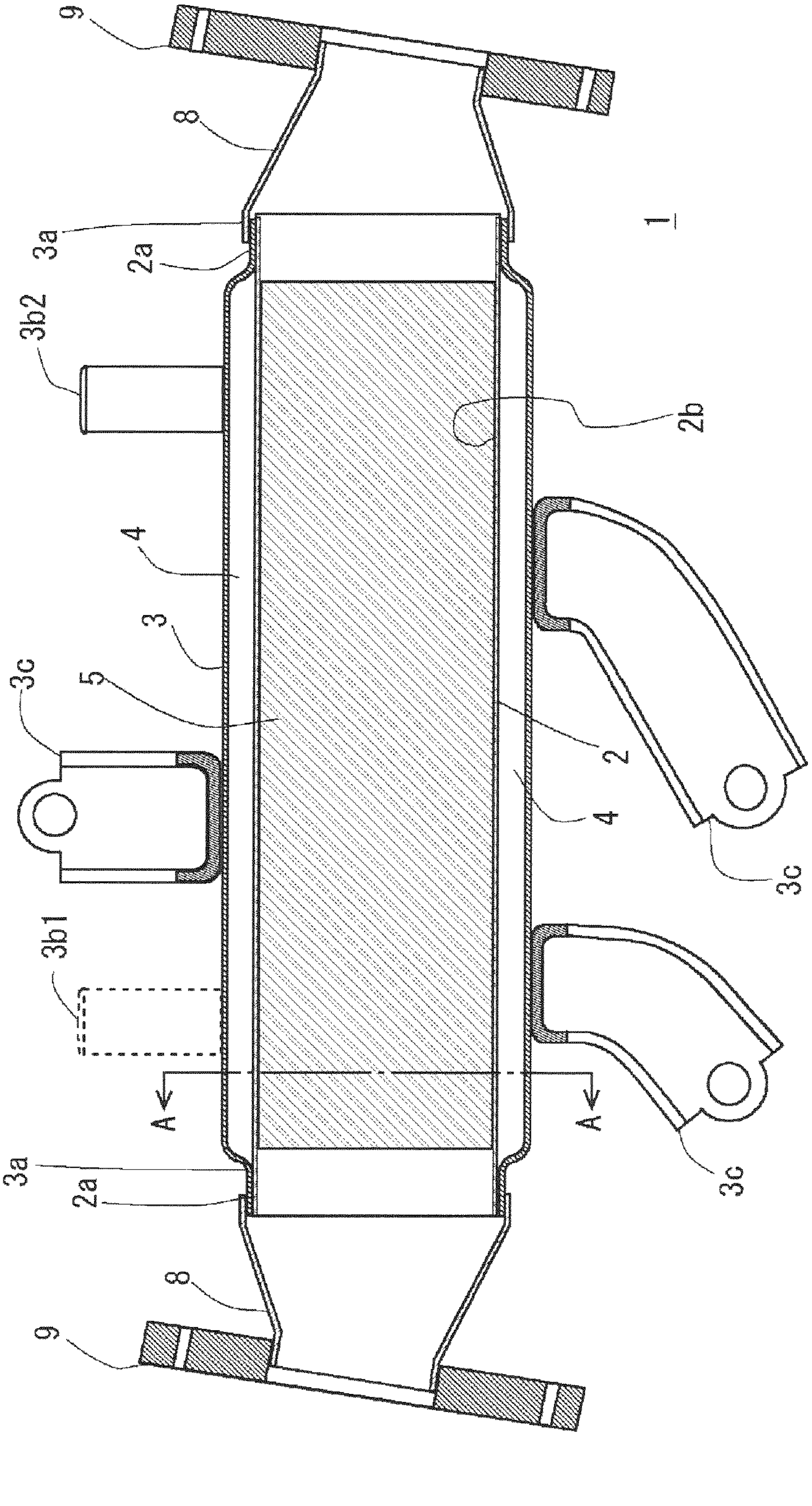


FIG. 1

FIG. 2

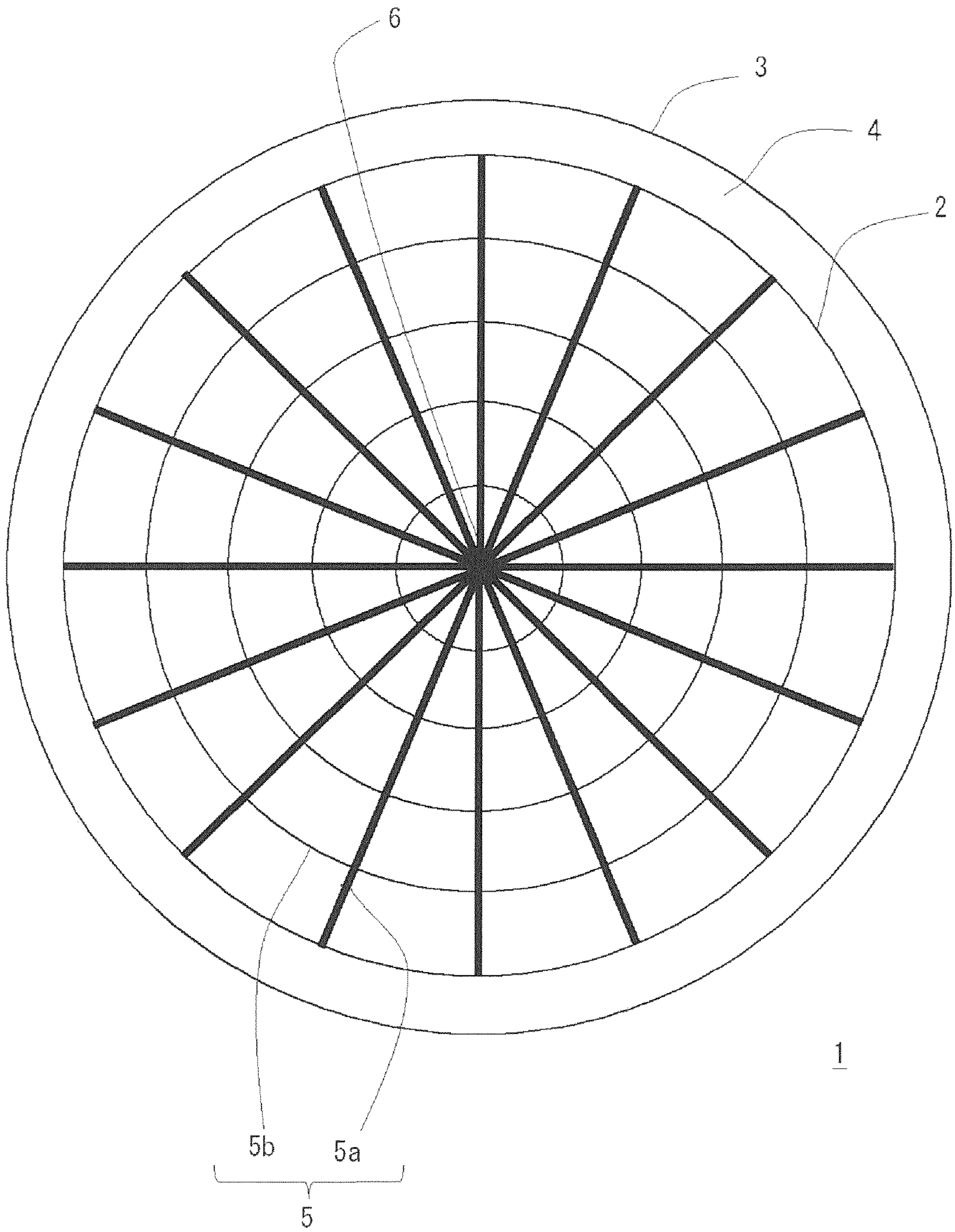


FIG. 3

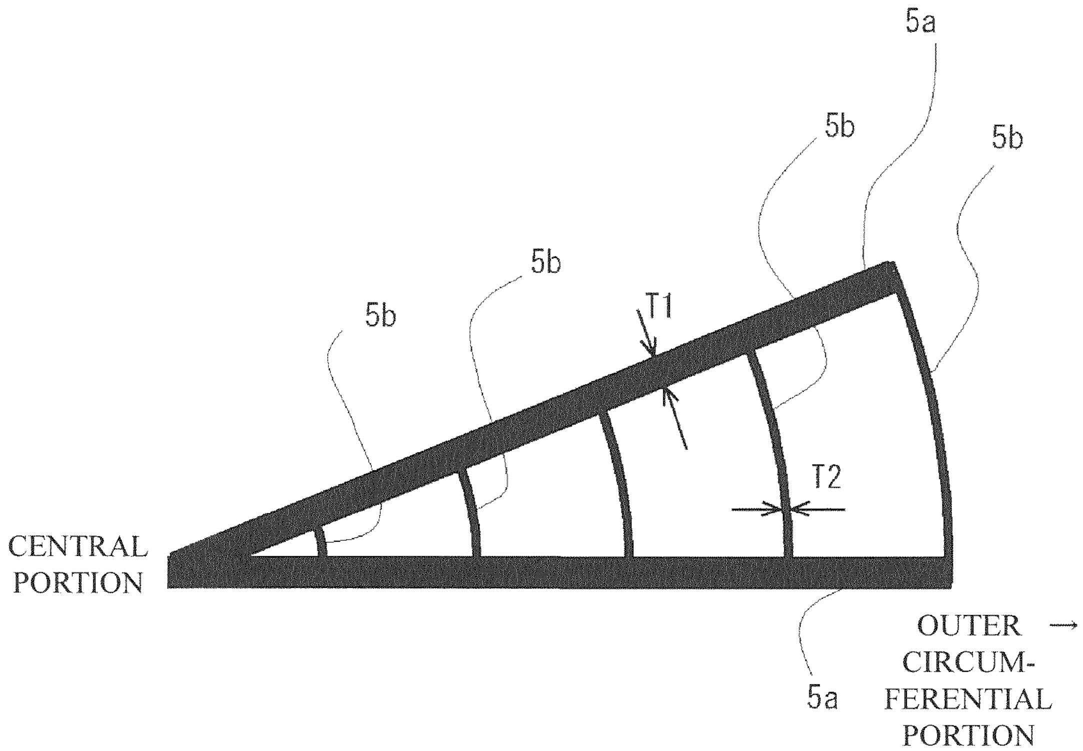

5a
5b
5b
5b
5b
T1
T2
CENTRAL
PORTION
OUTER →
CIRCUM-
FERENTIAL
PORTION
5a

FIG. 4

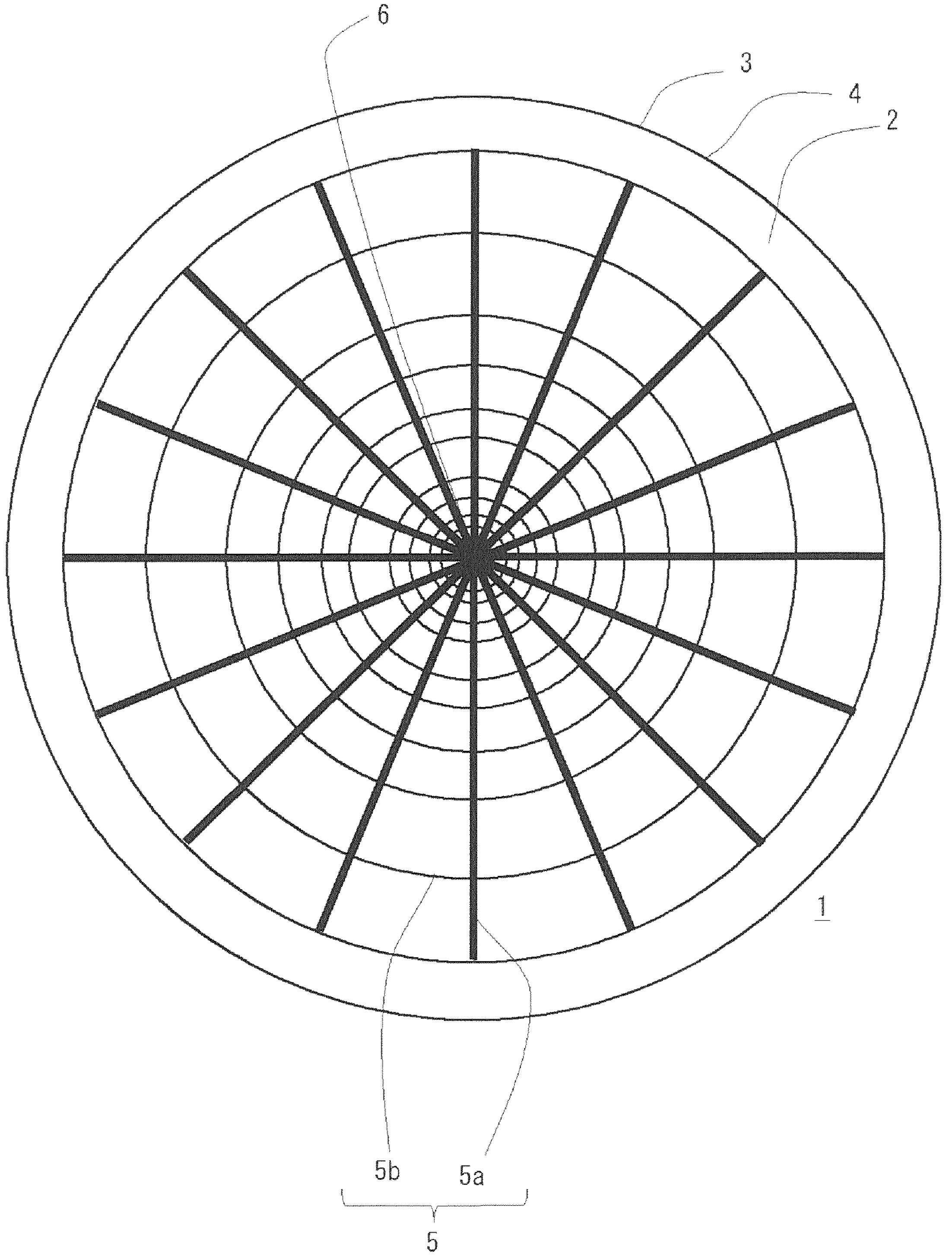
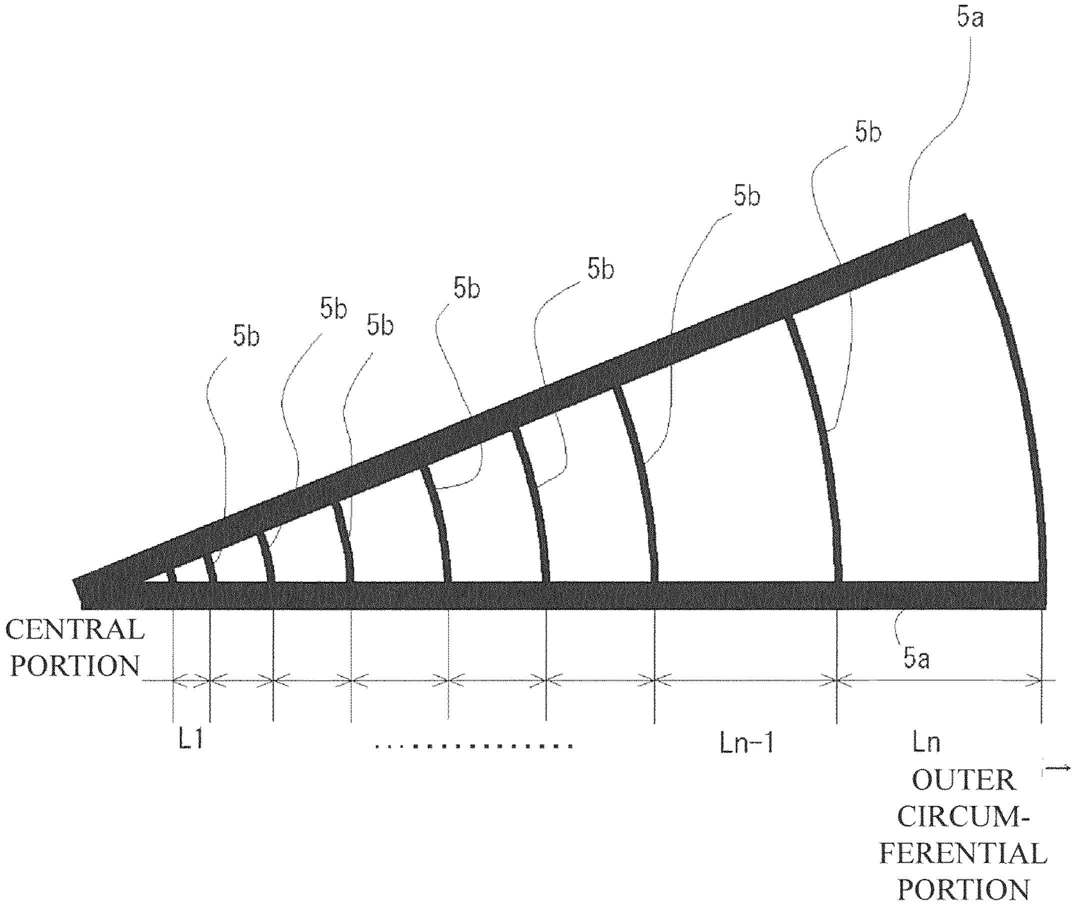


FIG. 5


5a
5b
5b
5b
5b
5b
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CENTRAL PORTION
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L1
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Ln-1
Ln
OUTER CIRCUM-FERENTIAL PORTION

FIG. 6

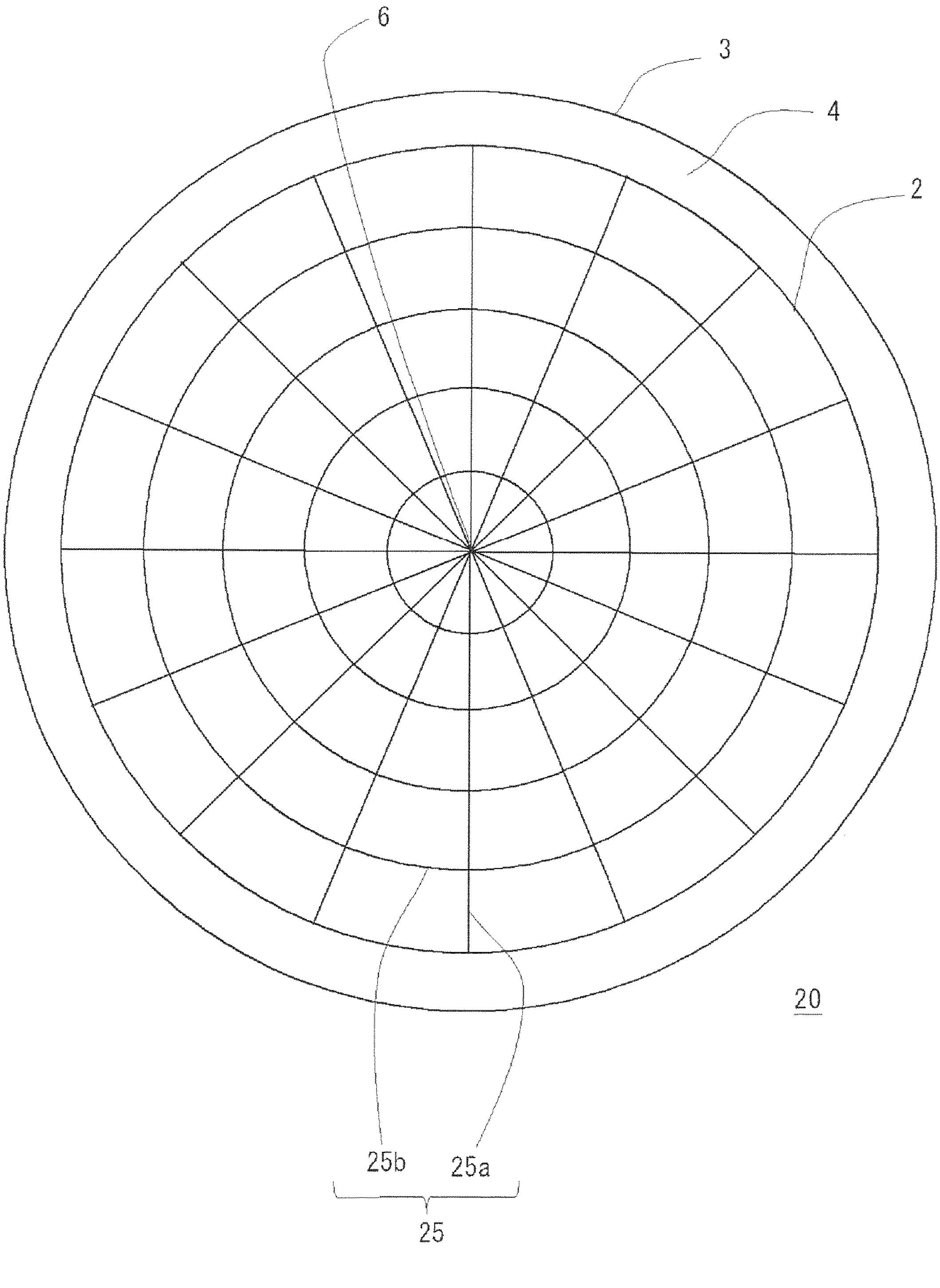


FIG. 7A

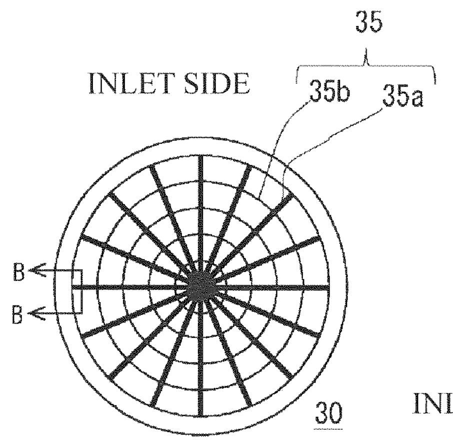


FIG. 7B

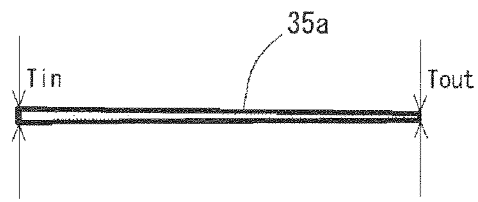


FIG. 7C

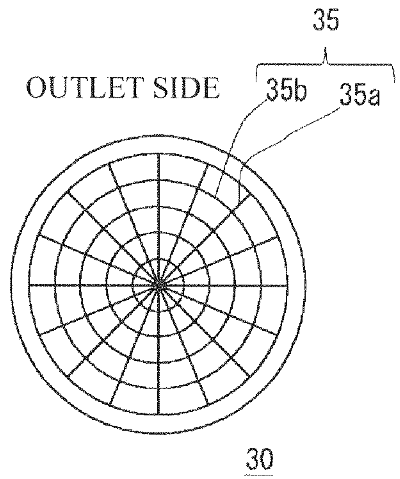


FIG. 8A

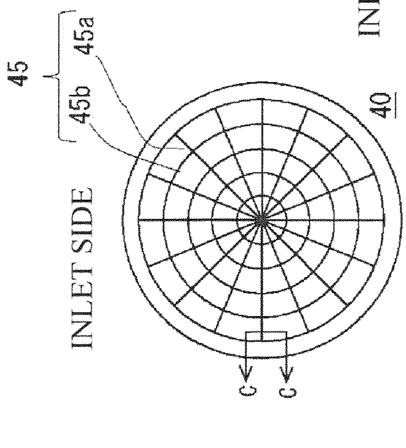


FIG. 8B

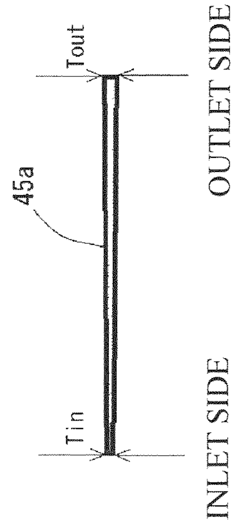


FIG. 8C

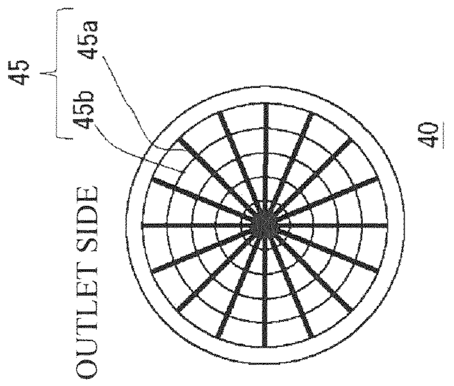


FIG. 9

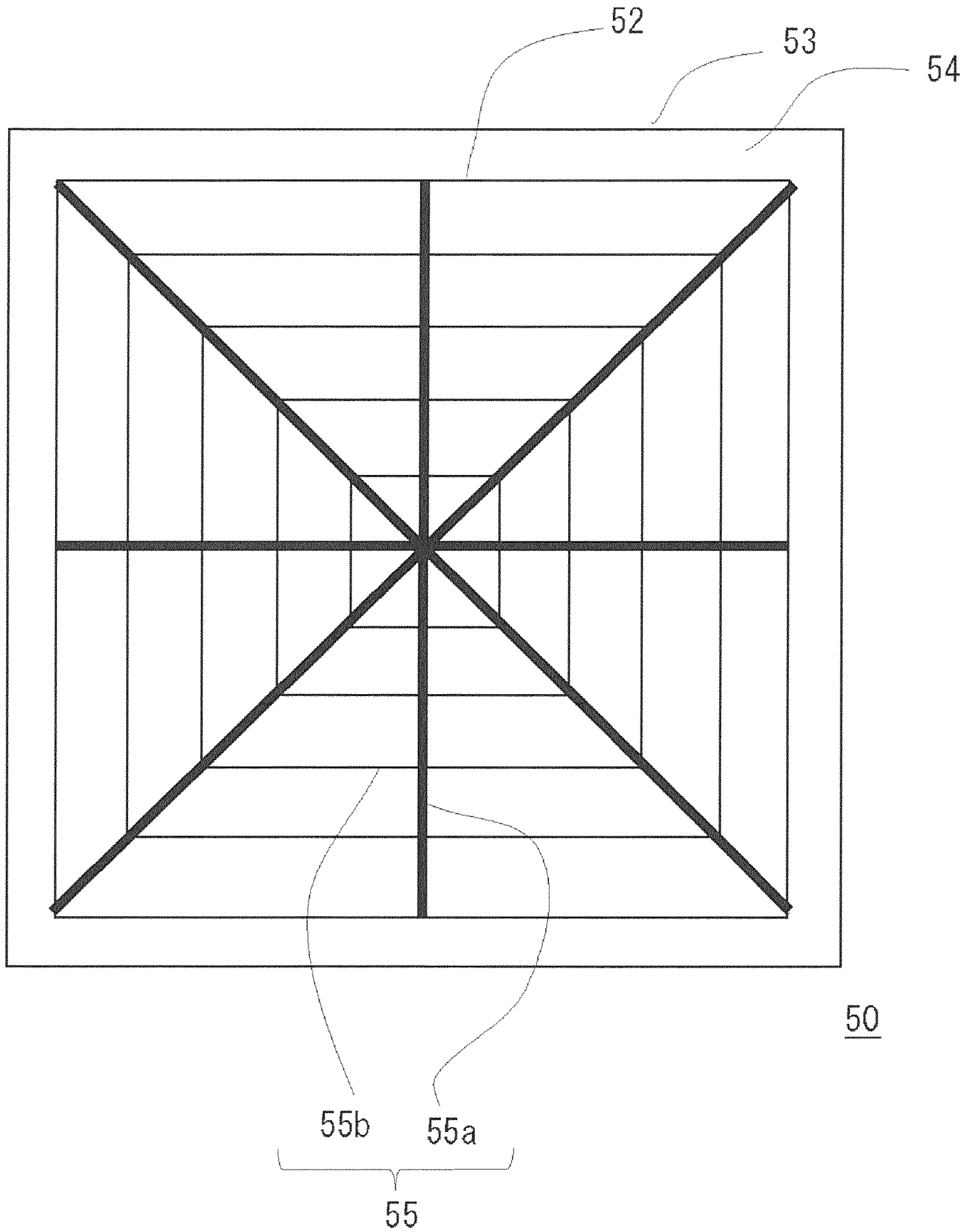


FIG. 10

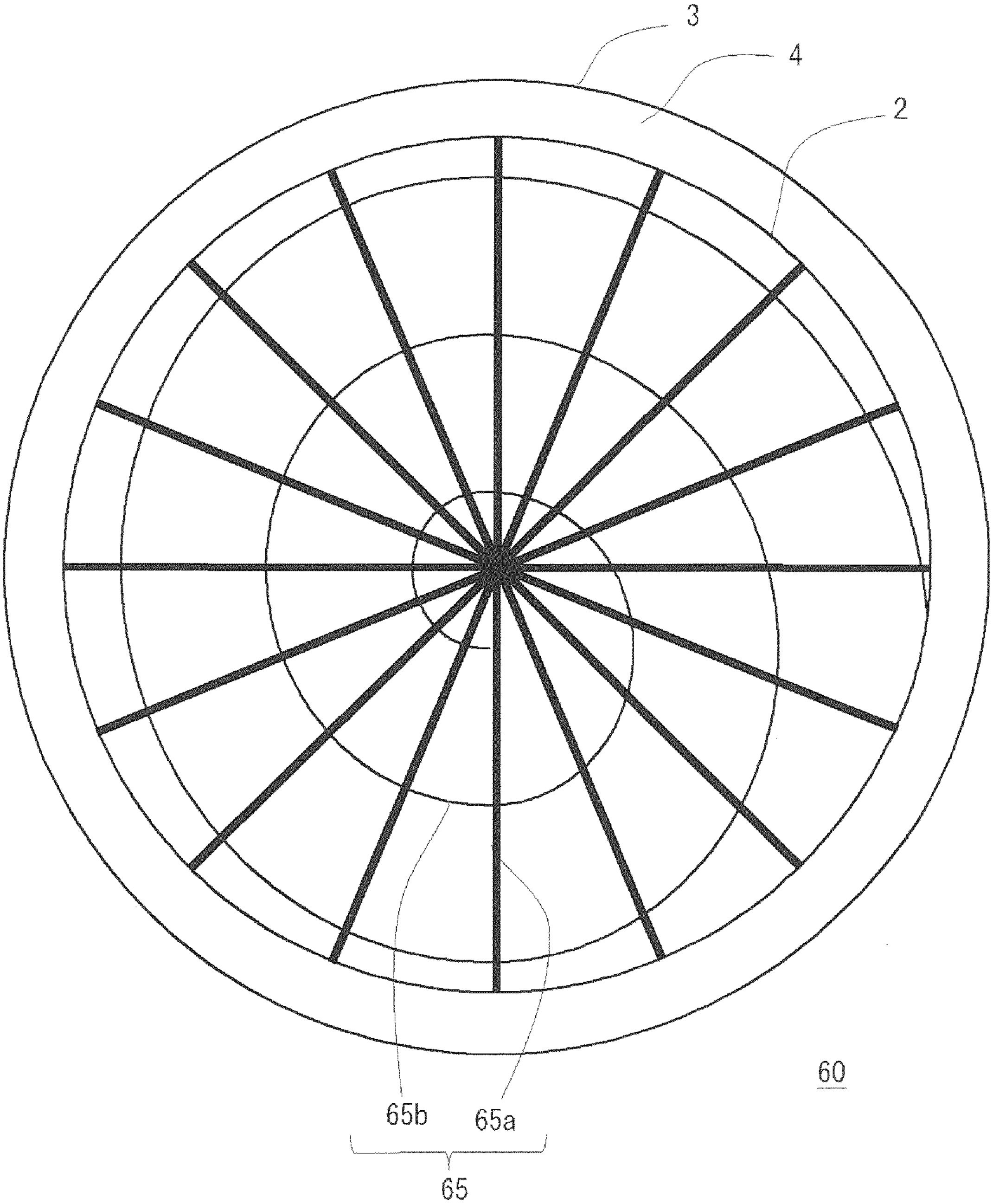


FIG. 11

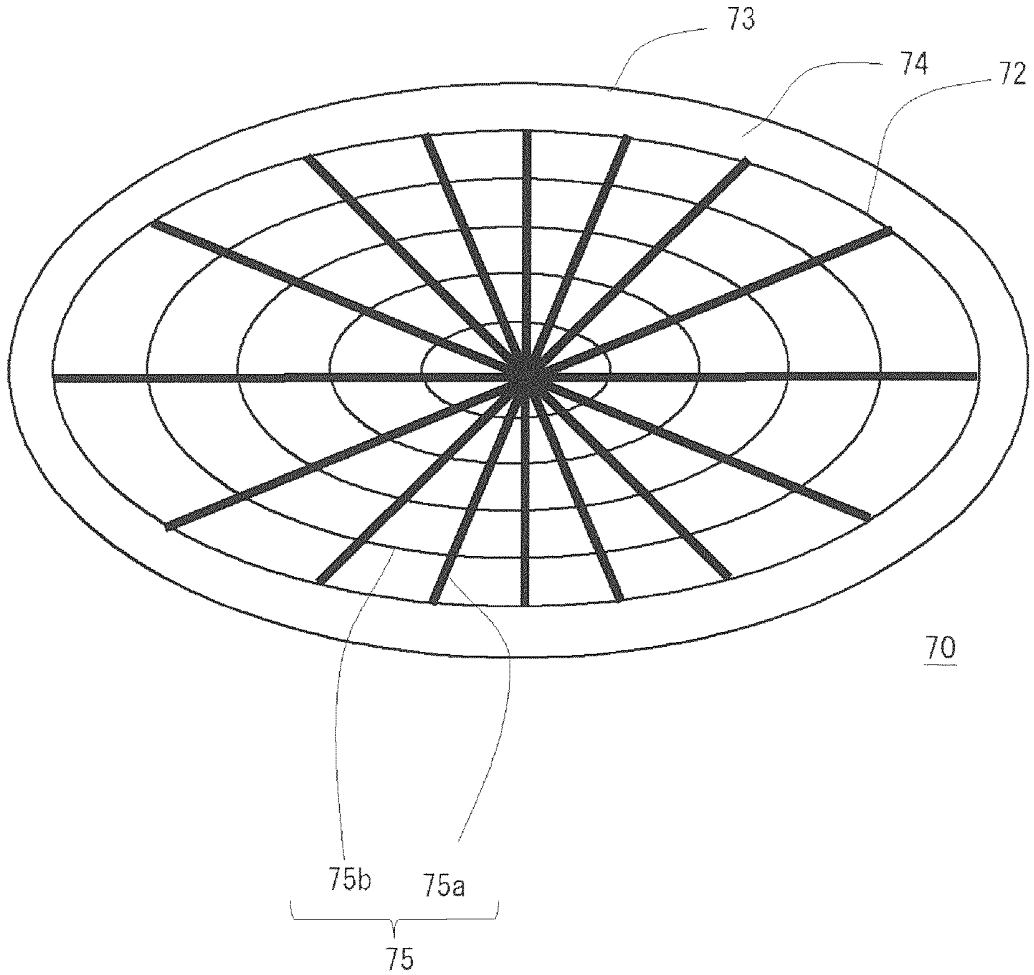
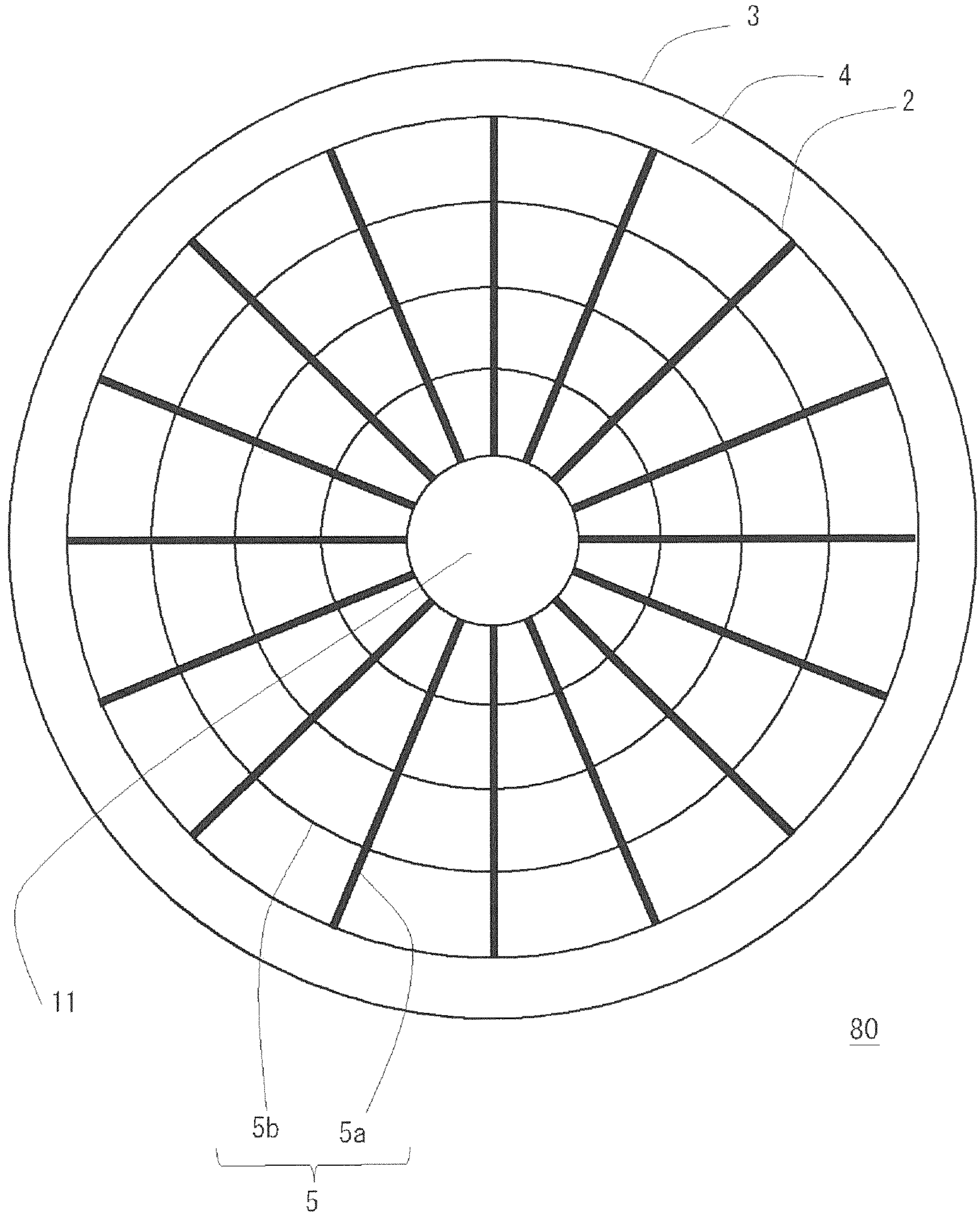


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/077641

A. CLASSIFICATION OF SUBJECT MATTER
F28F1/40(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28F1/40

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 04-356689 A (Kazumi Seisakusyo Co., Ltd.), 10 December 1992 (10.12.1992), column 3, line 48 to column 4, line 34; fig. 1 to 3, 8 (Family: none)	1-3 4-5
X Y	JP 63-150584 A (Dai-Ichi High Frequency Co., Ltd.), 23 June 1988 (23.06.1988), page 2, upper right column, line 16 to lower right column, line 12; fig. 4 to 5 (Family: none)	1-3 4-5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search 07 January, 2013 (07.01.13)	Date of mailing of the international search report 15 January, 2013 (15.01.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/077641

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2011-518303 A (Wolverine Tube, Inc.), 23 June 2011 (23.06.2011), page 7, lines 35 to 44; fig. 4 & US 2009/0260792 A1 & EP 2291249 A & WO 2009/128824 A1 & MX 2010011346 A & KR 10-2011-0003498 A	4-5
A	JP 2008-292017 A (Toyota Motor Corp.), 04 December 2008 (04.12.2008), entire text; all drawings (Family: none)	1-5
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 144232/1984(Laid-open No. 059111/1986) (Isuzu Motors Ltd.), 21 April 1986 (21.04.1986), entire text; all drawings (Family: none)	1-5
A	JP 2012-189229 A (NGK Insulators, Ltd.), 04 October 2012 (04.10.2012), entire text; all drawings (Family: none)	1-5
A	JP 2011-075216 A (Daikin Industries, Ltd.), 14 April 2011 (14.04.2011), entire text; all drawings (Family: none)	1-5
A	JP 61-149790 A (Isuzu Motors Ltd.), 08 July 1986 (08.07.1986), entire text; all drawings (Family: none)	1-5
A	JP 2003-100974 A (TDK Corp.), 04 April 2003 (04.04.2003), entire text; all drawings (Family: none)	1-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2011071161 A **[0003]**
- JP 2003100974 A **[0003]**