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(54) SERPENTINE HEAT EXCHANGER

(57) A serpentine heat exchanger includes a tube formed by bonding two press-molded tube sheets and folded back in a serpentine shape, and a corrugated fin arranged in a space enclosed by the tube that is folded-back. An inside of a folded-back portion of the tube includes a plurality of protrusions at a distance from one another, the protrusions protruding from one tube sheet and contacting the other tube sheet.

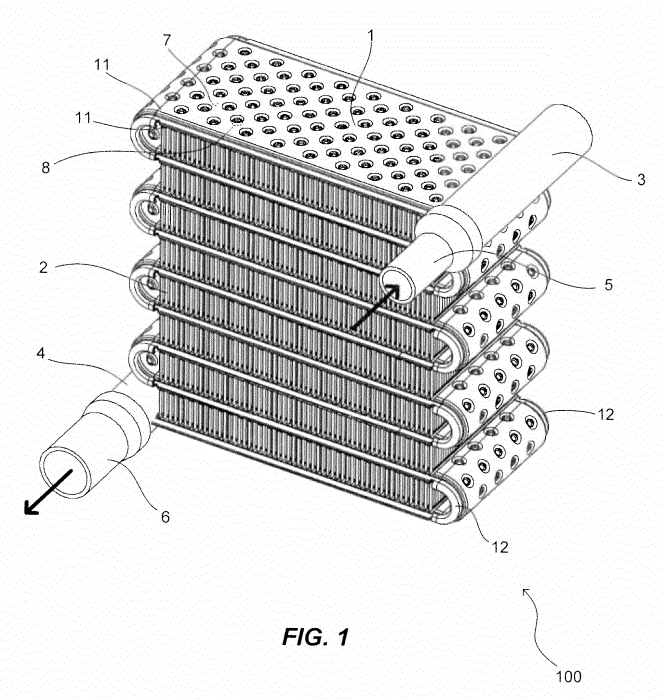


FIG. 1

EP 2 722 628 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a serpentine heat exchanger.

BACKGROUND ART

[0002] A serpentine heat exchanger disclosed in JP2001-27484A has been known as a heat exchanger used as an evaporator or a capacitor of an air conditioner for a vehicle.

[0003] The serpentine heat exchanger has a configuration in which a tube having a medium passage inside thereof is folded back in a serpentine (meandering) shape, and a fin is arranged in a space enclosed by the folded tube.

[0004] The serpentine heat exchanger has an advantage that changes in length and folding positions/the number of folds of the tube enable various sizes, that is, various capacities, of heat exchangers to be manufactured.

SUMMARY OF INVENTION

[0005] A serpentine heat exchanger needs to include fins as many as possible to achieve size reduction and high efficiency thereof by reducing a curvature radius of a folded portion of a tube by thinning a wall of the tube, and reducing a space inside the folded portion, the space being in which the fin is not arranged.

[0006] However, since the tube used for the serpentine heat exchanger is molded by an extrusion molding, a wall of the tube has been difficult to be thinned.

[0007] Moreover, medium passages formed in the tube are a plurality of parallel passages as illustrated in Fig. 6. In such a passage structure, a medium flowing in one passage is not mixed with a medium flowing in the other passage, so that a temperature difference is generated between the passages, causing difficulty in achieving high efficiency of the heat generator.

[0008] The present invention has been made to solve such technical problems, and an object of the present invention to achieve size reduction and high efficiency of a serpentine heat exchanger.

[0009] According to one aspect of the present invention, a serpentine heat exchanger includes a tube formed by bonding two press-molded tube sheets and folded back in a serpentine shape, and a fin arranged in a space enclosed by the tube that is folded-back, wherein an inside of a folded-back portion of the tube includes a plurality of protrusions at a distance from one another, the protrusions protruding from one tube sheet and contacting the other tube sheet.

[0010] According to the above aspect, the serpentine-shaped tube is formed by superposing the press-molded tube sheets and folding back the superposed tube sheets. Since a wall of the tube can be thinner than that of a tube manufactured by extrusion molding, a curvature radius of the folded portion can be reduced. This can reduce a space inside the folded portion, the space being in which the fin cannot be disposed. Thus, a larger number of the fins can be arranged, thereby achieving size reduction and high efficiency of the heat exchanger.

[0011] Moreover, a medium flowing inside the tube flows while being constantly mixed through gaps among the protrusions. This also allows the heat exchanger to achieve high efficiency.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

[Fig. 1] Fig. 1 is an overall configuration view of a serpentine heat exchanger according to a first embodiment of the present invention.
[Fig. 2A] Fig. 2A is a diagram illustrating a tube which is cut in a folded-back portion in a lateral direction.
[Fig. 2B] Fig. 2B is a diagram illustrating a tube which is cut in a straight portion in a lateral direction.
[Fig. 2C] Fig. 2C is a diagram illustrating a tube which is cut in a folded-back portion and a straight portion in a longitudinal direction.
[Fig. 3] Fig. 3 is a cross-sectional view of a tube.
[Fig. 4A] Fig. 4A is a diagram explaining a manufacturing method.
[Fig. 4B] Fig. 4B is a diagram explaining the manufacturing method.
[Fig. 4C] Fig. 4C is a diagram explaining the manufacturing method.
[Fig. 4D] Fig. 4D is a diagram explaining the manufacturing method.
[Fig. 4E] Fig. 4E is a diagram explaining the manufacturing method.
[Fig. 4F] Fig. 4F is a diagram explaining the manufacturing method.
[Fig. 4G] Fig. 4G is a diagram explaining the manufacturing method.
[Fig. 4H] Fig. 4H is a diagram explaining the manufacturing method.
[Fig. 5] Fig. 5 is a cross-sectional view of a tube according to a second embodiment of the present invention.
[Fig. 6] Fig. 6 is a cross-sectional view of a conventional tube.

DESCRIPTION OF EMBODIMENTS

[0013] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

<First embodiment>

[0014] Fig. 1 is an overall configuration view of a serpentine heat exchanger (hereinafter called "a heat ex-

changer") 100 according to a first embodiment of the present invention.

[0015] The heat exchanger 100 includes a tube 1, a corrugated fin 2, an inlet adapter 3, an outlet adapter 4, an inlet pipe 5, and an outlet pipe 6.

[0016] The tube 1 is formed by superposing tube sheets 11 (see Fig. 4A) and folding back the superposed tube sheets 11 in a serpentine (meandering) shape. Each of the tube sheets 11 includes a recessed groove 7 and a plurality of truncated conical protrusions 8 (see Fig. 2A through Fig. 2C and Fig. 3) formed by press molding, the truncated conical protrusions 8 protruding inside the recessed groove 7. In the description below, a folded back portion of the tube 1 is expressed as "a folded-back portion", whereas a portion that is not folded back is expressed as "a straight portion".

[0017] Fig. 2A through Fig. 2C are diagrams respectively illustrating the tube 1 cut in the folded-back portion in a lateral direction, the tube 1 cut in the straight portion in a lateral direction, and the tube 1 cut in the folded-back portion and the straight portion in a longitudinal direction. Fig. 3 is a cross-sectional view of the tube 1.

[0018] As illustrated in these diagrams, the protrusions 8 of one tube sheet 11 butt the protrusions 8 of the other tube sheet 11, so that pillars extending in a thickness direction of the tube 1 are formed inside the tube 1. The protrusions 8 are formed at a distance from one another in a surface direction (a flow direction of a medium and a direction perpendicular thereto) of the tube sheet 11. The protrusions 8 reinforce the straight portion, and prevent reduction in an area of passage cross-section due to a crush of the tube 1 in the folded-back portion. The protrusions 8 are arranged in a staggered pattern, and do not block the passage of the medium.

[0019] In the folded-back portion of the tube 1, tabs 12 of the tube sheets 11 are folded in a folding back direction of the tube 1, so that the tube sheets 11 are swaged together.

[0020] The corrugated fin 2 is a fin formed by folding a metal plate in a corrugated shape. The corrugated fin 2 is arranged in each of the plurality of U-shaped spaces formed by the folded-back tube 1, and an upper end and a lower end thereof contact the tube 1.

[0021] The inlet adapter 3 and the inlet pipe 5 are connected to one end of the tube 1. The outlet adapter 4 and the outlet pipe 6 are connected to the other end of the tube 1.

[0022] The heat exchanger 100 according to the first embodiment is configured as described above, so that a medium flowing into the inlet adapter 3 from the inlet pipe 5 flows from a lower side to an upper side in the figure by passing inside the meandering tube 1. In the course of this process, heat of the medium is exchanged with the air passing through the corrugated fins 2. After exchanging the heat, the medium is fed to the outlet adapter 4 and discharged from the outlet pipe 6.

[0023] Next, a manufacturing method of the heat exchanger 100 according to the first embodiment is described with reference to Fig. 4A through Fig. 4H.

[0024] First, the tube sheet 11 is manufactured by press working (Fig. 4A). The tube sheet 11 has the recessed groove 7 extending in a longitudinal direction in the middle thereof. The plurality of protrusions 8, at a distance from one another in a surface direction of the tube sheet 11, protrudes from a bottom of the recessed groove 7. The protrusion 8 has a height equal to a depth of the recessed groove 7. Moreover, the tabs 12 are formed on both sides of a portion to be the folded-back portion.

[0025] Next, two tube sheets 11 are prepared and superposed such that the recessed grooves 7 are provided inside, thereby forming the tube 1 (Fig. 4B). Herein, the two tube sheets 11 are aligned such that positions of the protrusions 8 and the tabs 12 of one tube sheet 11 coincide with positions of the protrusions 8 and the tabs 12 of the other tube sheet 11. The superposition of the recessed grooves 7 forms a medium passage inside the tube 1. Moreover, the protrusions 8 are butted together, so that the pillars extending in a thickness direction are formed inside the tube 1.

[0026] Subsequently, the tabs 12 are folded, and the tube sheets 11 are swaged together (Fig. 4C). The tabs 12 are folded in the same direction as that in which the tube 1 is folded.

[0027] Next, the tube 1 is folded back at a plurality of locations, and thus formed in a serpentine shape (Fig. 4D). When the tube 1 is fold back, force is applied to both sides of the portion to be folded back while a jig is contacting this portion. In this portion, since the tube sheets 11 are swaged together by the tabs 12, the two tube sheets 11 can remain in close contact with each other even after the tube 1 is folded back, and a gap is not generated on a side surface of the tube 1.

[0028] Next, the inlet adapter 3 is connected to one end of the tube 1, and the outlet adapter 4 is connected to the other end (Fig. 4E). Each of the inlet adapter 3 and the outlet adapter 4 has a cylindrical shape, and includes an opening on an end surface thereof and a slit-shaped opening on a side surface thereof. The inlet pipe 5 or the outlet pipe 6 is connected to the opening, whereas the end of the tube 1 is connected to the slit-shaped opening.

[0029] Subsequently, the corrugated fin 2 is inserted and arranged in a space between the folded-back tube 1 (Fig. 4F).

[0030] Next, the inlet pipe 5 is connected to the inlet adapter 3, and the outlet pipe 6 is connected to the outlet adapter 4 (Fig. 4G).

[0031] Lastly, the entire heat exchanger is placed in a furnace, and each of the components is bonded by blazing (Fig. 4H).

[0032] Now, an operational effect of the first embodiment is described.

[0033] According to the first embodiment, the serpentine-shaped tube 1 is formed by superposing the press-molded tube sheets 11 and folding back the superposed tube sheets 11 at a plurality of locations. Since a wall of

the tube 1 can be thinner than that of a tube manufactured by extrusion molding, a curvature radius of the folded portion can be reduced. This can reduce a space inside the folded portion, the space being in which the corrugated fin 2 cannot be disposed. Thus, a larger number of the corrugated fins 2 can be arranged, thereby achieving size reduction and high efficiency of the heat exchanger 100.

[0034] Moreover, in a case where a wall thickness of the tube 1 is reduced, there is a possibility that the tube 1 may be crushed in a folded portion. In the first embodiment, however, since pillars are formed inside the tube 1 by the protrusions 8 protruding from the tube sheet 11, a reduction in a passage cross-sectional area due to a crush of the tube 1 in the folded portion does not occur.

[0035] In addition, a medium flowing inside the tube 1 flows while being constantly mixed through gaps among the protrusions 8 (pillars). This also enables the heat exchanger 100 to achieve high efficiency.

[0036] Moreover, in the folded-back portion, the tube sheets 11 are swaged together with the tabs 12. Accordingly, when the tube 1 is folded back, the tube sheets 11 are not separated from each other, thereby preventing generation of a gap on a side surface of the tube 1.

[0037] Moreover, since the protrusion 8 formed on the tube sheet 11 has a truncated conical shape, strength of the tube 1 in the straight portion can be ensured, and foldability in the folded portion can also be ensured.

<Second embodiment>

[0038] A second embodiment differs from the first embodiment in a forming method of a pillar to be formed inside a tube 1.

[0039] In the first embodiment, the protrusions 8 are formed on both of the two tube sheets 11 forming the tube 1, and then butted together to form pillars. In the second embodiment, however, protrusions 8 are formed on only one tube sheet 11. The protrusions 8 are not formed on the other tube sheet 11. In the second embodiment, the protrusions 8 formed on one tube sheet 11 are butted on a flat surface of the other tube sheet 11, so that pillars are formed inside the tube 1.

[0040] Fig. 5 is a cross-sectional view of the tube 1 according to the second embodiment. The protrusions 8 are formed on only one tube sheet 11, and not formed on the other tube sheet 11. With such a structure, pillars can be formed inside the tube 1. This structure does not require alignment of the protrusions 8, and can simplify a manufacturing process.

[0041] Since other configurations are the same as the first embodiment, the descriptions thereof are omitted.

[0042] While the embodiments of the present invention have been described, it is to be understood that the above embodiments are examples of application of the present invention, and a technical scope of the present invention is not limited to the particular configurations of the above embodiments.

[0043] For example, in the above embodiments, the protrusions 8 are formed on the entire tube 2. However, the protrusions 8 may be provided in at least a folded portion. If strength of a straight portion can be ensured without the protrusions 8, the straight portion does not need to have the protrusions 8.

[0044] Moreover, the protrusion 8 may have a cylindrical shape or a prism shape (a triangular prism, a quadrangular prism, and the like) instead of a truncated conical shape.

[0045] This application claims priority from Japanese Patent Application No. 2011-135178 filed with Japan Patent office on June 17, 2011, which is hereby incorporated by reference herein in its entirely.

Claims

1. A serpentine heat exchanger comprising:

   a tube formed by bonding two press-molded tube sheets and folded back in a serpentine shape; and
   a fin arranged in a space enclosed by the tube that is folded-back, wherein
   an inside of a folded-back portion of the tube includes a plurality of protrusions at a distance from one another, the protrusions protruding from a first tube sheet and contacting a second tube sheet.

2. The serpentine heat exchanger according to claim 1, wherein
   an inside of a straight portion of the tube also includes the protrusions.

3. The serpentine heat exchanger according to claim 1, wherein
   the protrusion is butted on another protrusion protruding from the second tube sheet.

4. The serpentine heat exchanger according to claim 1, wherein
   the protrusions are formed only on the first tube sheet.

5. The serpentine heat exchanger according to claim 1, wherein
   the protrusions are arranged in a staggered pattern.

6. The serpentine heat exchanger according to claim 1, wherein
   the protrusion has a truncated conical shape, a cylindrical shape, or a prism shape.

7. The serpentine heat exchanger according to claim 1, wherein
   the first tube sheet and the second tube sheet are

swaged together on both sides in the folded-back portion of the tube.

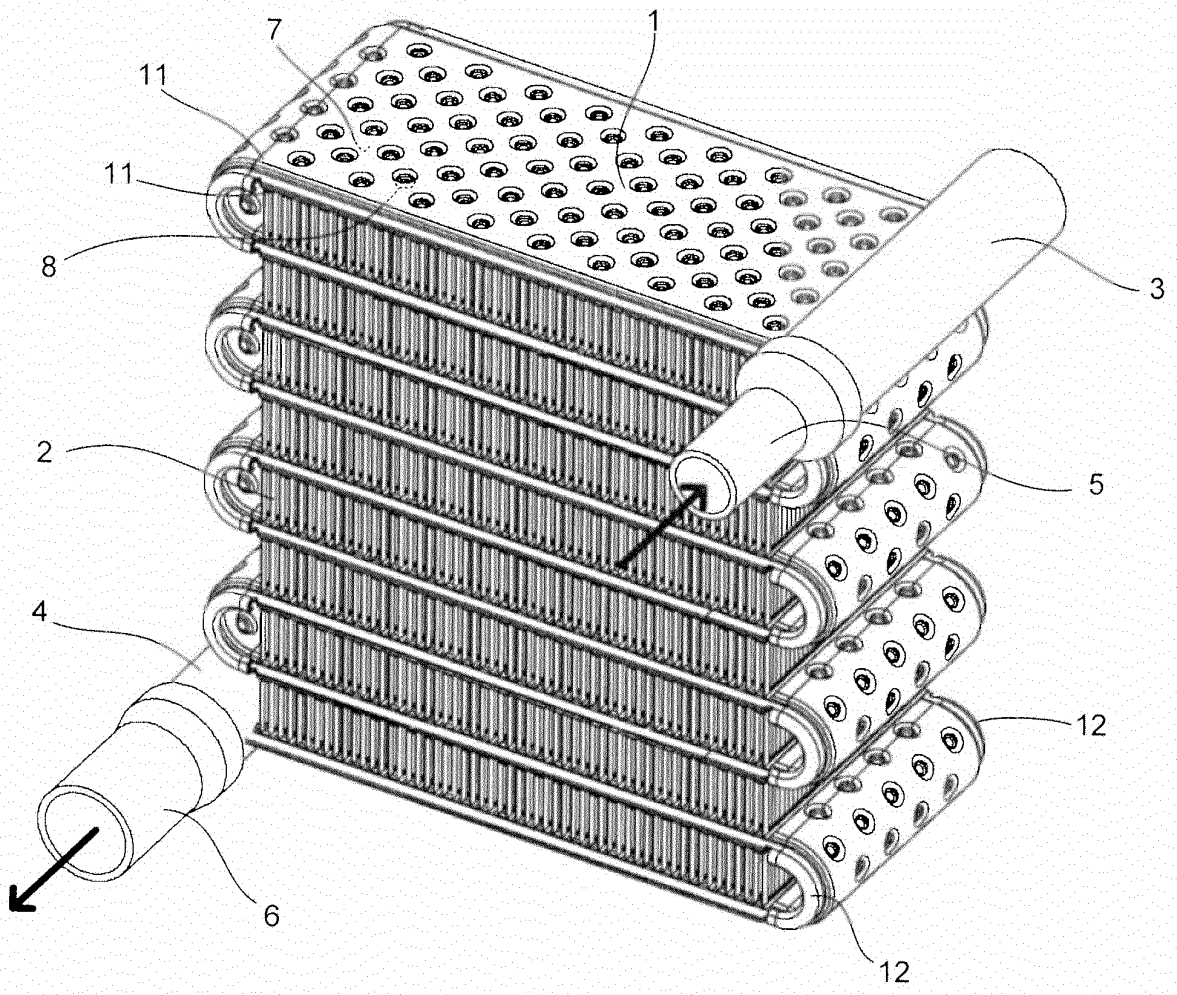


FIG. 1

FIG. 2A

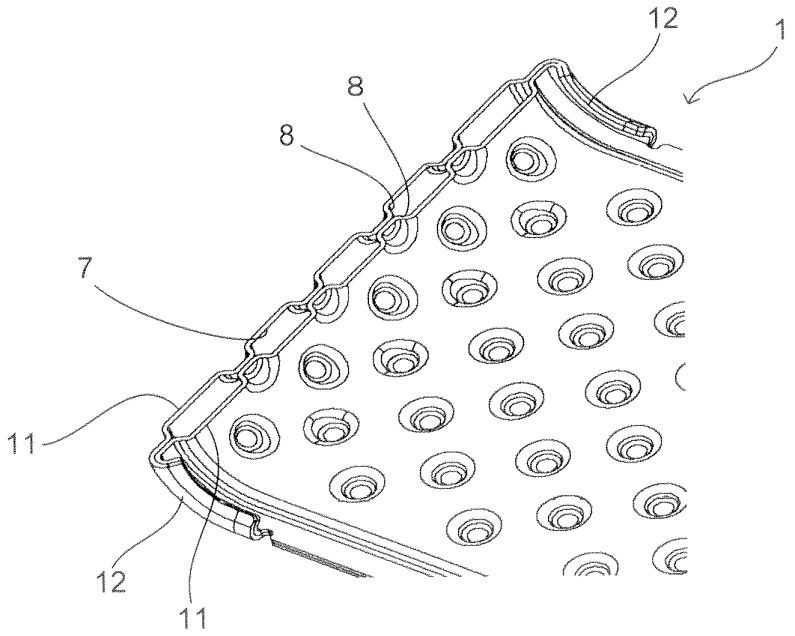


FIG. 2B

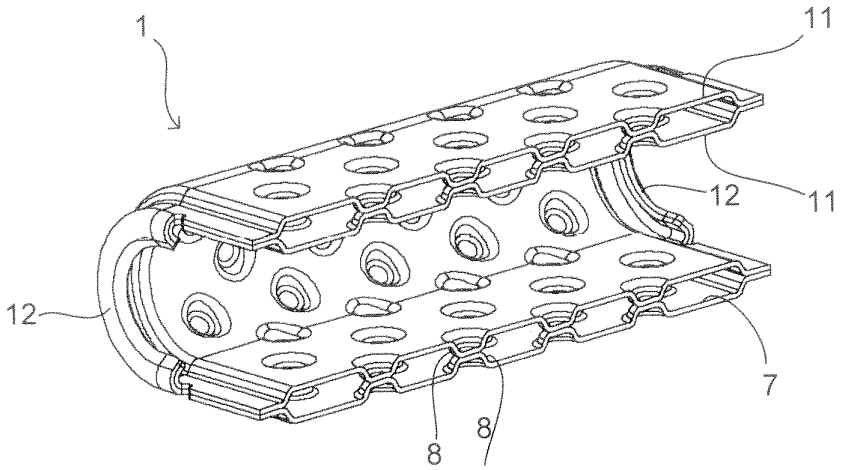
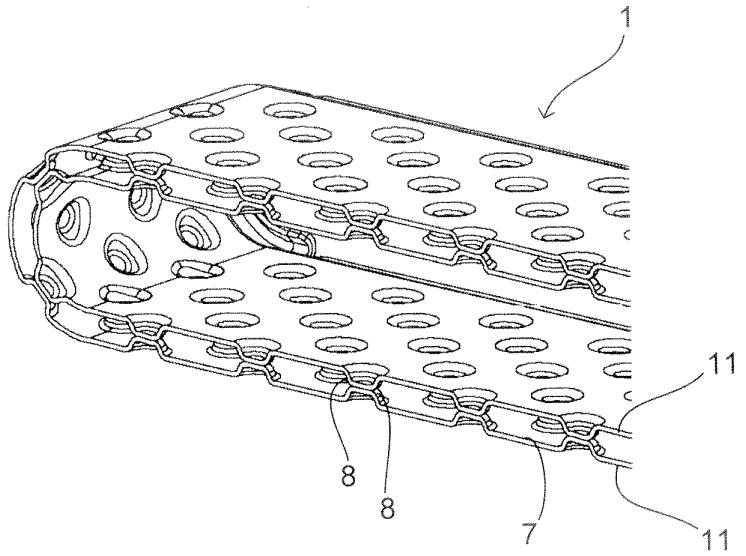


FIG. 2C



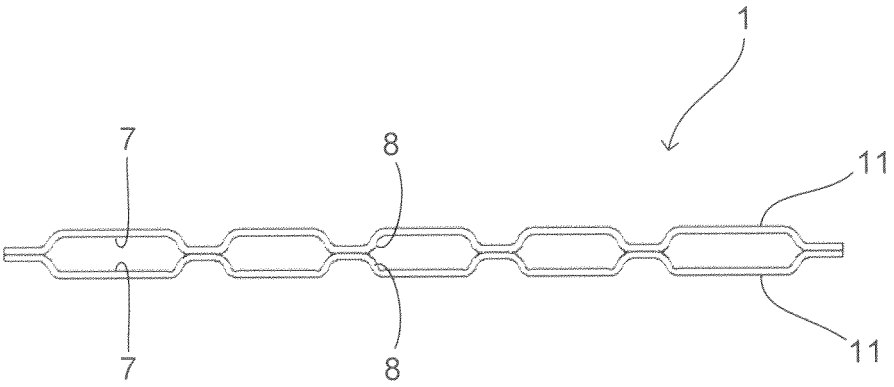


FIG. 3

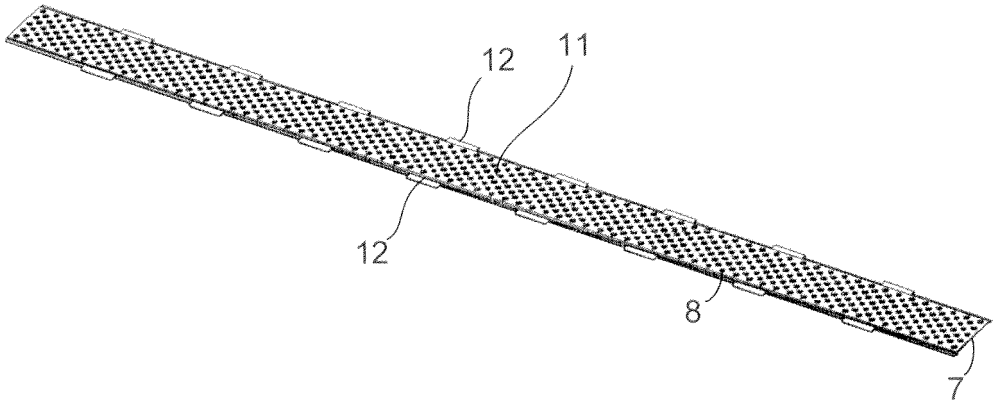


FIG. 4A

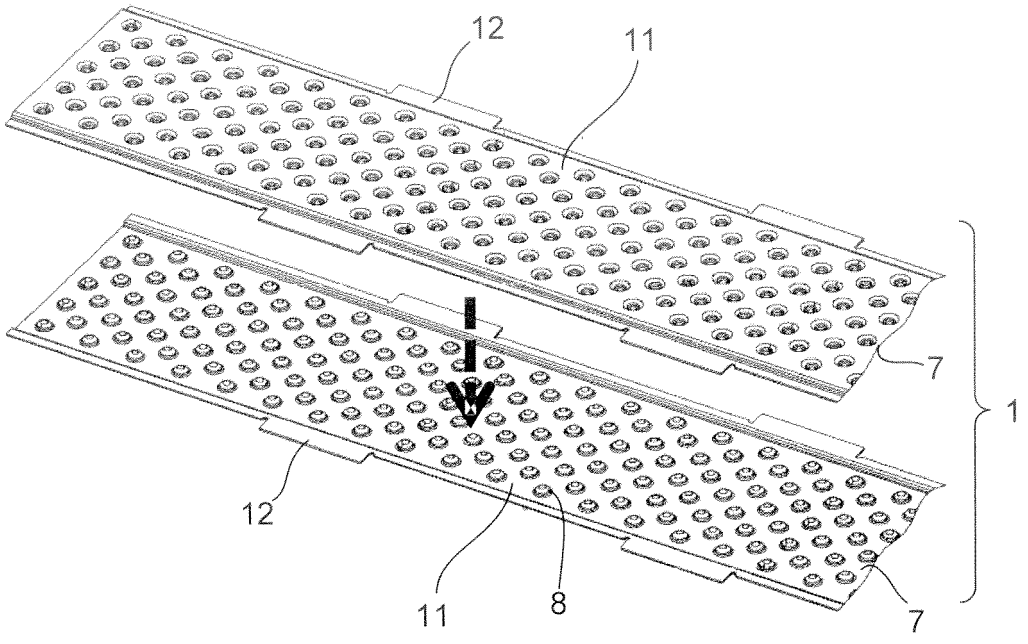


FIG. 4B

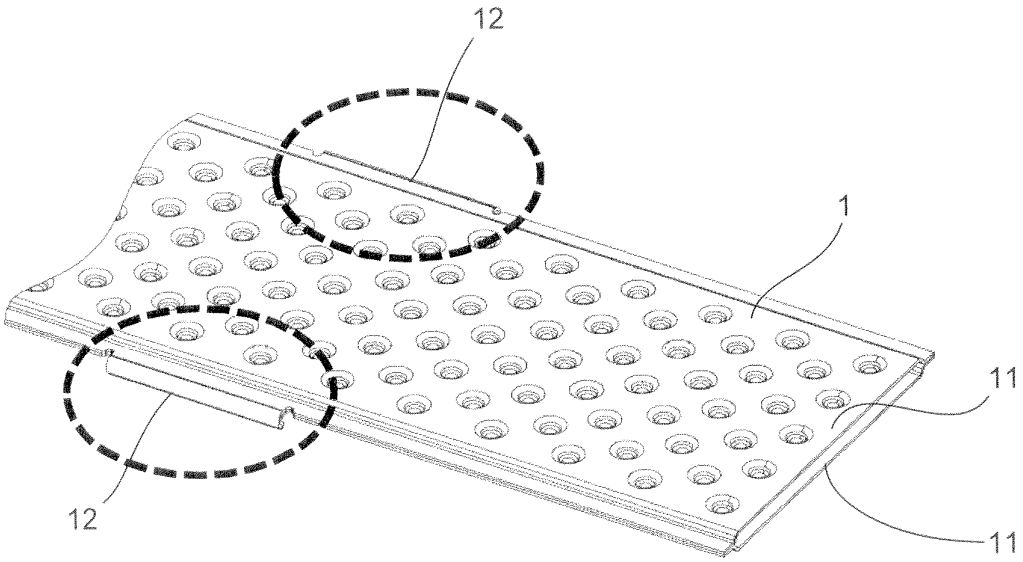


FIG. 4C

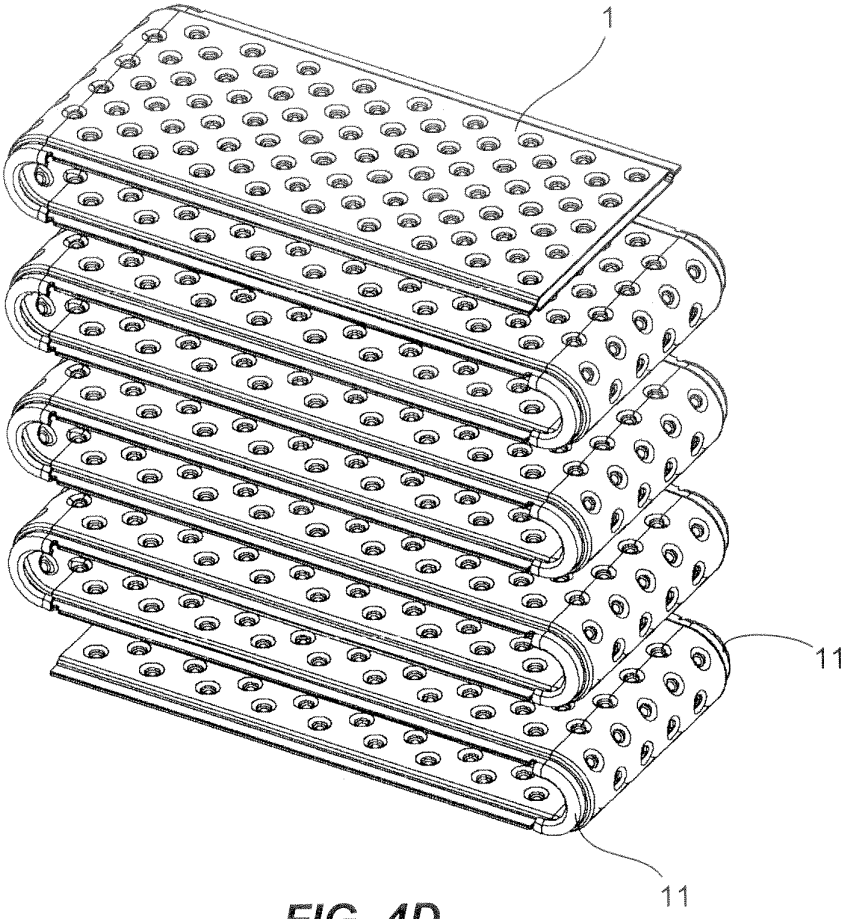


FIG. 4D

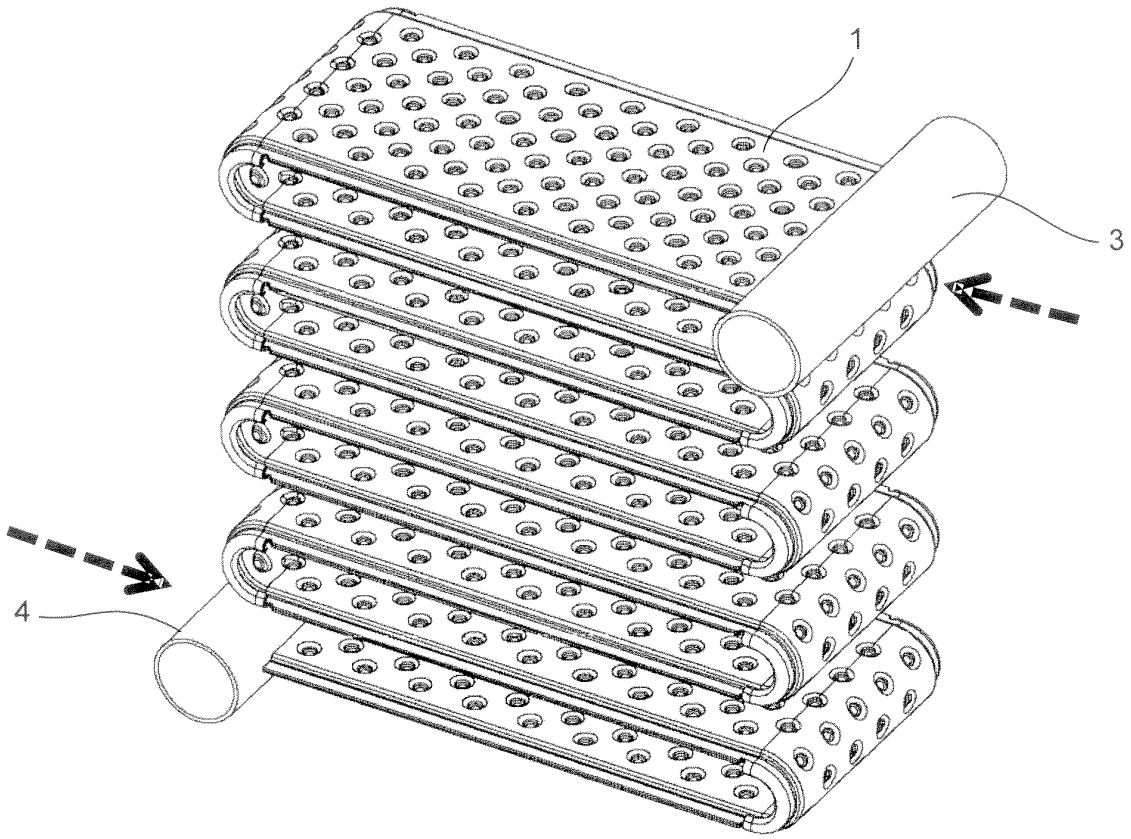


FIG. 4E

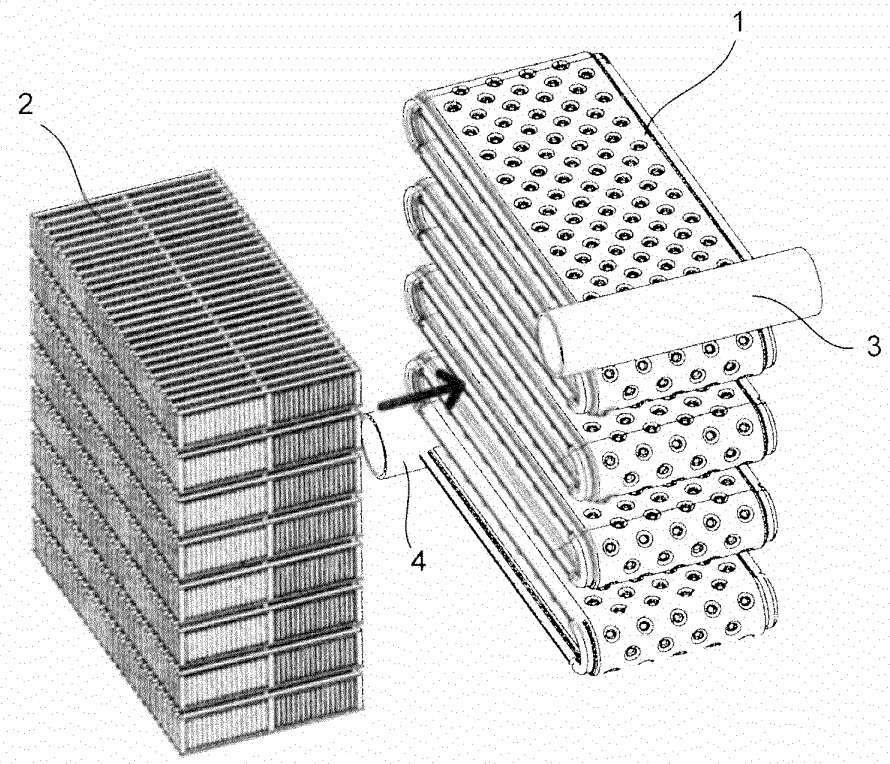


FIG. 4F

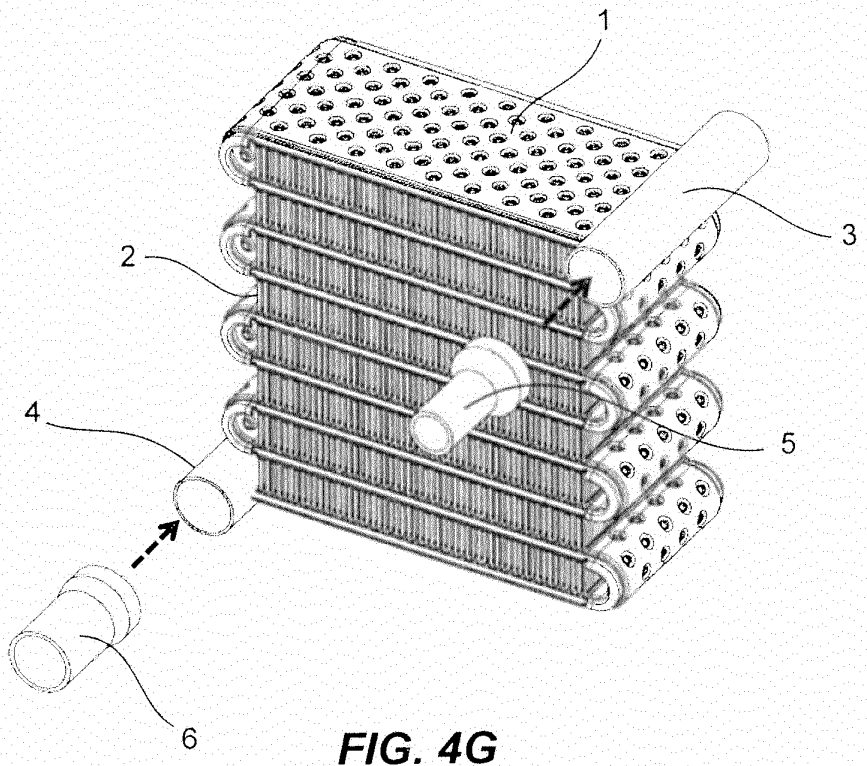
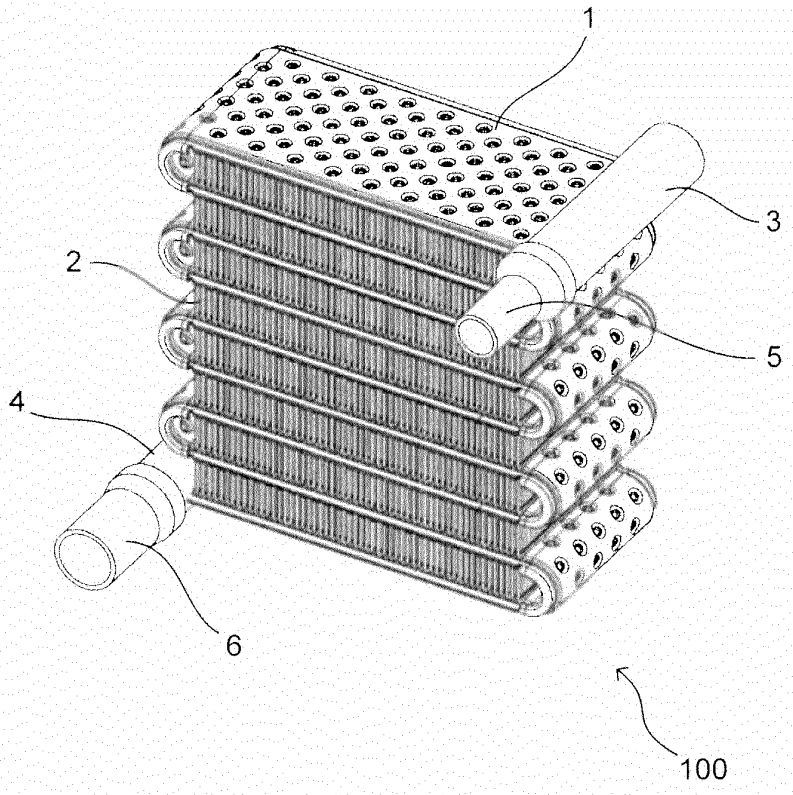


FIG. 4G

FIG. 4H



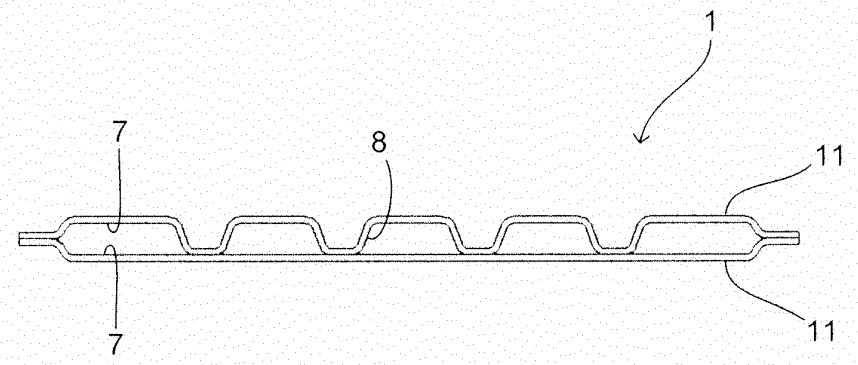
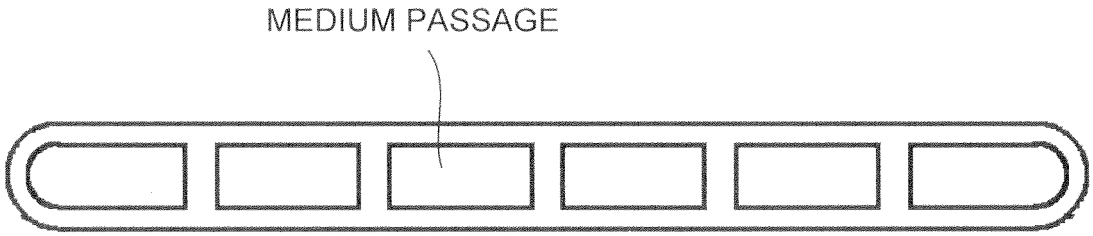


FIG. 5



PRIOR ART

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/062900

A. CLASSIFICATION OF SUBJECT MATTER
F28D1/047(2006.01)i, *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)
F28D1/047, 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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 108712/1980(Laid-open No. 30582/1982) (Showa Aluminum Corp.), 17 February 1982 (17.02.1982), fig. 1 to 6; specification, page 2, line 13 to page 5, line 2 (Family: none)	1-3,5,6 4,7

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 July, 2012 (10.07.12)	17 July, 2012 (17.07.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/062900

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 166738/1982(Laid-open No. 70180/1984) (Showa Aluminum Corp.), 12 May 1984 (12.05.1984), fig. 4, 6 (Family: none)	4
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 154236/1982(Laid-open No. 59688/1984) (Nippondenso Co., Ltd.), 18 April 1984 (18.04.1984), fig. 4 to 8; specification, page 3, line 5 to page 6, line 4 (Family: none)	7
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 093092/1972(Laid-open No. 50857/1974) (Nippondenso Co., Ltd.), 04 May 1974 (04.05.1974), fig. 1, 2; specification, page 4, lines 2 to 11 (Family: none)	1-7
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 080297/1972(Laid-open No. 037857/1974) (Nippondenso Co., Ltd.), 03 April 1974 (03.04.1974), fig. 3, 4; specification, page 2, line 14 to page 4, line 2 (Family: none)	1-7

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/062900

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/062900

Continuation of Box No.III of continuation of first sheet(2)

Document 1 (Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 108712/1980(Laid-open No. 30582/1982) (Showa Aluminum Corp.), 17 February 1982 (17.02.1982), fig. 1 to 6; specification, page 2, line 13 to page 5, line 2) discloses a serpentine heat exchanger configured by bonding two press-formed tube sheets together, the serpentine heat exchanger comprising a tube (2) which is folded back on itself in a serpentine shape and fins (6) which are arranged in the spaces sandwiched between the folded back tube sections, the serpentine heat exchanger also comprising protrusions (4, 9) formed at intervals inside the folded back sections of the tube, the protrusions (4, 9) protruding from one of the tube sheets and in contact with the other tube sheet (hereinafter referred to as invention specific matter A).

Consequently, the invention of claim 1 has no novelty in relation to the invention disclosed in document 1 and therefore has no special technical feature. Further, the inventions of claims 2, 3, 5, and 6 are also disclosed in document 1. Accordingly, the claims include three invention groups having the following special technical features.

The inventions of claims 1 to 3, 5, and 6 having no special technical feature are categorized in invention 1.

(Invention 1) The inventions of claims 1 to 3, 5, and 6

Claims 1 to 3, 5, and 6 have no special technical feature.

(Invention 2) The invention of claim 4

A serpentine heat exchanger provided with invention specific matter A and configured in such a manner that the protrusions are formed only on one of the tube sheets.

(Invention 3) The invention of claim 7

A serpentine heat exchanger provided with invention specific matter A and configured in such a manner that, in the folded back sections of the tube, one of the tube sheets and the other tube sheet are staked on both sides.

Form PCT/ISA/210 (extra sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2001027484 A **[0002]**
- JP 2011135178 A **[0045]**