(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 354 067 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
17.04.2024 Bulletin 2024/16

(21) Application number: **22819374.4**

(22) Date of filing: **26.05.2022**

(51) International Patent Classification (IPC):
F28D 1/047 *(2006.01)* ***F28D 1/053*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F28D 1/0476; F28D 1/047; F28D 1/053; F28D 7/00; F28F 1/02; F28F 1/022; F28F 1/025; F28F 1/24;
F28D 1/05383; F28F 1/126

(86) International application number:
PCT/CN2022/095334

(87) International publication number:
WO 2022/257776 (15.12.2022 Gazette 2022/50)

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

(30) Priority: **09.06.2021 CN 202110645778**

(71) Applicant: **Zhejiang Dunan Artificial Environment Co., Ltd.**
Shaoxing, Zhejiang 311835 (CN)

(72) Inventors:
- **FENG, Zhongbo**
  Shaoxing, Zhejiang 311835 (CN)
- **LAN, Zhaozhong**
  Shaoxing, Zhejiang 311835 (CN)
- **LIANG, Xinyu**
  Shaoxing, Zhejiang 311835 (CN)
- **WANG, Guanjun**
  Shaoxing, Zhejiang 311835 (CN)
- **DING, Ergang**
  Shaoxing, Zhejiang 311835 (CN)

(74) Representative: **Nederlandsch Octrooibureau**
P.O. Box 29720
2502 LS The Hague (NL)

(54) FLAT TUBE AND HEAT EXCHANGER

(57) The present invention provides a flat tube and a heat exchanger, in which a bent section is formed in the middle of the flat tube, regions of the flat tube outside the bent section form two straight sections, the bent section includes a bent portion and two twisting portions, two ends of each twisting portion are connected to one end of the bent section and one straight section respectively; wherein the bent portion bends around an axis parallel to the thickness direction of the flat tube, the minimum radius of curvature of the inner side of the bent portion is RNmin, and the thickness of the flat tube is t, t<RNmin<5t. In the solution, bending deformation can be completed in cases where the minimum radius of curvature of the inner side of the bent portion is set to be relatively small, thus reducing the length of the bent section of the flat tube, increasing the length of the straight sections, and further improving the heat exchange performance of the flat tube and a heat exchanger using the flat tube.

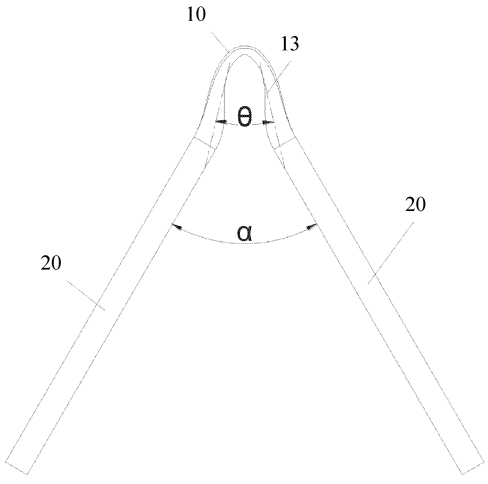

Fig. 1

EP 4 354 067 A1

Description

Technical Field

[0001] The present invention relates to the technical field of heat exchangers, and in particular to a flat tube and a heat exchanger.

Background

[0002] With regard to a heat exchanger using a flat tube, in order to increase a heat exchange area and simplify the structure, in some heat exchangers, the flat tube is bent to form a double-row structure. In existing heat exchangers, a bent section of the flat tube has a relatively long length, which shortens the length of a non-bent section relatively, so that regions for arranging fins are relatively small, thereby affecting the heat exchange performance of the heat exchanger.

Summary

[0003] Some embodiments of the present invention provide a flat tube and a heat exchanger, so as to solve the problem of poor heat exchange performance of existing heat exchangers.

[0004] In order to solve the described problem, according to one aspect of some embodiments of the present invention, the present invention provides a flat tube, in which a bent section is formed in the middle of the flat tube, regions of the flat tube outside the bent section form two straight sections, the bent section includes a bent portion and two twisting portions, two ends of each twisting portion are connected to one end of the bent section and one straight section respectively; wherein the bent portion bends around an axis parallel to the thickness direction of the flat tube, the minimum radius of curvature of the inner side of the bent portion is RNmin, and the thickness of the flat tube is t, t<RNmin<5t.

[0005] Further, the maximum radius of curvature of the inner side of the bend portion is RNmax, t<RNmax<5t.

[0006] Further, the minimum radius of curvature of the outer side of the bent portion is RWmin, t<RWmin<5t.

[0007] Further, the maximum radius of curvature of the outer side of the bent portion is RWmax, t<RWmax<5t.

[0008] Further, RNmin is 4.5t, 4t or 3t.

[0009] Further, the maximum radius of curvature of the inner side of the bent portion is RNmax, RNmax≥5t; and the minimum radius of curvature of the outer side of the bent portion is RWmin, RWmin≥5t.

[0010] Further, joints of the two twisting portions and the bent portion respectively have preset tangent lines, an included angle between the two preset tangent lines is θ, and an included angle between the two straight sections is α, where $\alpha>\theta$.

[0011] Further, $\alpha\leq 90°$.

[0012] Further, the flat tube has a preset symmetrical surface, the symmetrical surface divides the bent portion into two symmetrical portions, the two twisting portions are symmetrically arranged relative to the symmetrical surface, and the two straight sections are symmetrically arranged relative to the symmetrical surface.

[0013] According to another aspect of some embodiments of the present invention, a heat exchanger is provided, the heat exchanger comprises a plurality of flat tubes arranged side by side, and fins are arranged between straight sections of two adjacent flat tubes.

[0014] By applying the technical solution of the present invention, a flat tube is provided, a bent section is formed in the middle of the flat tube, regions of the flat tube outside the bent section form two straight sections, the bent section includes a bent portion and two twisting portions, two ends of each twisting portion are connected to an end of the bent section and one straight section respectively; wherein the bent portion bends around an axis parallel to the thickness direction of the flat tube, the minimum radius of curvature of the inner side of the bent portion is RNmin, and the thickness of the flat tube is t, t<RNmin<5t. In the embodiments, bending deformation is completed in cases where the minimum radius of curvature of the inner side of the bent portion is set to be relatively small, thus reducing the length of the bent section of the flat tube, increasing the length of the straight sections, and further improving the heat exchange performance of the flat tube and a heat exchanger using the flat tube.

[0015] The bending radius of a conventional bending heat exchanger is relatively large, and the bending angle is limited, especially the lower limit of the angle; and the bending radius of a conventional microchannel heat exchanger is generally required to be greater than 5t, so as to satisfy the strength and corrosion resistance of a bent section of a flat tube. The present solution discloses a flat tube structure with a smaller bending radius, and through experimental verification, while satisfying the requirements of the strength and corrosion resistance of the flat tube, the length of the bent section can be further reduced effectively, and the length of effective sections of the fins can be increased. That is, a ratio of an effective heat exchange area to an area of the overall heat exchanger is increased. In addition, straight line sections connected to the bent section of the flat tube are appropriately bent outwards in an opposite direction, so that the height of the heat exchanger is reduced; and the bottom of the flat tube is appropriately opened, such that the overall height of a heat exchanger having the flat tube structure can be reduced, and the windward area of the heat exchanger is increased, thereby improving the heat exchange performance.

Brief Description of the Drawings

[0016] The drawings of the description, constituting a part of some embodiments of the present invention, are used for providing further understanding of some embodiments of the present invention, and the illustrative em-

bodiments of some embodiments of the present invention and illustrations thereof are used to explain some embodiments of the present invention, rather than constitute inappropriate limitation on some embodiments of the present invention. In the drawings:

Fig. 1 shows a front view of a flat tube provided according to embodiments of the present invention;
Fig. 2 shows a perspective view of the flat tube in Fig. 1;
Fig. 3 shows a side view of the flat tube in Fig. 1;
Fig. 4 shows a schematic structural diagram of a heat exchanger provided according to embodiments of the present invention; and
Fig. 5 shows a schematic diagram of the heat exchanger in Fig. 4 before the flat tube is bent.

[0017] The figures include the following reference signs:
10. Bent section; 11. Bent portion; 12. Twisting portion; 13. Preset tangent line; 20. Straight section; 30. Fin.

Detailed Description of the Embodiments

[0018] The technical solutions in the embodiments of the present invention will be clearly and completely described below with reference to the accompanying drawings in the embodiments of the present invention. It is apparent that the embodiments described are not all embodiments but a part of embodiments of the present invention. The following description of at least one exemplary embodiment is merely illustrative in nature and is in no way intended to limit some embodiments of the present invention and any applications or uses thereof. All other embodiments obtained by a person of ordinary skill in the art on the basis of the embodiments of the present invention without any inventive effort shall all fall within the scope of protection of some embodiments of the present invention.

[0019] As shown in Fig. 1 to Fig. 3, the embodiments of the present invention provide a flat tube; a bent section 10 is formed in a middle of the flat tube, regions of the flat tube outside the bent section 10 form two straight sections 20, the bent section 10 includes a bent portion 11 and two twisting portions 12, two ends of each twisting portion 12 are connected to one end of the bent section 10 and one straight section 20 respectively; wherein the bent portion 11 bends around an axis parallel to the thickness direction of the flat tube, a minimum radius of curvature of an inner side of the bent portion 11 is RNmin, and a thickness of the flat tube is t, t<RNmin<5t. Two surfaces in a width direction on one side of the two straight sections 20 of the flat tube are located on the same plane, and two surfaces in the width direction on the other side are located on another same plane, thereby facilitating the arrangement of a plurality of flat tubes and the arrangement of fins in heat exchange by using the flat tube. The radius of curvature of the outer side of the bent portion 11 is greater than the radius of curvature of the inner side of the bent portion.

[0020] In the solution, the minimum radius of curvature of the inner side of the bent portion 11 is set as t<RNmin<5t, such that bending deformation can be completed with a relatively small minimum radius of curvature, thus reducing the length of the bent section 10 of the flat tube, increasing the length of the straight sections 20, and further improving the heat exchange performance of the flat tube and a heat exchanger using the flat tube.

[0021] In some embodiments, RNmin may be set as a size of 4.5 t, 4 t, 3 t, or the like.

[0022] In some other embodiments, t<RNmin<5t, and the maximum radius of curvature of the inner side of the bent portion 11 is RNmax, t<RNmax<5t. In this way, it can be ensured that the maximum radius of curvature of the inner side of the bent portion 11 is relatively small, so as to reduce the length of the flat tube occupied by the bent portion 10, thereby increasing the length of the straight sections 20. Fins can be provided on the straight sections 20, so that regions for arranging fins are increased, thereby improving the heat exchange performance of the heat exchanger.

[0023] In some other embodiments, t<RNmin<5t, and the minimum radius of curvature of the outer side of the bent portion 11 is RWmin, t<RWmin<5t. In some embodiments, t<RNmin<4t and 2t<RWmin<5t. In this way, the curvature of the bent portion 11 can be reduced, so that the bent portion is formed by bending with a small bending radius, and therefore compared with the related art, the length of the bent portion 10 is reduced.

[0024] Or in some other embodiments, t<RNmin<5t, and the maximum radius of curvature of the outer side of the bent portion 11 is RWmax, t<RWmax<5t. In some embodiments, t<RNmax<4t and 2t<RWmax<5t. In this way, the length of the bent section 10 can be further reduced while meeting strength and process requirements.

[0025] Or in some other embodiments, t<RNmin<5t, and the maximum radius of curvature of the inner side of the bent portion 11 is RNmax, RNmax≥5t; and the minimum radius of curvature of the outer side of the bent portion 11 is RWmin, RWmin≥5t. In this way, the bent portion 11 is easy to be formed by bending.

[0026] In the embodiments above, joints of the two twisting portions 12 and the bent portion 11 respectively have preset tangent lines 13, an included angle between the two preset tangent lines 13 is θ, and an included angle between the two straight sections 20 is α, where $\alpha>\theta$. That is, after the bent portion 11 is bent and formed, a part of the two straight sections 20 of the flat tube is bent outwards, so that the height of the flat tube is reduced, facilitating arrangement of the flat tube in a limited space. Furthermore, a bottom of the flat tube is appropriately opened, such that the overall height of a heat exchanger having the flat tube structure can be reduced, and the windward area of the heat exchanger is increased, thereby improving the heat exchange performance.

[0027] Specifically, $\alpha \leq 90°$. For example, α is set to 30° or 60°.

[0028] In some embodiments, the flat tube has a preset symmetrical surface, the symmetrical surface divides the bent portion 11 into two symmetrical portions, the two twisting portions 12 are symmetrically arranged relative to the symmetrical surface, and the two straight sections 20 are symmetrically arranged relative to the symmetrical surface. This facilitates the shaping of the flat tube and the arrangement of a plurality of flat tubes.

[0029] As shown in Figs. 4 and 5, some embodiments of the present invention provide a heat exchanger; the heat exchanger includes a plurality of flat tubes arranged side by side, and fins 30 are provided between straight sections 20 of two adjacent flat tubes. In the solution, the minimum radius of curvature of the inner side of the bent portion 11 is set as t<RNmin<5t, such that bending deformation can be completed with a relatively small minimum radius of curvature, thus reducing the length of the bent section 10 of the flat tube, increasing the length of the straight sections 20, and further improving the heat exchange performance of the flat tube and the heat exchanger using the flat tube.

[0030] The bending radius of a conventional bending heat exchanger is relatively large, and the bending angle is limited, especially the lower limit of the angle; and the bending radius of a conventional microchannel heat exchanger is generally required to be greater than 5t, so as to satisfy the strength and corrosion resistance of a bent section of a flat tube. The some embodiments of the present solution disclose a flat tube structure with a smaller bending radius, and through experimental verification, while satisfying the requirements of the strength and corrosion resistance of the flat tube, the length of the bent section can be further reduced effectively, and the length of effective sections of the fins can be increased. That is, a ratio of an effective heat exchange area to an area of the overall heat exchanger is increased. In addition, straight line sections connected to the bent section of the flat tube are appropriately bent outwards in an opposite direction, so that the height of the heat exchanger is reduced; and the bottom of the flat tube is appropriately opened, such that the overall height of a heat exchanger having the flat tube structure can be reduced, and the windward area of the heat exchanger is increased, thereby improving the heat exchange performance.

[0031] The content above merely relates to some embodiments of the present invention and is not intended to limit some embodiments of the present invention. For a person skilled in the art, some embodiments of the present invention may have various modifications and variations. Any modifications, equivalent replacements, improvements, etc. made within the spirit and principle of some embodiments of the present invention shall all belong to the scope of protection of some embodiments of the present invention.

Claims

1. A flat tube, wherein

a bent section (10) is formed in a middle of the flat tube, regions of the flat tube outside the bent section (10) form two straight sections (20), the bent section (10) comprises a bent portion (11) and two twisting portions (12), two ends of each twisting portion (12) are connected to an end of the bent section (10) and one straight section (20) respectively;
wherein the bent portion (11) bends around an axis parallel to a thickness direction of the flat tube, a minimum radius of curvature of an inner side of the bent portion (11) is RNmin, and a thickness of the flat tube is t, t<RNmin<5t.

2. The flat tube according to claim 1, wherein a maximum radius of curvature of the inner side of the bent portion (11) is RNmax, t<RNmax<5t.

3. The flat tube according to claim 1, wherein a minimum radius of curvature of an outer side of the bent portion (11) is RWmin, t<RWmin<5t.

4. The flat tube according to claim 1, wherein
a maximum radius of curvature of an outer side of the bent portion (11) is RWmax, t<RWmax<5t.

5. The flat tube according to claim 1, wherein RNmin is 4.5t, 4t or 3t.

6. The flat tube according to claim 1, wherein

a maximum radius of curvature of the inner side of the bent portion (11) is RNmax, RNma≥5t; and a minimum radius of curvature of an outer side of the bent portion (11) is RWmin, RWmin≥5t.

7. The flat tube according to claim 1, wherein joints of the two twisting portions (12) and the bent portion (11) respectively have preset tangent lines (13), an included angle between the two preset tangent lines (13) is θ, and an included angle between the two straight sections (20) is α, where $\alpha > \theta$.

8. The flat tube according to claim 7, wherein $\alpha \leq 90°$.

9. The flat tube according to claim 1, wherein the flat tube has a preset symmetrical surface, the symmetrical surface divides the bent portion (11) into two symmetrical portions, the two twisting portions (12) are symmetrically arranged relative to the symmetrical surface, and the two straight sections (20) are symmetrically arranged relative to the symmetrical surface.

10. A heat exchanger, wherein the heat exchanger comprises a plurality of flat tubes arranged side by side, and fins (30) are arranged between straight sections (20) of two adjacent flat tubes.

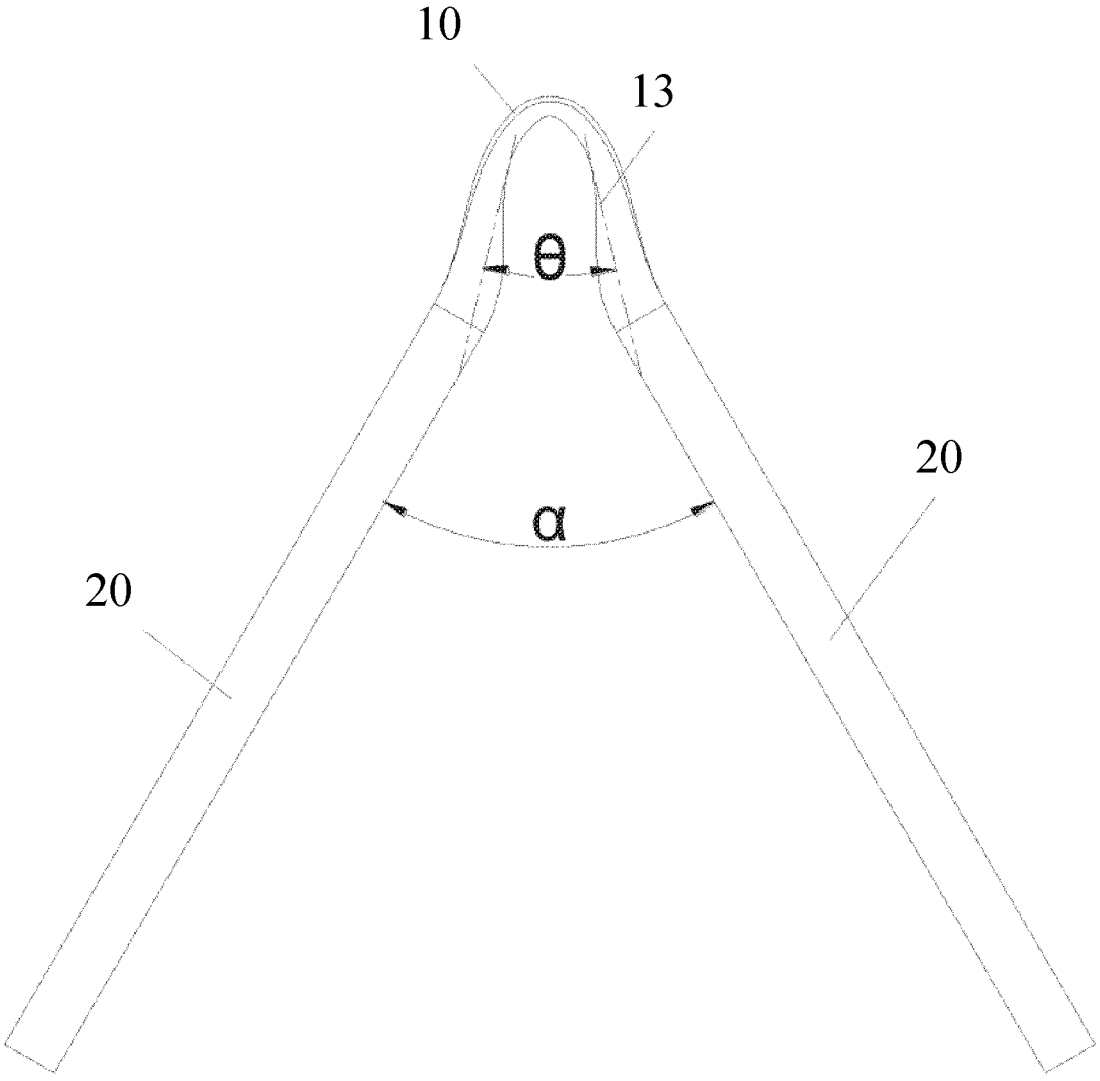

Fig. 1

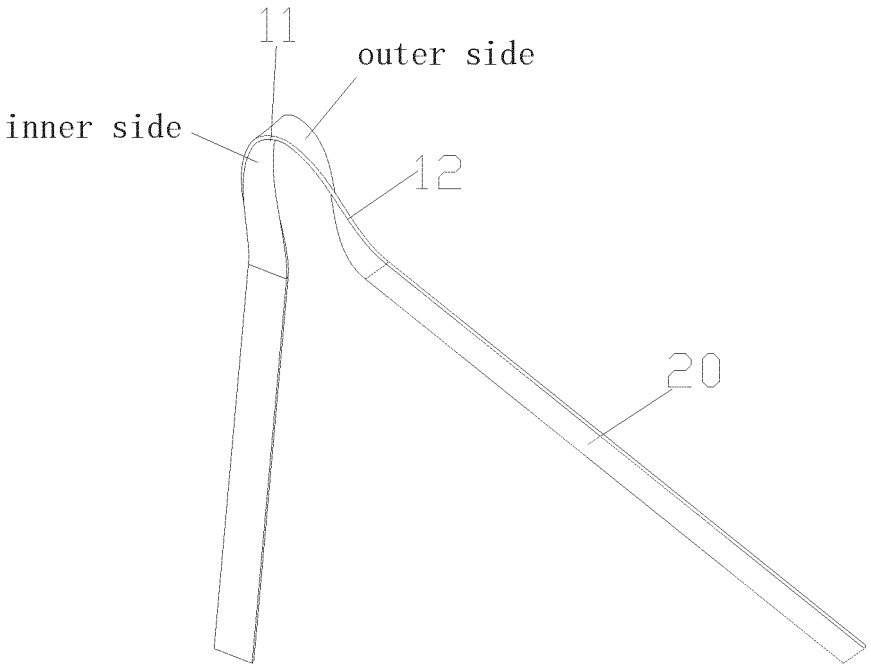

Fig. 2

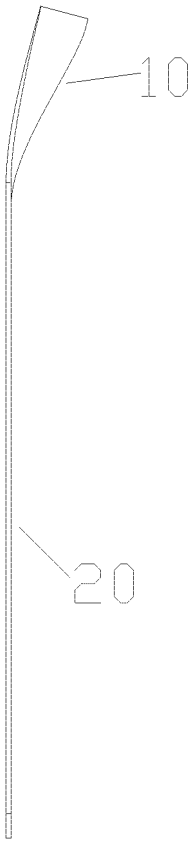

Fig. 3

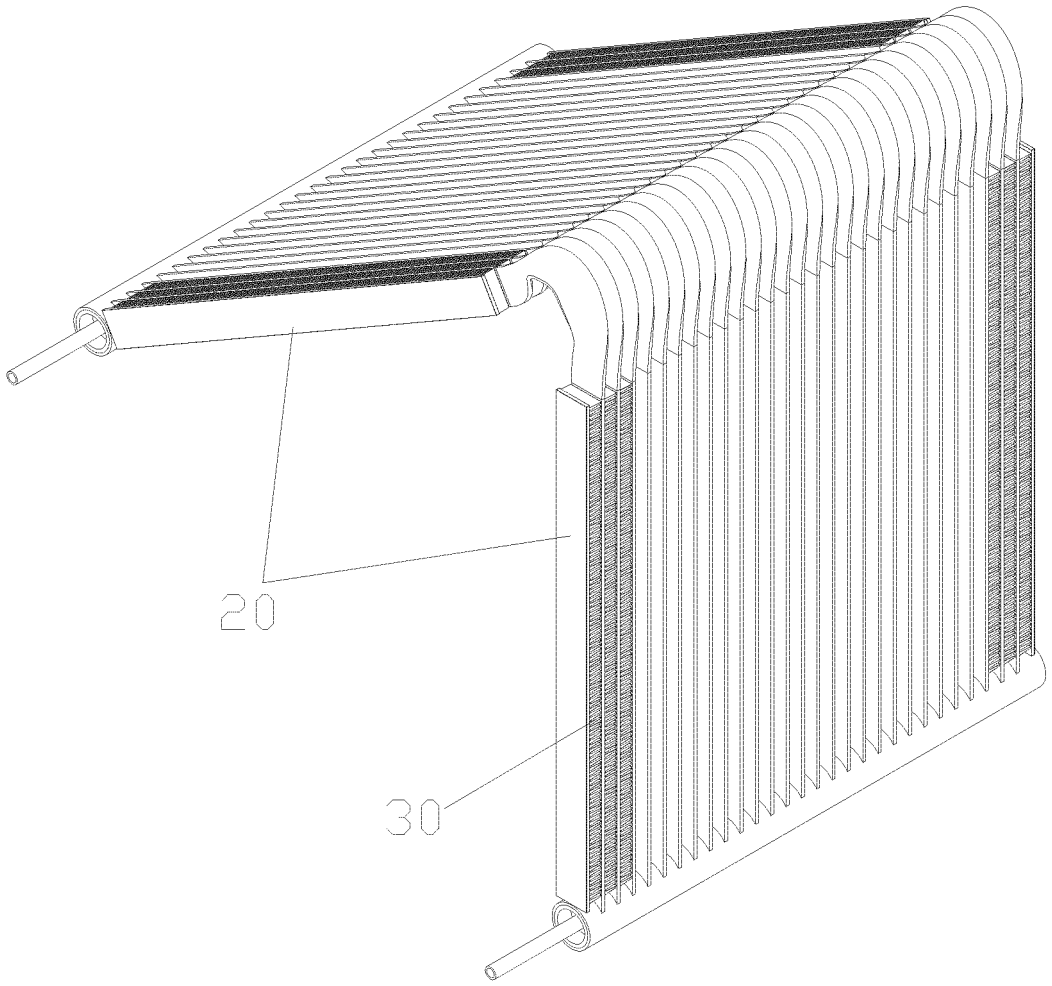

Fig. 4

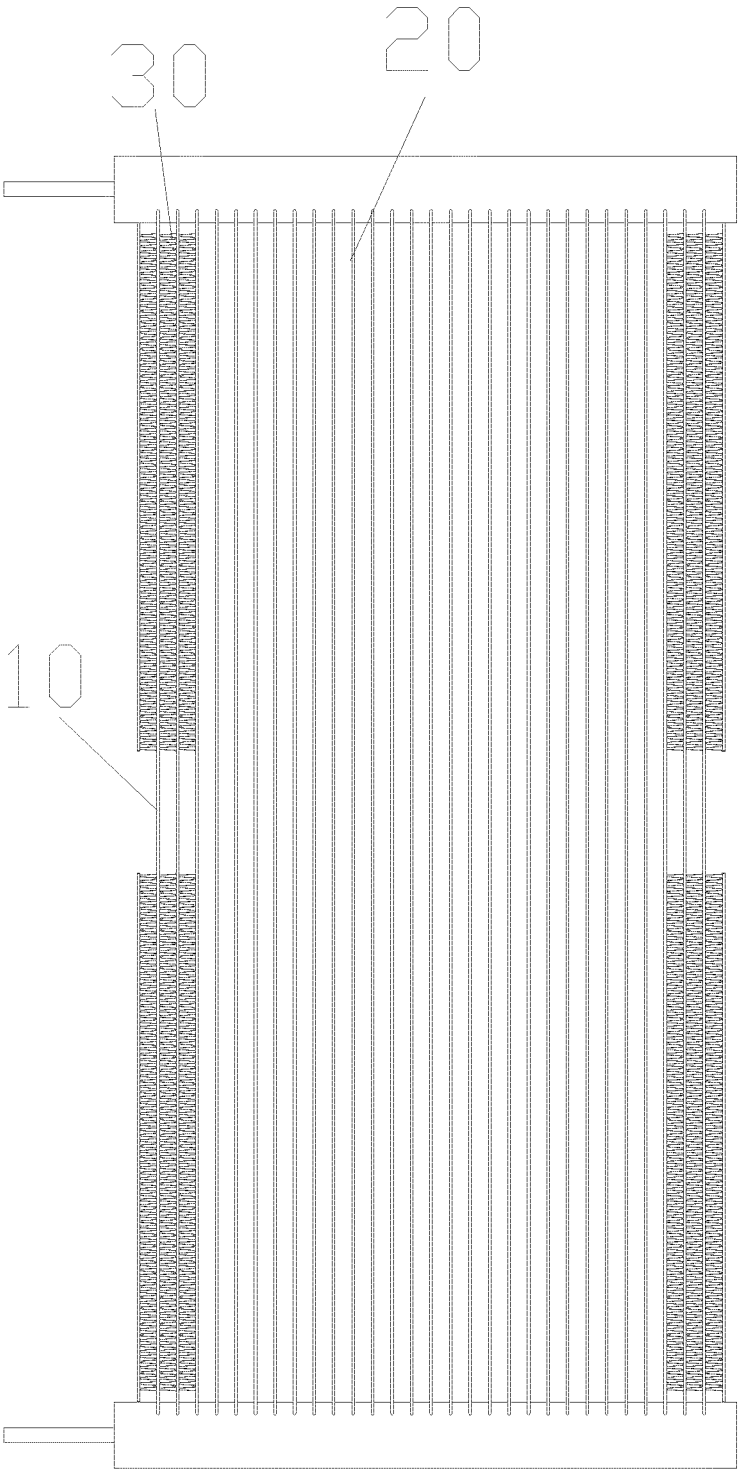

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/095334

A. CLASSIFICATION OF SUBJECT MATTER

F28D 1/047(2006.01)i; F28D 1/053(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)

F28D 1;F25B 39

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

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

CNTXT, CNKI, VEN: 换热, 热交换, 扁平管, 扁管, 厚度, 曲率半径, heat exchanger, flat tube?, flat pipe?, thickness, radius of curvature

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 1107221 A (SHOWA ALUMINUM CORP.) 23 August 1995 (1995-08-23) description, page 5, line 14-page 13, line 15, and figures 1-22	10
Y	CN 1107221 A (SHOWA ALUMINUM CORP.) 23 August 1995 (1995-08-23) description, page 5, line 14-page 13, line 15, and figures 1-22	1-9
X	CN 101532786 A (SHOWA DENKO K.K.) 16 September 2009 (2009-09-16) description, page 16, paragraph 5, and figures 8 and 9	10
Y	CN 101532786 A (SHOWA DENKO K.K.) 16 September 2009 (2009-09-16) description, page 16, paragraph 5, and figures 8 and 9	1-9
X	CN 105518405 A (DAIKIN INDUSTRIES LTD.) 20 April 2016 (2016-04-20) description, paragraph [0146], and figures 12 and 15	10
Y	CN 105518405 A (DAIKIN INDUSTRIES LTD.) 20 April 2016 (2016-04-20) description, paragraph [0146], and figures 12 and 15	1-9
A	US 2015168071 A1 (HANGZHOU SANHUA RESEARCH INSTITUTE CO., LTD.) 18 June 2015 (2015-06-18) entire document	1-10

☐ 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
13 July 2022	**21 July 2022**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/095334

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 1107221 A	23 August 1995	US 5531268 A	02 July 1996
		DE 69415779 D1	18 February 1999
		EP 0654645 A2	24 May 1995
		KR 950014830 A	16 June 1995
		ES 2127358 T3	16 April 1999
		AU 7898194 A	01 June 1995
		JP H07146089 A	06 June 1995
		AT 175492 T	15 January 1999
CN 101532786 A	16 September 2009	JP 2009216315 A	24 September 2009
CN 105518405 A	20 April 2016	WO 2015037235 A1	19 March 2015
		JP 2015078829 A	23 April 2015
US 2015168071 A1	18 June 2015	PL 2884209 T3	28 February 2018
		EP 2884209 A1	17 June 2015

Form PCT/ISA/210 (patent family annex) (January 2015)