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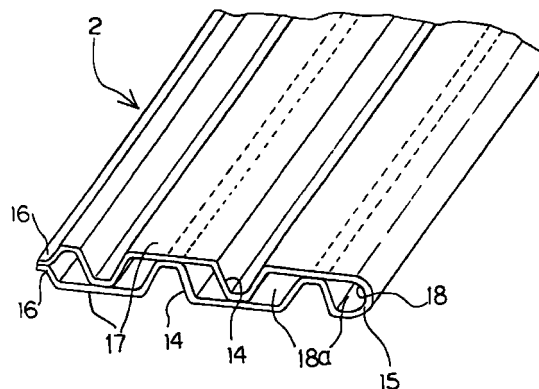
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(54) **HEAT EXCHANGER**

(57) A heat exchanger (1) has tubes (2) and fins (3) alternately stacked and ends of the tubes inserted into and connected to header pipes (4); wherein the tubes (2) are formed of a flat tube material by roll molding or press molding, a tube material for forming the tubes (2) has an aluminum alloy of Al-Mn-based one or the like as a core material and an Al-Zn-based aluminum alloy not containing Si clad on a layer to be the outer surface of the tube, so to improve pitting corrosion resistance of the tubes.

FIG. 2



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Description

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger used for a refrigeration cycle, and more particularly to a heat exchanger having its tube's corrosion resistance improved.

BACKGROUND ART

[0002] Generally, a parallel flow type heat exchanger has a plurality of tubes and fins alternately stacked, and both ends of the stacked tubes are inserted to be joined into insertion holes formed on right and left header pipes. And, it is configured that partition plates for dividing the header pipes in their longitudinal directions are provided at required points of the header pipes to divide the header pipes in the longitudinal directions, so that a heat-exchanging medium is flowed to meander a plurality of times between an inlet joint and an outlet joint provided on the header pipes.

[0003] In such a heat exchanger, the tubes through which a heat-exchanging medium is flowing are generally known to be formed of, for example, an improved material which has Cu added to JIS(Japanese Industrial Standards) A1050 (99.0 wt% Al) and undergone an extrusion molding process, as described in Japanese Patent Application Laid-Open Publication No. Sho 62-97766 and Japanese Patent Application Laid-Open Publication No. Hei 2-138455. And, fins are made of a material which has a brazing material, which is an improved material having Zn added to an Al-Si-based alloy, clad thereon.

[0004] The aforesaid tube is sprayed Zn on the surface of its extrusion molded tube to improve its corrosion resistance. By virtue of the spraying of Zn, the Zn layer on the tube surface having a potential lower than the core material Al is undergone sacrifice corrosion with priority to form a protective film of zinc rust $\{ZnO + Zn(OH)_2\}$ so to protect the core material Al alloy from corrosion. The spraying on the tube surface, for example, is the method described in Japanese Patent Application Laid-Open Publication No. Hei 2-138455 as shown in Fig. 5, which places extrusion-molded tubes horizontally at predetermined intervals between top and bottom spray guns 19, pulls out horizontally by an unillustrated puller (a jig which catches and pulls the ends of the tubes), runs the puller in synchronization with a tube extrusion speed, and operates the spray guns 19 disposed above and below the tubes 20 when the puller speed has reached a constant speed (about 50 m/min.) to continuously spray metal Zn from above and below the tubes 20 so to uniformly adhere 3 to 30 g/m² of Zn to the top and bottom flat surfaces of the tubes.

[0005] Tubes other than the extrusion-molded tubes are generally formed by roll molding or press molding

using a brazing sheet which has a brazing material coated as an Al-Si-based improved material having Zn added to the layer to be the outer surface of the tube with JIS A3003 (Al-Mn-based) alloy or the like as the core material.

[0006] As described above, a device is required for spraying Zn to the tubes, and it is difficult to uniformly spray Zn. For example, if the spraying on the tube surface is uneven, Zn spreads from the uneven spray portion, and corrosion develops on the spread portions. Therefore, corrosion does not develop uniformly. Generally, corrosion of the aluminum alloy develops in a pitting corrosion condition, and if the sacrifice corrosion resistance of the Zn layer is not uniform because of the uneven spray of Zn, the core material Al section is also corroded, and since the corrosion develops in a pitting corrosion condition, there are problems that corroded through holes are formed in the tube to adversely affect safety of the heat exchanger.

[0007] And, when a brazing sheet which has a Zn-added brazing material coated on the Al-Si based alloy is used to form a tube, potential of Si crystals in the brazing material becomes higher than that of around the Si crystals, and corrosion develops along the Si crystal grain boundary. In other words, so-called grain boundary corrosion develops, to reach the core material aluminum alloy, causing a problem that pitting corrosion resistance is not secured.

[0008] Conventionally, in combining fins and tubes, the potential of the tubes is determined to be high, the surfaces of the fins and tubes are subjected to the sacrifice corrosion resistance treatment with priority to make the tubes to be corrosion resistive. But, they are corrosion resistive in connection with the fins, and the tubes having the beads formed therein tend to accumulate water, impurities and the like in the bead sections formed on the surfaces, and the tubes are corroded due to the accumulated water and others. Therefore, it is necessary to improve the corrosion resistance of the tubes themselves.

[0009] Accordingly, it is an object of the invention to provide a heat exchanger which has the corrosion resistance of the tubes themselves improved.

DISCLOSURE OF THE INVENTION

[0010] The present invention is directed to a heat exchanger which has tubes and fins alternately stacked and ends of the tubes inserted into and connected to header pipes, characterized in that the tubes are formed of a flat tube material by roll or press molding; and the tube material for the tubes is formed of an aluminum alloy such as Al-Mn-based one as a core material and an Al-Zn-based aluminum alloy not containing Si clad on a layer to be the outer surface of the tube to form the tubes.

[0011] Thus, since the tubes are formed of the brazing sheet which has the layer to be the outer surfaces of

the tubes uniformly clad with Al-Zn-based aluminum alloy not containing Si, the potential of the core material is determined to be high according to a potential difference between the clad material and the core material Al-Mn-based aluminum alloy, and the pitting corrosion resistance of the tubes themselves can be improved because the clad material to be the outer layer is made to have uniform sacrifice corrosion by the sacrifice anode effect of the clad material.

[0012] And, by using the Al-Zn-based aluminum alloy not containing Si as the clad material, the potential difference between Zn having the sacrifice corrosion preventive effect and Al made to be anti-corrosive becomes large, and the corrosion resistance of the core material can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a front view of a heat exchanger according to an embodiment of the present invention;
 Fig. 2 is a perspective view of a tube viewed from its edge according to the embodiment of the invention;
 Fig. 3 is a diagram showing measurements of corroded depth from the surface of each tube by a corrosion resistance test, according to the embodiment of the invention;
 Fig. 4 is a perspective view of a tube viewed from its edge according to an embodiment of the invention; and
 Fig. 5 is a schematic view showing a state of spraying Zn to extruded flat tubes, according to a conventional embodiment.

BEST MODE FOR CARRYING OUT THE INVENTION

[0014] Embodiments of the present invention will be described with reference to the accompanying drawings.

[0015] As shown in Fig. 1, a heat exchanger 1 has a plurality of tubes 2, 2 stacked with fins 3, 3 interposed between them, ends of the plurality of tubes 2 being made to have substantially a flat surface to be described afterward and inserted into tube insertion holes 7 formed on header pipes 4. Top and bottom openings of the header pipes 4 are closed by caps 8, 8, and partition plates 9 are provided at predetermined positions of the respective header pipes 4. Besides, the header pipes 4 are provided with an inlet joint 10 and an outlet joint 11, between which a heat-exchanging medium is meandered a plurality of times to flow. In Fig. 1, 12 indicates a side plate disposed at top and bottom sides of the stacked tubes 2.

[0016] Fig. 2 is a perspective view of the tube 2 produced by forming a single plate and viewed from its one edge. As shown in Fig. 2, the tube 2 is formed to have substantially an oval cross section with a parallel sec-

tion and long-grooved beads 14 integrally formed to extend through the tube interior, to form a plurality of passages 18a, 18a by the beads 14 within the tube 2.

[0017] The tube 2 is produced by forming a plate which is a brazing sheet consisting of a layer to be the tube's outer layer having a clad material of an Al-Zn-based alloy to be described afterward coated by using an Al-Mn-based alloy or the like as a core material, and a layer to be the tube's inner surface having an aluminum material of an Al-Si alloy or the like coated. And, this brazing sheet is good in thermal conductivity, formability and brazing property. In other words, the plate is rolled or pressed to form beads 14, 14 with a predetermined shape, a folding portion 15 and joints 16, 16, and further subjected to bend rolling and shape rolling to fold the plate about the folding portion 15 to overlay the joints 16, 16. Then, it is cut to a tube length according to a size of the heat exchanger, and brazed. These steps are automatically performed continuously at a high speed.

[0018] The material for the tube includes a three-layered structure having a brazing material clad on the layer to be the tube's inner surface and a two-layered structure without having a brazing material clad on the tube's inner surface. When the tube material has the three-layered structure, the tube is formed by folding and joining a single plate or overlaying two plates. When the tube material has the two-layered structure, an inner fin having a brazing material clad is inserted into the tube, and the tube and the inner fin are mutually connected by the brazing material.

[0019] Now, a corrosion resistance test performed on the tube formed of a brazing sheet, which has a conventional brazing material coated on a plate made of a predetermined aluminum alloy as a core material or a brazing sheet which has the clad material of this embodiment coated thereon, and the tube which has Zn sprayed to an extrusion-molded tube will be described with reference to the drawings.

[0020] Fig. 3 is a diagram showing results of CASS test performed on tubes formed of various types of materials. The CASS test sprays a predetermined corrosive solution to promote corrosion for a predetermined time and measures a corroded depth from the tube surface so to determine corrosion resistance.

[0021] In the drawing, A indicates a test result of a tube which is formed by roll forming or press forming of a brazing sheet which has a brazing material of Al-Si-Zn-based alloy (Si of 7.5%, Zn of 1%) clad with JIS A3000-based alloy containing the aforesaid Cu and Mn, as the core material.

[0022] In the drawing, B indicates a test result of a tube formed of a brazing sheet which has JIS A7072 alloy (Al-Zn based) coated as the clad material with JIS A3000-based alloy containing the aforesaid Cu and Mn, as the core material.

[0023] In the drawing, C indicates a test result of a tube formed of a brazing sheet which has conventionally

used JIS A3003 alloy (Al-Fe-Mn based), as the core material, and JIS A7072 alloy (Al-Zn based) coated as the clad material in the same way as B above.

[0024] In the drawing, T indicates a test result of a tube which has Zn sprayed to a tube formed by extrusion molding of an improved material with Cu added to MS A1050 (99.0 wt% Al).

[0025] As indicated by A, B, C and T in Fig. 3, as a result of the CASS test conducted for 336 hours (14 days), a pitting depth is not so different among A, B, C and T. But, as a result of the CASS test conducted for 672 hours (28 days), there is a clear difference between the results of A and T showing the conventional embodiments and those of B, C showing the present embodiment.

[0026] As shown in Fig. 3, it is confirmed that the corrosion resistance was improved from the results of the CASS test conducted for 672 hours that the tube A which is formed of a brazing sheet having an Al-Si-Zn based brazing material coated has a pitting depth of 250 μm , while the tube B has a pitting depth of about 70 μm . The tube C formed of a brazing sheet, which has a clad material of Al-Zn-based alloy not containing Si in the same way as the tube B with the generally used JIS A3003 alloy as the core material, has a pitting depth of about 100 μm , assuring that its corrosion resistance is improved better than the tube indicated by A in the drawing.

[0027] The extrusion molded tube T indicated in the drawing and having Zn sprayed has a corrosion depth of 150 μm in terms of corrosion resistance, indicating that its corrosion resistance is inferior to tubes B, C in the drawing which are formed of a brazing sheet having a clad material of Al-Zn-based alloy not containing Si coated.

[0028] As shown in Fig. 3, it was confirmed that the tube which has the brazing sheet coated with a clad material of Al-Zn-based alloy not containing Si and roll-molded or press-molded is improved its corrosion resistance better than the tube which is made of the brazing sheet having the conventional Al-Si-Zn-based brazing material coated, and that its corrosion depth is smaller and pitting corrosion resistance improved as compared with the tube which is formed by extrusion-molding JIS A1050 alloy and spraying Zn thereon.

[0029] Although, in this embodiment the tube formed of a single plate is tested, the test can also be applied to a heat exchanger which has tubes formed of two plates overlaid or provided with inner fin type tubes disposed.

[0030] For example, Fig. 4 is a perspective view of an inner fin type tube 21 viewed from its edge.

[0031] As shown in Fig. 4, the inner fin type tube 21 is formed by folding a plate having a predetermined size into a tube 24 having an oval cross section, fitting inner fins 23 for dividing an inside flowing passage 22 into a plurality of flowing passages 22a within the tube 24, and brazing them. The inner fin 23 has a predetermined

plate coated with a brazing material, and the brazing sheet used for the inner fin type tube 21 is produced by using Al-Mn-based alloy as the core material and a plate which is a brazing sheet having a clad material of the aforesaid Al-Zn-based alloy coated for the layer to be outside surface of the tube and forming them.

[0032] In this case, the material for the tube 21 has a two-layered structure which does not have a brazing material clad on a layer to be the inside surface of the tube.

[0033] Thus, even when the brazing sheet which does not have the brazing material coated on the layer to be the inner surface is used, the tube 21 and the inner fin 23 are securely joined because the inner fin 23 is coated with the brazing material. And, the corrosion resistance of the tube itself can be improved by using the plate which is the aforesaid brazing sheet having the clad material of the Al-Zn-based alloy coated on the layer to be the outside surface.

[0034] Further, the tube is formed by using the brazing sheet which has the clad material of Al-Zn-based alloy uniformly coated on the surface to be the outer layer of the tube, and owing to a potential difference between the core material and the clad material on the surface layer, the core material has high potential. Thus, the corrosion resistance of the tube itself can be improved owing to the sacrifice anode effect which provides a uniform surface to the clad material.

INDUSTRIAL APPLICABILITY

[0035] The present invention is suitable for an automobile refrigerating cycle used under sever conditions because it can improve pitting corrosion resistance of tubes.

Claims

1. A heat exchanger which has tubes and fins alternately stacked and ends of the tubes inserted into and connected to header pipes, characterized in that:

the tubes are formed of a flat tube material by roll or press molding; and

the tube material for the tubes is formed of an aluminum alloy such as Al-Mi-based one as a core material and an Al-Zn-based aluminum alloy not containing Si clad on a layer to be the outer surface of the tube to form the tubes.

2. The heat exchanger according to claim 1, wherein the tube material for the tubes has a three-layered structure which has a brazing material clad on a layer to be the inner surface of the tube.
3. The heat exchanger according to claim 2, wherein the tube is formed of a single plate by folding it.

4. The heat exchanger according to claim 2, wherein the tube is formed of two plates by mutually overlaying them.
5. The heat exchanger according to claim 1, wherein an inner fin having a brazing material clad is inserted into the tubes, and the tube material for the tubes has a two-layered structure which does not have a brazing material clad on a layer to be the inner surface of the tube.

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FIG. 1

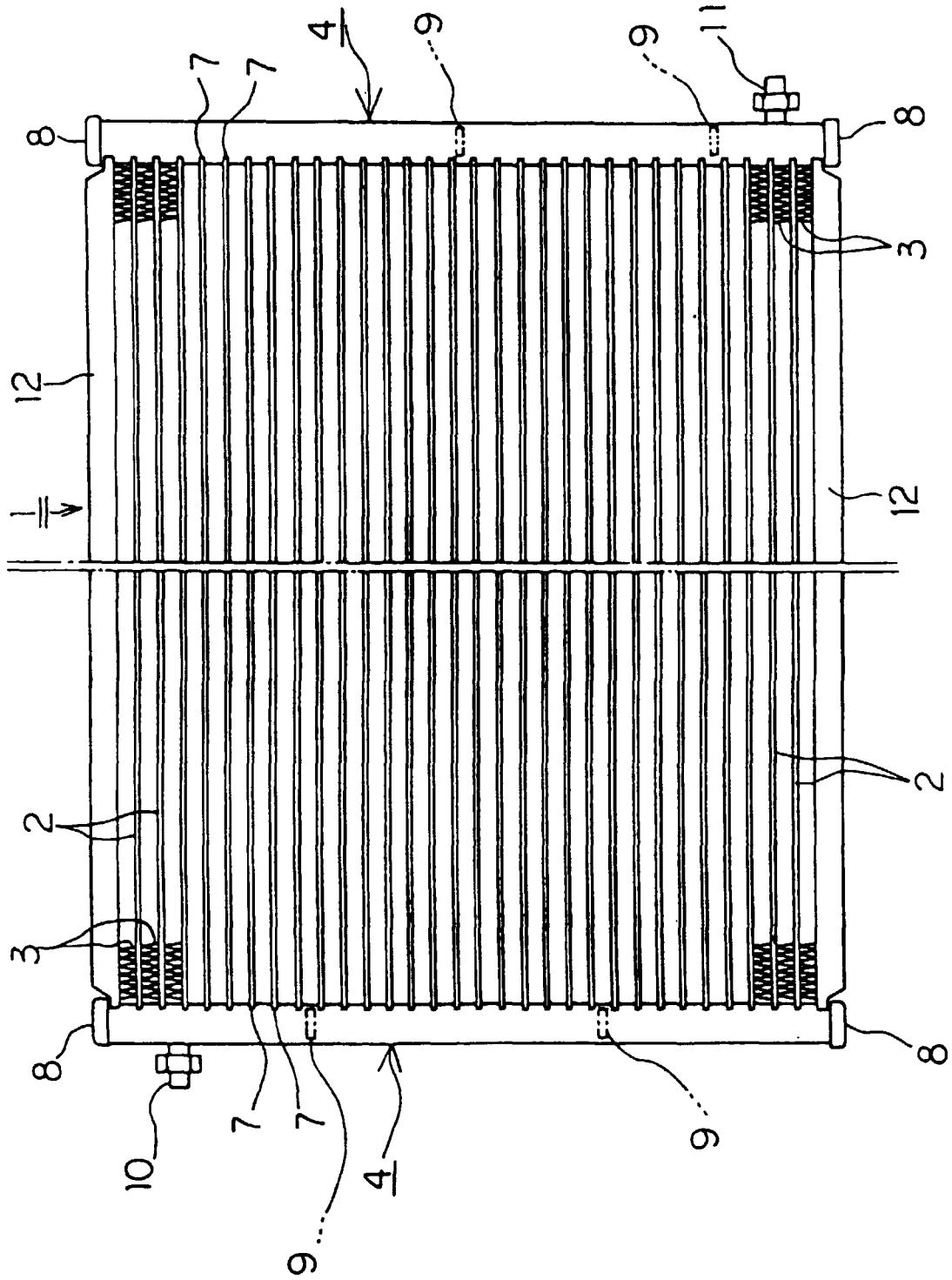


FIG. 2

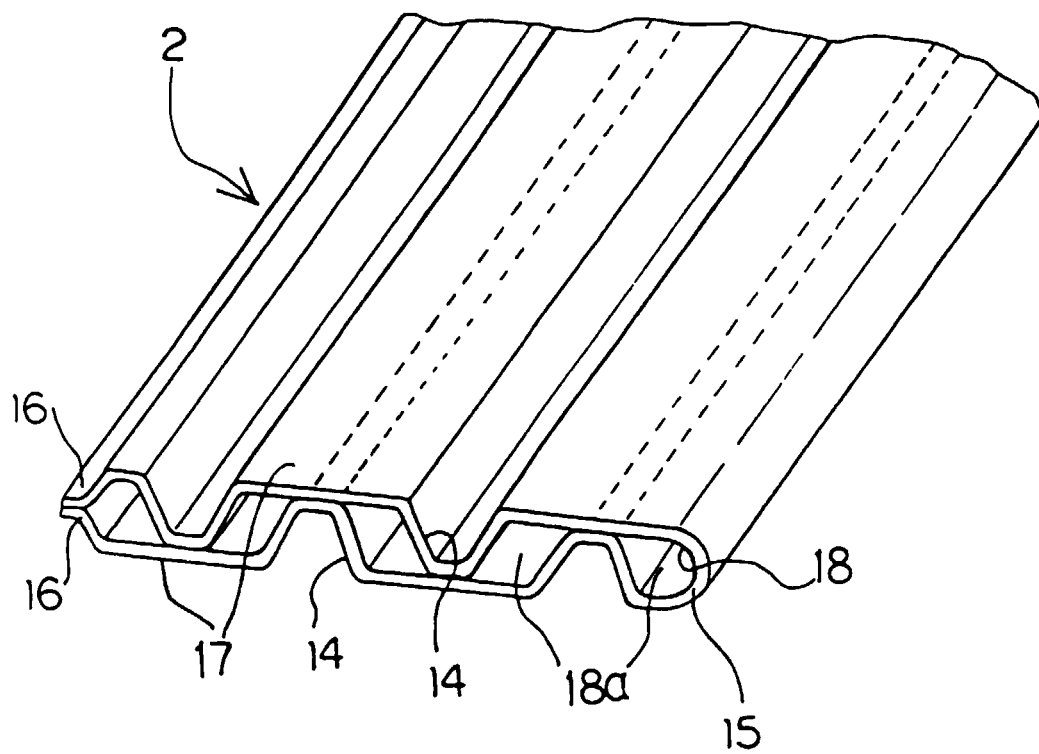
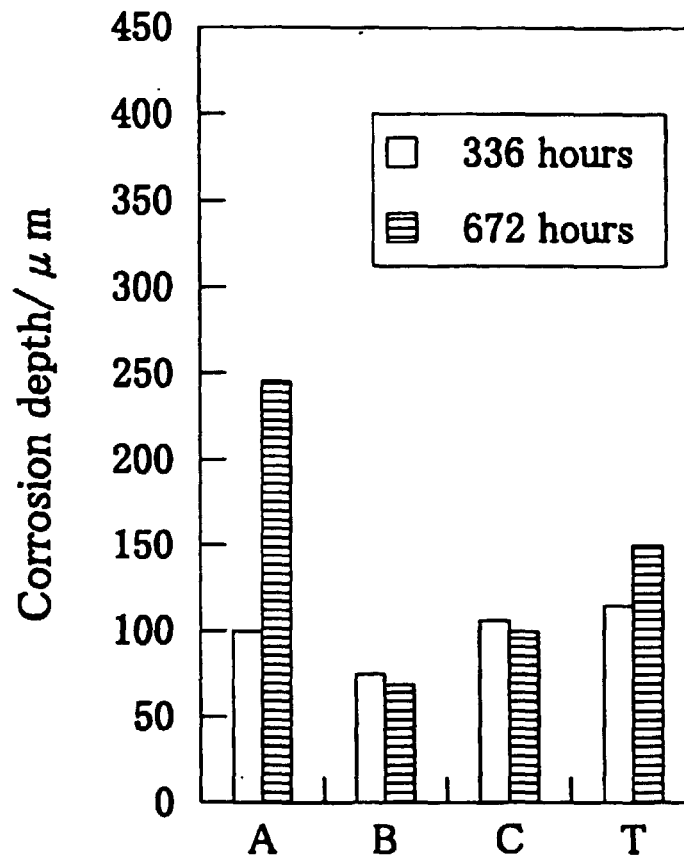


FIG. 3



A: JIS A3000-based (Cu, Mn added) alloy core material
Al-Si-Zn-based alloy brazing material

B: JIS A3000-based (Cu, Mn added) alloy core material
JIS A7072 alloy (Al-Zn based)

C: JIS A3003-based (Al-Fe-Mn based) alloy core material
JIS A7072 alloy (Al-Zn based)

T: JIS A1050 (99.00 wt% Al) alloy core material, Zn spraying

FIG. 4

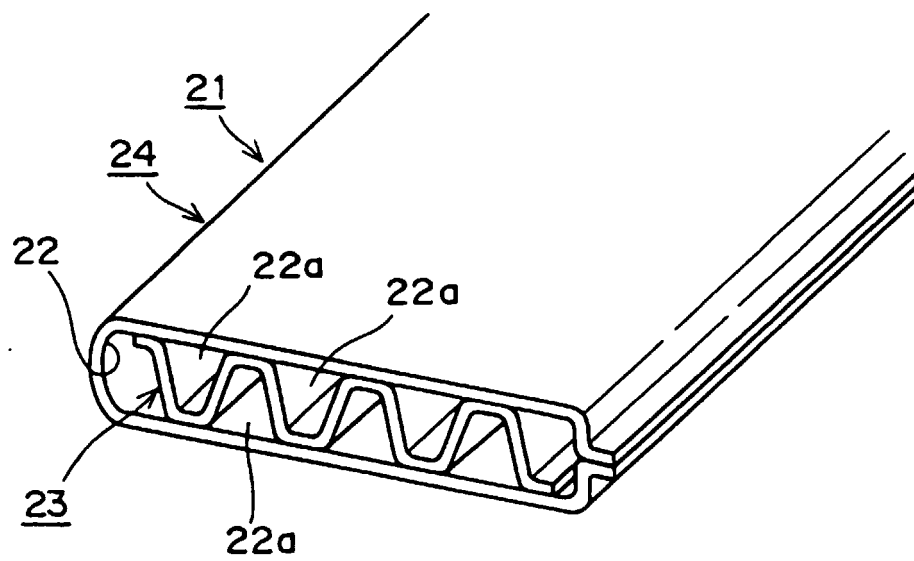
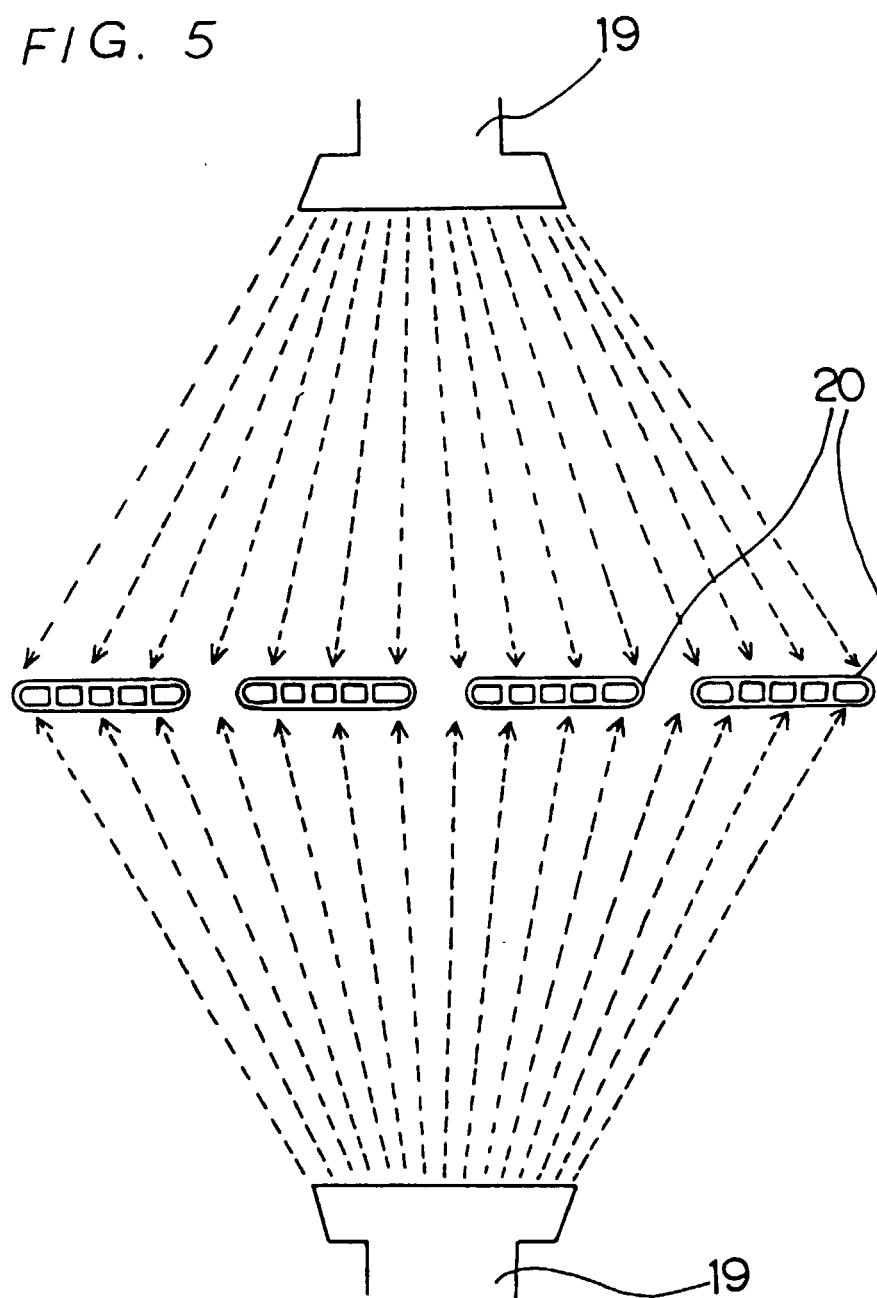


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP98/04375

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl⁶ C22C21/00, F28F21/08, B23K1/00, 1/19

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)

Int.Cl⁶ C22C21/00, F28F21/08, B23K1/00, 1/19

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

Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-1998
 Kokai Jitsuyo Shinan Koho 1971-1998 Jitsuyo Shinan Toroku Koho 1996-1998

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.
Y	JP, 5-45082, A (Showa Aluminium Corp.), 23 February, 1993 (23. 02. 93), Claims ; column 1, lines 21 to 42 ; column 2, line 49 to column 4, line 22 (Family: none)	1-5
Y	Microfilm of the specification and drawings first annexed to the request of Japanese Utility Model Application No. 106784/1988 (Laid-open No. 28981/1990) (Nippon Radiator K.K.), 23 February, 1990 (23. 02. 90), Claims ; page 2, line 10 to page 5, line 4 ; page 7, line 11 to page 8, line 4 ; page 10, line 7 to page 11, line 11 (Family: none)	1-5
Y	JP, 56-127767, A (Sumitomo Light Metal Industries, Ltd.), 6 October, 1981 (06. 10. 81), Claims ; page 1, lower left column, line 17 to lower right column, line 10 ; page 2, upper right column (Family: none)	1-5

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

* Special categories of cited documents:	"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
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP98/04375

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, 64-4449, A (Nippon Radiator K.K.), 9 January, 1989 (09. 01. 89), Page 2, upper left column, line 17 to upper right column, line 20 (Family: none)	2-4

Form PCT/ISA/210 (continuation of second sheet) (July 1992)