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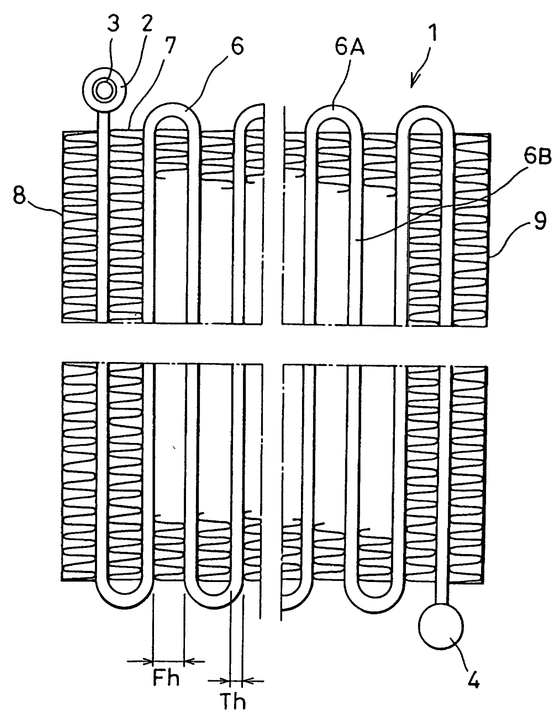
(54) **SERPENTINE TYPE HEAT EXCHANGER**

(57) A serpentine type heat exchanger, comprising at least an inlet side header pipe, an outlet side header pipe, at least one serpentine tube which is extended from the inlet side header pipe, folded back in multiple stages with specified intervals, and led to the outside header pipe, and a corrugated fins disposed between multiple-stage folded-back refrigerant passages formed of the serpentine tubes, wherein the width of the heat exchanger in the direction of air flowing through the corrugated fins is formed within the range of approximately 35mm or longer to 65mm or shorter, the fin height pf the corrugated fins is formed within the range of approximately 5mm or longer to 13 mm or shorter, and the intervals between the folded-back refrigerant passages of the serpentine tubes are formed corresponding to the fin height.

FIG.1



EP 1 195 569 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger and, more specifically, a serpentine type heat exchanger that is required to have good pressure withstanding performance, which may be utilized as an evaporator in a refrigerating cycle in which carbon dioxide is used as a refrigerant, or as an evaporator or a condenser depending upon the direction of the refrigerant flow in a refrigerating cycle adopting a heat pump system.

BACKGROUND ART

[0002] Japanese Unexamined Utility Model Publication No. S 57-40893 discloses a heat exchanger achieved by setting the two ends of a tube formed in a continuous serpentine shape at a single position, connecting the two ends of the tube to an intake port and an output port formed at a single assembly member and connecting a connecting pipe to the intake port and the output port at the assembly member.

[0003] In addition, Japanese Unexamined Utility Model Publication No. S 57-82690 discloses a heat exchanger achieved by providing fins between a flat tube folded back over a plurality of stages with an appropriate distance set between the individual stages. This heat exchanger includes a horizontal portion at which the flat surface of the flat tube positioned at the upper and lower ends during the hate exchanger production is allowed to extend horizontally and a connector linking device having a connector which is provided at each of the horizontal portions of the flat tube.

[0004] Japanese Unexamined Utility Model Publication No. S 57-178993 discloses a condenser for automobiles, having two refrigerant passage systems on the left side and the right side achieving symmetry that are formed by bonding both ends of a left tube and a right tube to an intake/outlet block provided at the center and a connecting plate provided near the front ends of an intake pipe and an outlet pipe with the intake pipe and the outlet pipe bonded to the intake/outlet block by securing the connecting plate to the intake/outlet block.

[0005] In order to meet the increasing need for achieving miniaturization and a smaller wall thickness in heat exchangers today, it is crucial to improve the heat exchanger performance and a higher degree of efficiency in serpentine type heat exchangers such as those described above. Since the curvature R of the tube must be reduced to miniaturize a serpentine type heat exchanger by reducing the fin height, it is essential that the optimal balance in the serpentine type heat exchanger.

[0006] Accordingly, an object of the present invention is to provide a serpentine type heat exchanger having dimensions that achieve maximum efficiency.

DISCLOSURE OF THE INVENTION

[0007] In order to achieve the object described above, in the serpentine type heat exchanger according to the present invention comprising at least an inflow-side header pipe through which a refrigerant flows in, an outlet-side header pipe through which the refrigerant flows out, at least one serpentine tube that is folded back over a plurality of stages by maintaining a specific distance between the individual folded portions of the serpentine tube and communicates between the inflow-side header pipe and the outlet-side header pipe and corrugated fins provided between multiple-stage folded-back refrigerant passages formed by the serpentine tube, the width of the heat exchanger along the direction in which air flows through the corrugated fins is set within an approximate range of 35mm ~ 65mm, the fin height of the corrugated fins is set within an approximate range of 5mm ~ 13mm and the distance between the individual folded-back refrigerant passages formed by the serpentine tube is set in correspondence to the fin height. Since this makes it possible to reduce the dimension of the heat exchanger along the direction in which the folded-back refrigerant passages constituted of the serpentine tube and the fins are laminated and the width of the heat exchanger along the direction of the airflow while maintaining a specific level of heat exchanging capability, the object is achieved.

[0008] In addition, in the heat exchanger according to the present invention, it is desirable to set the fin pitch representing the distance between a bent portion of each corrugated fin coming in contact with the tube element on one side and the next bent portion coming in contact with the same side of the tube element within an approximate range of 2.8mm ~ 5.0mm and to set the plate thickness of the corrugated fins within an approximate range of 0.06mm ~ 0.15mm. These settings achieve optimal corrugated fins for the serpentine type heat exchanger having the dimensions noted earlier.

[0009] The corrugated fins should each include bent portions coming in contact with the tube element and flat portions formed between the bent portions that are in contact with one tube element an the bent portions that are in contact with the tube element on the other side. It is desirable to provide a plurality of louvers at each flat portion. they should be formed sequentially along the direction of the airflow to extend outward along the direction perpendicular to the direction of the airflow with the angle at which the louvers incline relative to the direction of the airflow set within an approximate range of 24° ~ 40°, in order to obtain corrugated fins having ideal louvers.

[0010] It is also desirable to set the distance between the ends of the louvers and the tube element within an approximate range of 0.2mm ~ 1.5mm and to set the wall thickness of the serpentine tube within an approximate range of 1.6mm ~ 3.9mm in the serpentine type heat exchanger described above, since these settings improve the drainage of water at the corrugated fins.

[0011] Alternatively, the serpentine type heat exchanger may include one inflow-side header pipe provided at an approximate center along the laminating direction which communicates with a refrigerant inlet portion extending out toward the downstream side along the direction of the airflow and a pair of outlet-side header pipes provided at the two ends along the laminating direction and communicating with a refrigerant output portion extending out toward the upstream side along the direction of the airflow. In this structure, the serpentine tube may be constituted of a first serpentine tube that communicates between the inflow-side header pipe and one of the outlet-side header pipes and a second serpentine tube that communicates between the inflow-side header pipe and the other outlet-side header pipe. Since this structure reduces the passage resistance at the serpentine tube and improves the distribution of the refrigerant, an improvement is achieved in the heat exchanger performance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG. 1 presents a front view illustrating the structure adopted in the serpentine type heat exchanger achieved in a first embodiment of the present invention;

FIG. 2 is a side elevation of the serpentine type heat exchanger shown in FIG. 1;

FIG. 3 presents a characteristics diagram illustrating the relationship between the width Cw of the heat exchanger along the direction of the airflow and the heat exchanging capability Fa;

FIG. 4(a) is a side elevation showing the structure of a corrugated fin and FIG. 4(b) presents a sectional view of the corrugated fin;

FIG. 5 is a partial sectional view of the corrugated fin in an enlargement;

FIG. 6 is a side elevation illustrating the state in which the corrugated fins are mounted;

FIG. 7 presents a characteristics diagram illustrating the relationship between the fin height Fh of the corrugated fins and the heat exchanging capability Fa;

FIG. 8 presents a characteristics diagram illustrating the relationship between the fin pitch Fp of the corrugated fins and the heat exchanger capability Fa;

FIG. 9 presents a characteristics diagram illustrating the relationship between the louver angle Ra at which the louvers are provided at the corrugated fins and the heat exchanging capability Fa;

FIG. 10 is a front view of the serpentine type heat exchanger achieved in a second embodiment of the present invention;

FIG. 11 presents a bottom view of the serpentine type heat exchanger achieved in the second embodiment; and

FIG. 12 presents a side elevation of the serpentine type heat exchanger achieved in the second embodiment.

BEST MODE FOR CARRYING OUT THE INVENTION

[0013] The following is an explanation of the embodiments of the present invention, given in reference to the drawings.

[0014] A serpentine type heat exchanger 1 shown in FIGS. 1 and 2 comprises at least an inflow-side header pipe 2 that communicates with a refrigerant inflow pipe 3 provided on one side and extends out toward the downstream side along the direction of the airflow (see FIG. 2), and an outflow-side header pipe 4 that communicates with a refrigerant outflow pipe 5 provided on the other side and extending out toward the upstream side along the direction of the airflow, a serpentine tube 6 that communicates between the inflow-side header pipe 2 and the outflow-side header pipe 4 and is constituted of a plurality of folded back portions 6A formed on the one side and also on the other side and a plurality of folded-back refrigerant passages 6B communicating between the folded back portions 6A on the one side and the folded back portions 6A on the other side and corrugated fins 7 provided between adjacent folded-back refrigerant passages 6B constituted of the serpentine tube 6. It is to be noted that in the embodiment, a pair of end plates 8 and 9 are provided at the two ends along the direction in which the folded-back refrigerant passages 6B and the corrugated fins 7 are laminated, with corrugated fins 7 also provided between the outermost folded-back refrigerant passages 6B and the end plates 8 and 9. It is desirable to form the serpentine tube 6 by using a Zn spray-coated tube material or a material constituted of a Zn spray-coated tube material and a highly corrosion-resistant tube material.

[0015] A factor that indicates the refrigerating performance (refrigerating capability) and a factor indicating the airflow resistance were determined through testing conducted on the serpentine type heat exchanger 1 structured as described above and a factor Fa that indicates the overall heat exchanging capability (heat exchanging capability) was ascertained based upon these factors (Fa = refrigerating capability/airflow resistance). It is to be noted that this heat exchanger capability Fa is in proportion to the refrigerating capability and is in reverse proportion to the airflow resistance. The "refrigerating capability / airflow resistance" representing the factor Fa that indicates the heat exchanging capability achieves the characteristics presented in the characteristics diagram in FIG. 3. This diagram indicates the maximum heat exchanging capability is achieved that a point at which the width Cwm along the airflow direction is 50mm and a heat exchanging capability of 80% or higher is achieved relative to the maximum heat exchanging capability set at 100% over an approximate range of the width Cw along the airflow direction between 35mm ~ 65mm.

[0016] As shown in FIGS. 4 through 6, the corrugated fins 7 are each constituted of bent portions 11a that are bonded in contact with one of adjacent folded-back refrigerant passages 6B of the serpentine tube 6, bent portions 11b bonded in contact with the other folded-back refrigerant passage 6B and flat portions 12 linking the bent portions 11a on the one side and the bent portions 11b on the other side, achieving a specific fin height Fh equivalent to the distance between the adjacent folded-back refrigerant passages 6B and a fin pitch Fp representing the distance between the apexes of the bent portions 11a bonded in contact to the folded-back refrigerant passage 6B on the one side.

[0017] While it is desirable to reduce the fin height Fh equivalent to the distance between the adjust folded-back refrigerant passages 6B of the serpentine tube 6 in order to reduce the dimension of the heat exchanger along the direction in which the folded-back refrigerant passages 6B and the corrugated fins 7 are laminated, a problem arises in that a smaller fin height Fh results in an increase in the airflow resistance. Accordingly, the relationship between the fin height Fh and the heat exchanging capability Fa was ascertained through testing to determine the optimal fin height, and from the resulting characteristics diagram presented in FIG. 7, a fin height Fhm of 9mm was obtained in correspondence to the maximum capability. It was also learned that the ideal range Fhs for the fin height Fh over which the heat exchanging capability Fa is at least 80 % of the maximum heat exchanging capability was approximately 5.0mm ~ 13mm. Accordingly, the distance between the adjacent folded-back refrigerant passages 6B must be set in conformance to the fin height Fh within this range and the bent portions 6A and 6B must be bent to achieve the distance.

[0018] In addition, while it is necessary to reduce the height Th of the serpentine tube 6 as well as the fin height Fh to reduce the dimension along the laminating direction, a problem arises in that as the height Th becomes smaller, the refrigerant flow passage resistance increases, and thus, the correct balance between the height Th and the refrigerant flow passage resistance must be struck. Accordingly, it is desirable to set the tube height Th within an approximate range of 1.6mm ~ 3.9mm.

[0019] The relationship between the fin pitch Fp and the heat exchanging capability Fa achieved in the serpentine type heat exchanger 1 having the width Cw along the airflow direction set to 50mm was ascertained through testing, and the resulting characteristics diagram presented in FIG. 8 indicates that the maximum capability is achieved when the fin pitch Fp is at 3.9mm. The characteristics diagram in FIG. 8 also indicates that the ideal range Fps for the fin pitch Fp over which the heat exchanging capability Fa is at least 80 % of the maximum heat exchanging capability as described earlier is approximately 2.8mm ~ 5.0mm.

[0020] In addition, the corrugated fins 7 each include a plurality of louvers 10 projecting out perpendicularly to the airflow direction and sequentially raised along the airflow direction. Since the presence of the louvers 10 allows the air passing along the corrugated fins 7 to travel by intersecting the corrugated fins 7 along the louvers 10, an improvement is achieved in the heat exchanging efficiency at the corrugated fins 7. However, while a higher heat exchanging capability can be achieved by increasing the angle Ra of inclination of the louvers (louver angle) relative to the flat portion 12 of the corrugated fin 7, a larger louver angle Ra increases the airflow resistance, resulting in a lowered heat exchanging capability. Thus, an optimal louver angle Ra must be ascertained.

[0021] Accordingly, the serpentine type heat exchanging capability Fa was ascertained through testing conducted by varying the louver angle Ra in the heat exchanger 1 structured as described above and the relationship between the louver angle Ra and the heat exchanging capability Fa as indicated in the characteristics diagram presented in FIG. 9 was determined. The louver angle Ram at which the maximum capability is achieved was determined to be 32°, and an ideal louver angle range Ras over which a heat exchanging capability of at least 80% relative to the maximum capability set at 100% was achieved was determined to be approximately 24° ~ 40°.

[0022] While it is desirable to keep down the fin plate thickness Ft for economical reasons, the fins need to have a specific minimum thickness in order to achieve sufficient fin strength, and accordingly, it is desirable to set the thin plate thickness Ft within an approximate range of 0.06mm ~ 0.15mm. In addition, the distance Dr between the ends of the louvers 10 formed at the corrugated fins 7 and the apexes of the bent portions 11a and 11b of the fins should be set within an approximate range of 0.2mm ~ 1.5mm. By setting the distance Dr within this range, the water drainage at the fins is improved and, at the same time, a sufficient fin strength is retained for the fins that are corrugated. Furthermore, an improvement is achieved in the bondability when the corrugated fins 7 and the serpentine tube 6 are bonded through braising.

[0023] A serpentine type heat exchanger 20 shown in FIGS. 10 through 12 comprises at least corrugated fins 7 each having a plurality of louver groups 10A each constituted of a plurality of louvers, and a single inflow-side header pipe 21 provided at one side of the heat exchanger at an approximate center along the direction in which the corrugated fins 7 are laminated, a pair of outflow-side header pipes 22 and 23 provided at the other end of the heat exchanger at the two sides along the laminating direction, a first serpentine tube 25 that communicates between the inflow-side header pipe 21 and one of the outflows side header pipes, i.e., the outflow-side header pipe 22 and is folded back over a plurality of stages between the one side and the other side of the heat exchanger and a second serpentine tube 26 that communicates between the inflow-side header pipe 21 and the other outflow-side header pipe 23 and is it folded back over a plurality of stages between the one side and the other side of the heat exchanger.

[0024] The first serpentine tube 25 is constituted of folded back portions 25A and folded-back refrigerant passages 25B extending between the folded back portions 25A, and likewise, the second serpentine tube 26, too, is constituted of folded back portions 26A and folded-back refrigerant passages 26B extending between the folded back portions 26B. The inflow-side header pipe 21 communicates with a refrigerant inlet portion 28 via an extension pipe 27 which distends out and bends toward the downstream side along the direction in which the air flows in the serpentine type heat exchanger 20 and is connected with a pipe (not shown) extending from, for instance, an expansion valve provided on the upstream side of the refrigerating cycle. The outlet-side header pipes 22 and 23 communicating with a refrigerant output portion 31 via a pair of extension pipes 29 and 30 which extend out and bend toward the upstream side along the airflow direction are connected to an accumulator, an internal heat exchanger or the like provided on the downstream side of the refrigerating cycle via pipes (not shown).

[0025] In this embodiment, in which two refrigerant flow paths through which the refrigerant is allowed to flow and parallel from the inflow-side header pipe 21 toward the outlet-side header pipes 22 and 23 are achieved by the first and second serpentine tubes 25 and 26, the refrigerant flow passage resistance can be reduced, which, in turn, allows a reduction in the width of the serpentine tubes 25 and 26, thereby achieving a further reduction in the width of the serpentine type heat exchanger along the laminating direction. While two parallel refrigerant flow paths are formed in the embodiment, more than two refrigerant flow paths may be formed as necessary. It is to be noted that the desirable dimensions of the individual elements explained earlier are also valid in the serpentine type heat exchanger in this embodiment.

INDUSTRIAL APPLICABILITY

[0026] As explained above, according to the present invention, the heat exchanging capability and the airflow resistance in the heat exchanger were ascertained through testing conducted on the serpentine type heat exchanger, the heat exchanging capability (heat exchanging capability/airflow resistance) was determined based upon these factors to set the dimension of the individual elements of the serpentine type heat exchanger within ranges over which the heat exchanging capability achieves a minimum specific value. As a result, a more compact heat exchanger is achieved while sustaining a specific level of heat exchanger performance, thereby allowing miniaturization of the automotive air-conditioning system in which the heat exchanger is mounted, achieving miniaturization of the vehicle itself and securing more space inside the cabin.

Claims

1. A serpentine type heat exchanger comprising at least;

   an inflow-side header pipe through which a refrigerant flows in;
   an outlet-side header pipe through which the refrigerant flows out;
   at least one serpentine tube that is folded back over a plurality of stages by maintaining a specific distance between the individual folded portions of said serpentine tube and communicates between said inflow-side header pipe and said outlet-side header pipe; and
   corrugated fins provided between multiple-stage folded-back refrigerant passages formed by said serpentine tube, **characterized in that**;
   the width of said heat exchanger along the direction in which air flows through said corrugated fins is set within an approximate range of 35mm ~ 65mm;
   the fin height of said corrugated fins is set within an approximate range of 5mm ~ 13mm; and
   the distance between the individual folded-back refrigerant passages formed by said serpentine tube is set in correspondence to said fin height.

2. A serpentine type heat exchanger according to claim 1, **characterized in that**;
   the fin pitch representing the distance between a bent portion of each corrugated fin coming in contact with said tube element on one side and the next bent portion coming in contact with said tube element on the other side is set within an approximate range of 2.8mm ~ 5.0mm

3. A serpentine type heat exchanger according to claim 1 or 2, **characterized in that**;
   the plate thickness of said corrugated fins is set within an approximate range of 0.06mm ~ 0.15mm.

4. A serpentine type heat exchanger according to claim 1, 2 or 3, **characterized in that**;
   said corrugated fins each include bent portions coming in contact with said tube element and flat portions formed between bent portions that are in contact with said tube element and bent portions that are in contact with said tube element on another

side;

a plurality of louvers are provided at each of said flat portions, formed sequentially along the direction of the airflow to extend outward along the direction perpendicular to the direction of the airflow; and

the angle at which said louvers incline relative to the direction of the airflow is set within an approximate range of 24° ~ 40°.

5. A serpentine type heat exchanger according to claim 4, **characterized in that**;

the distance between the ends of said louvers and said tube element is set within an approximate range of 0.2mm ~ 1,5mm.

6. A serpentine type heat exchanger according to any of claims 1 through 5, **characterized in that**;

the thickness of said serpentine tube is set within an approximate range of 1.6mm ~ 3.9mm.

7. A serpentine type heat exchanger according to any of claims 1 through 6, having;

one inflow-side header pipe provided at an approximate center along the laminating direction and a pair of outlet-side header pipes provided at the two ends along the laminating direction, **characterized in that**;

said serpentine tube is constituted of a first serpentine tube that communicates between said inflow-side header pipe and one of said outlet-side header pipes and a second serpentine tube that communicates between said inflow-side header pipe and the other outlet-side header pipe.

FIG.1

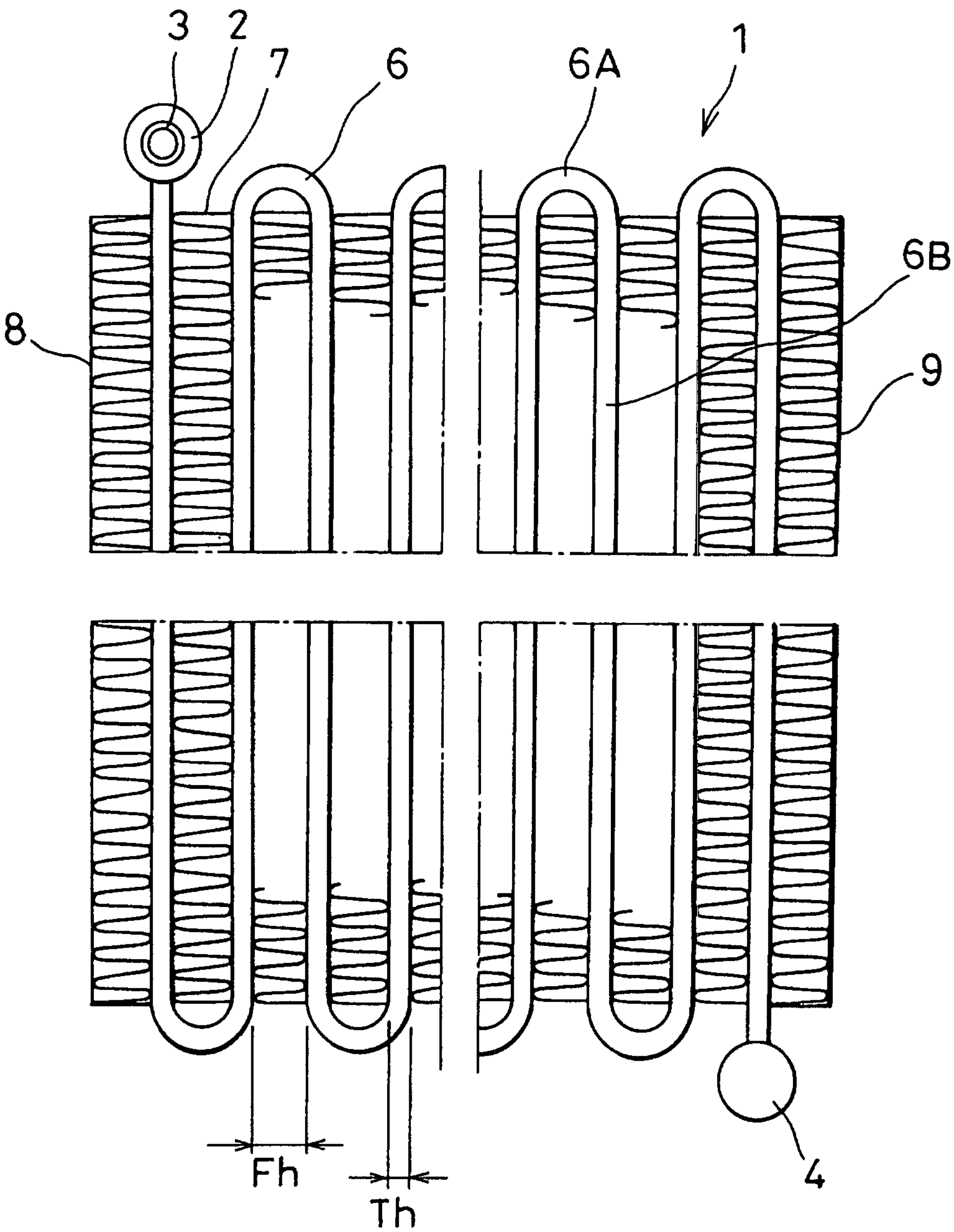


FIG.2

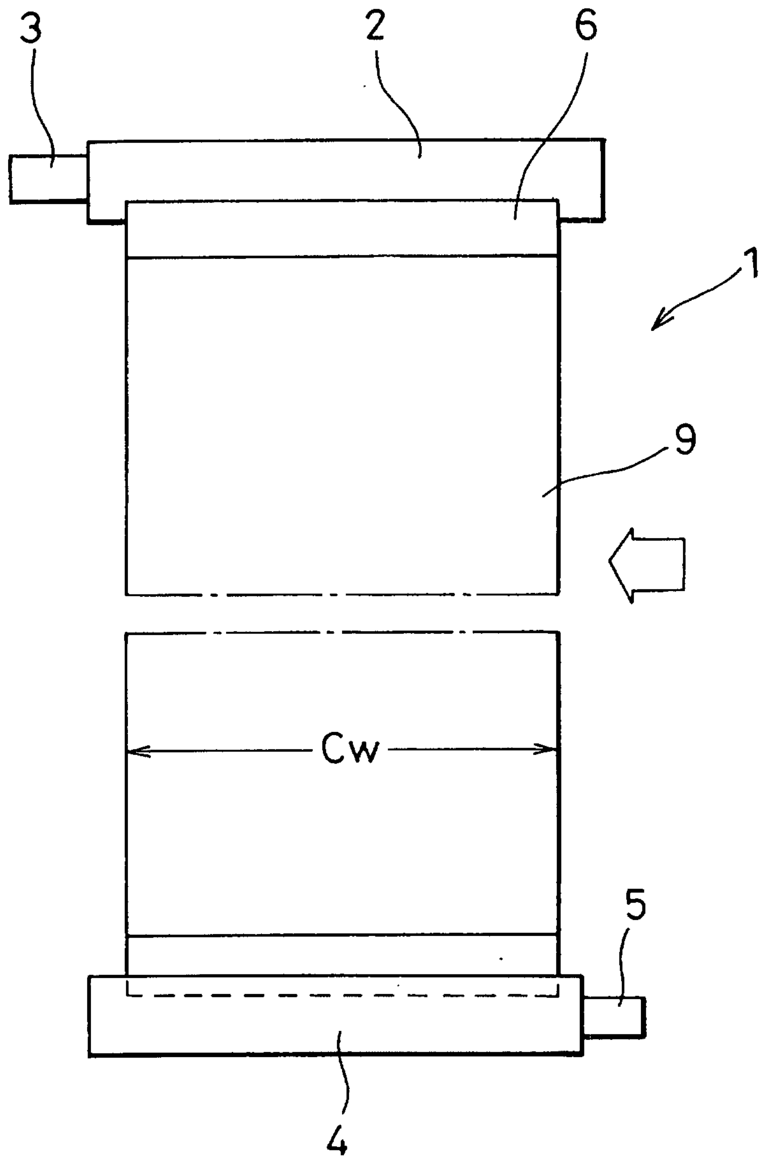


FIG.3

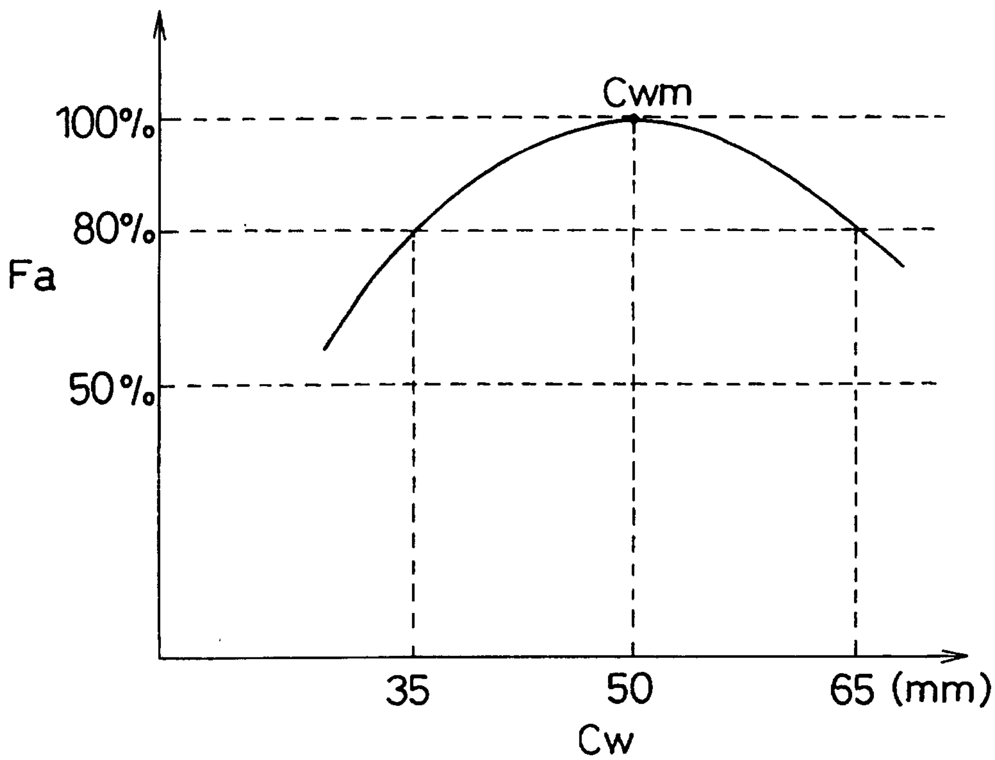


FIG.4

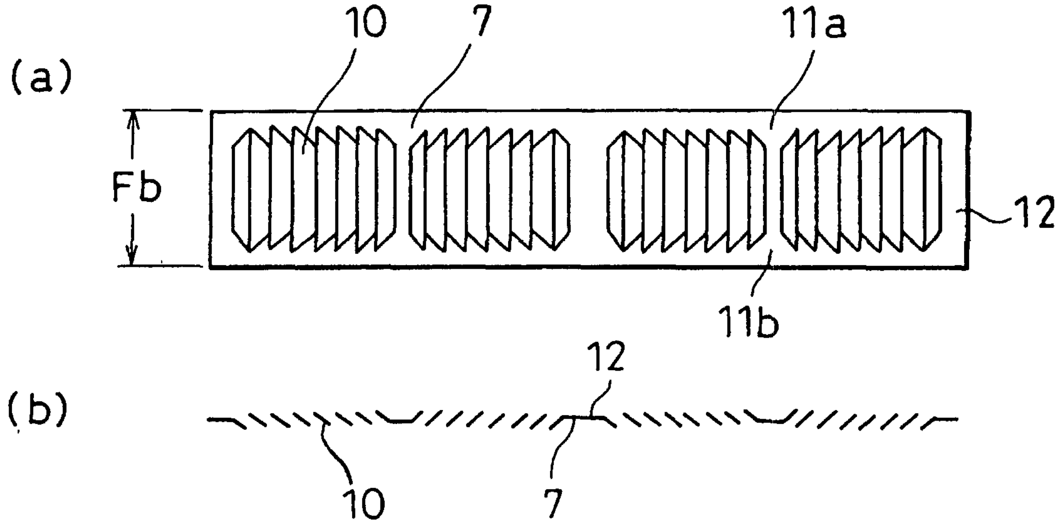


FIG.5

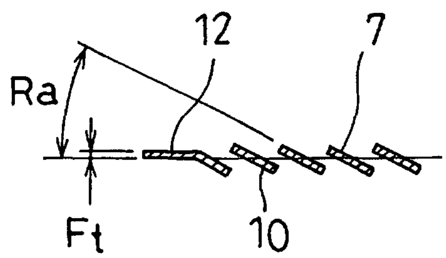


FIG.6

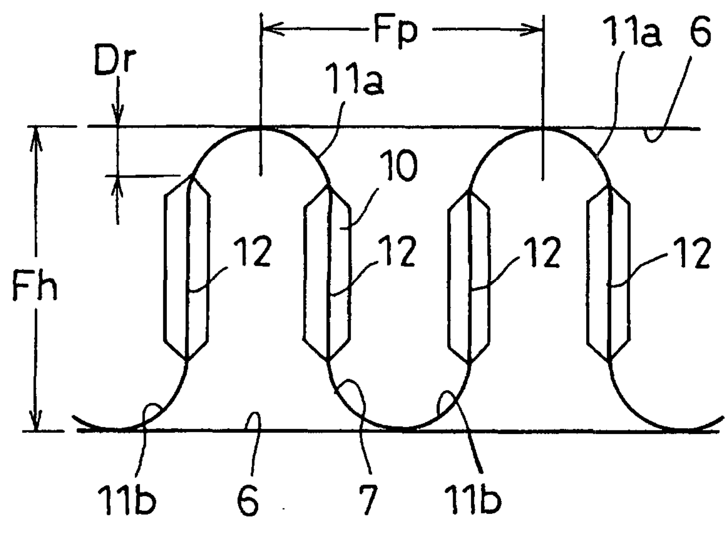


FIG.7

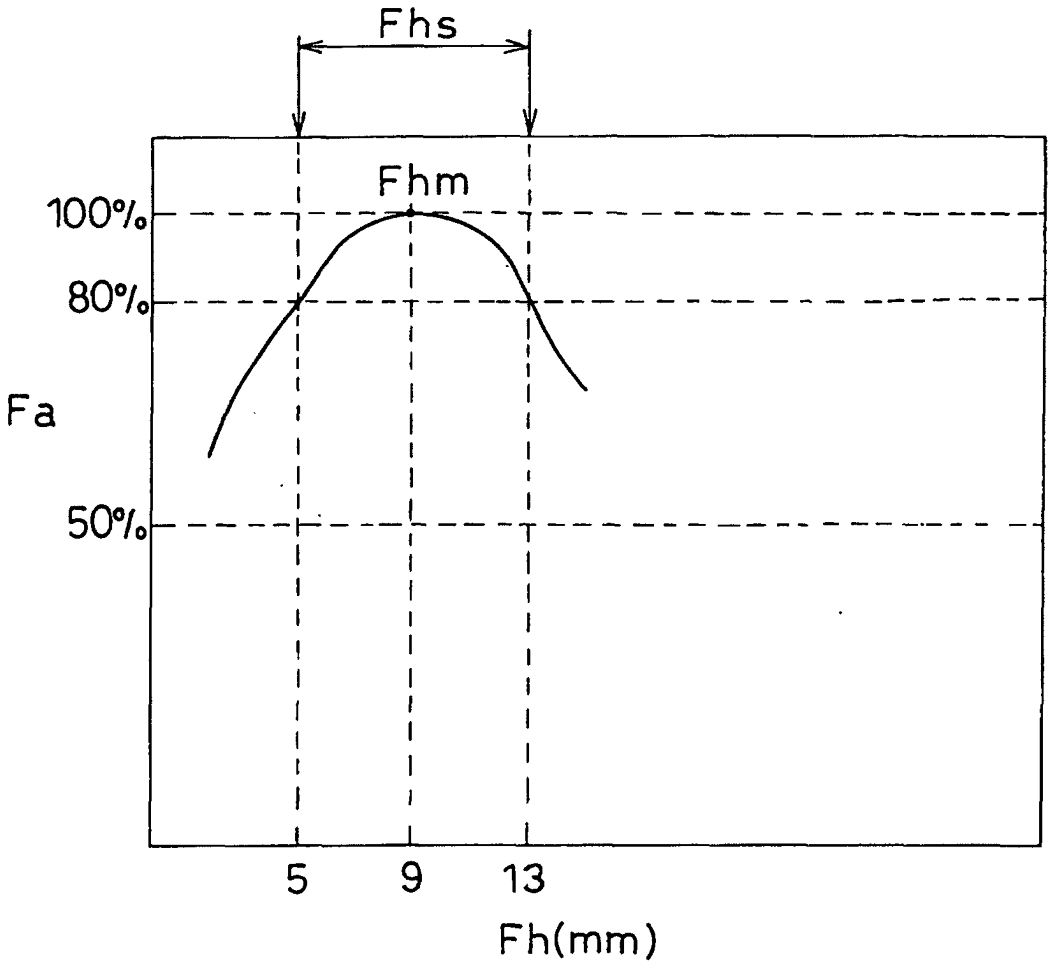


FIG.8

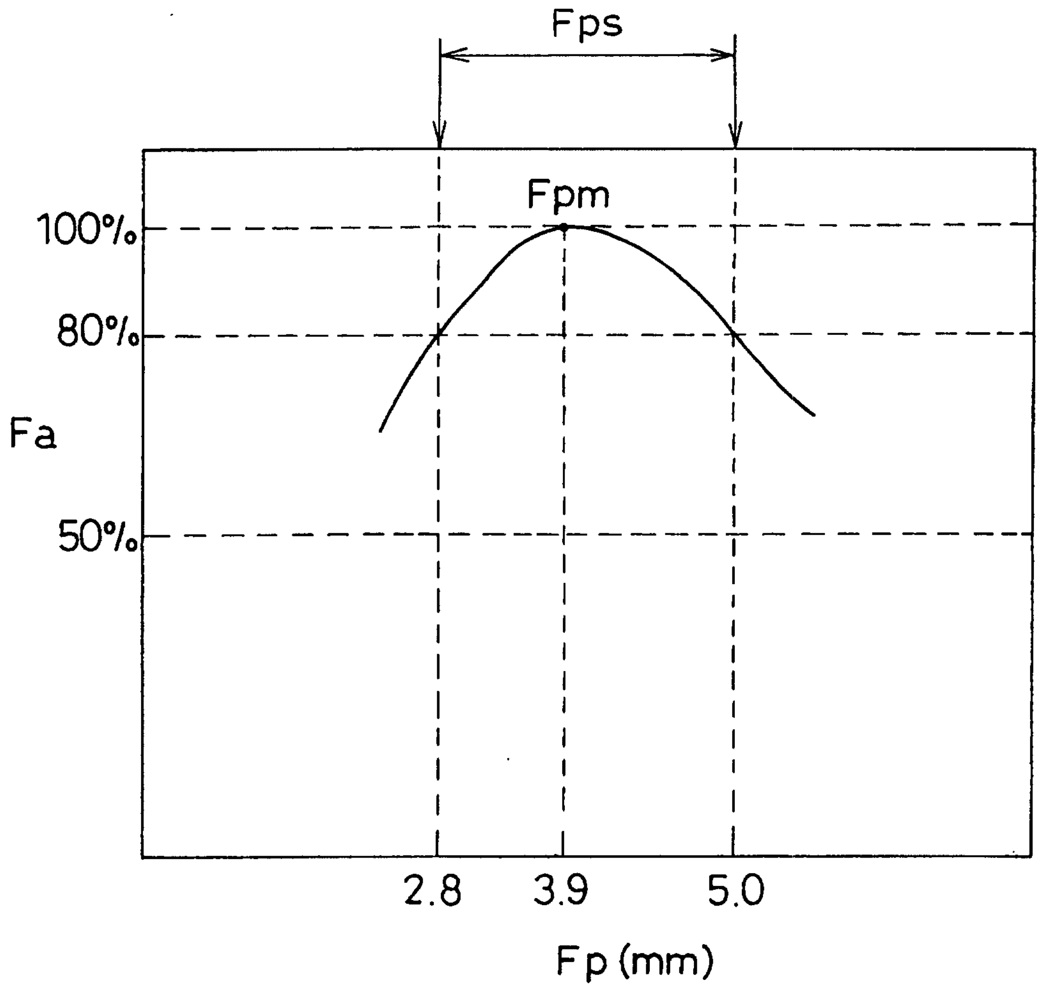


FIG.9

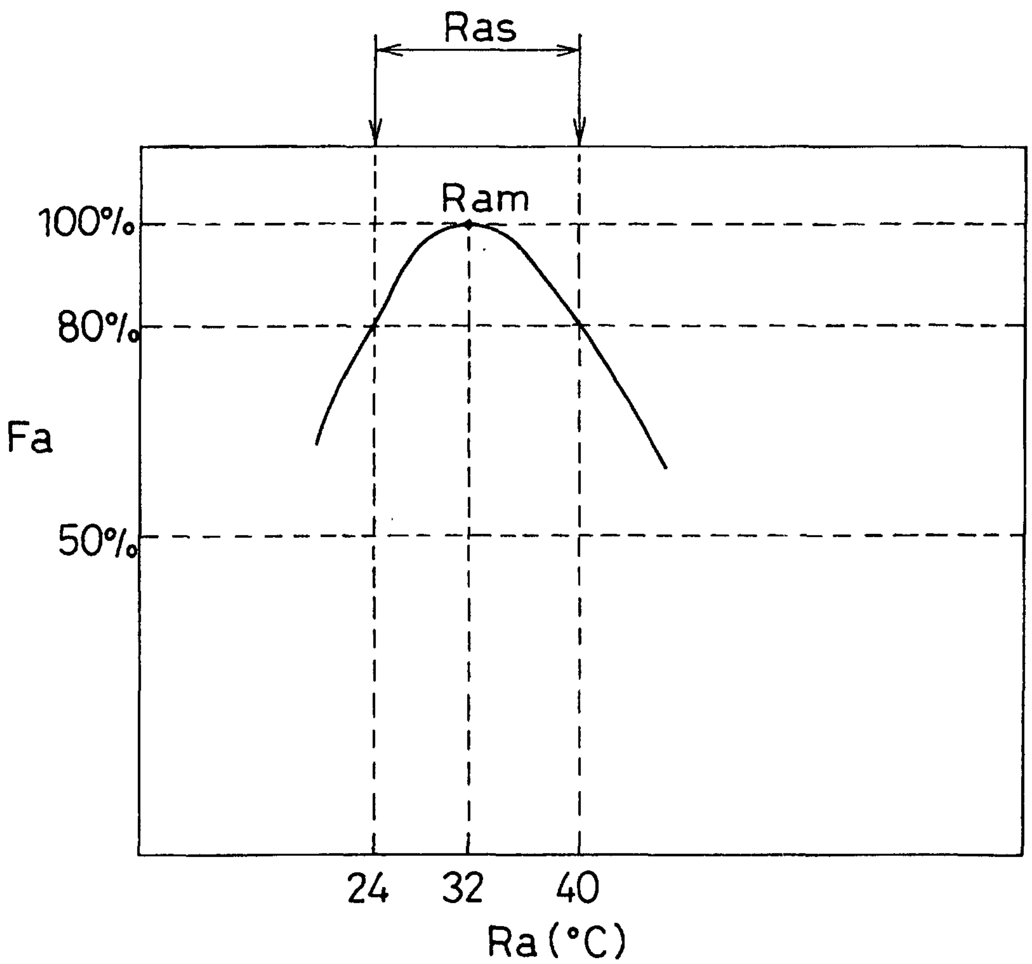


FIG.10

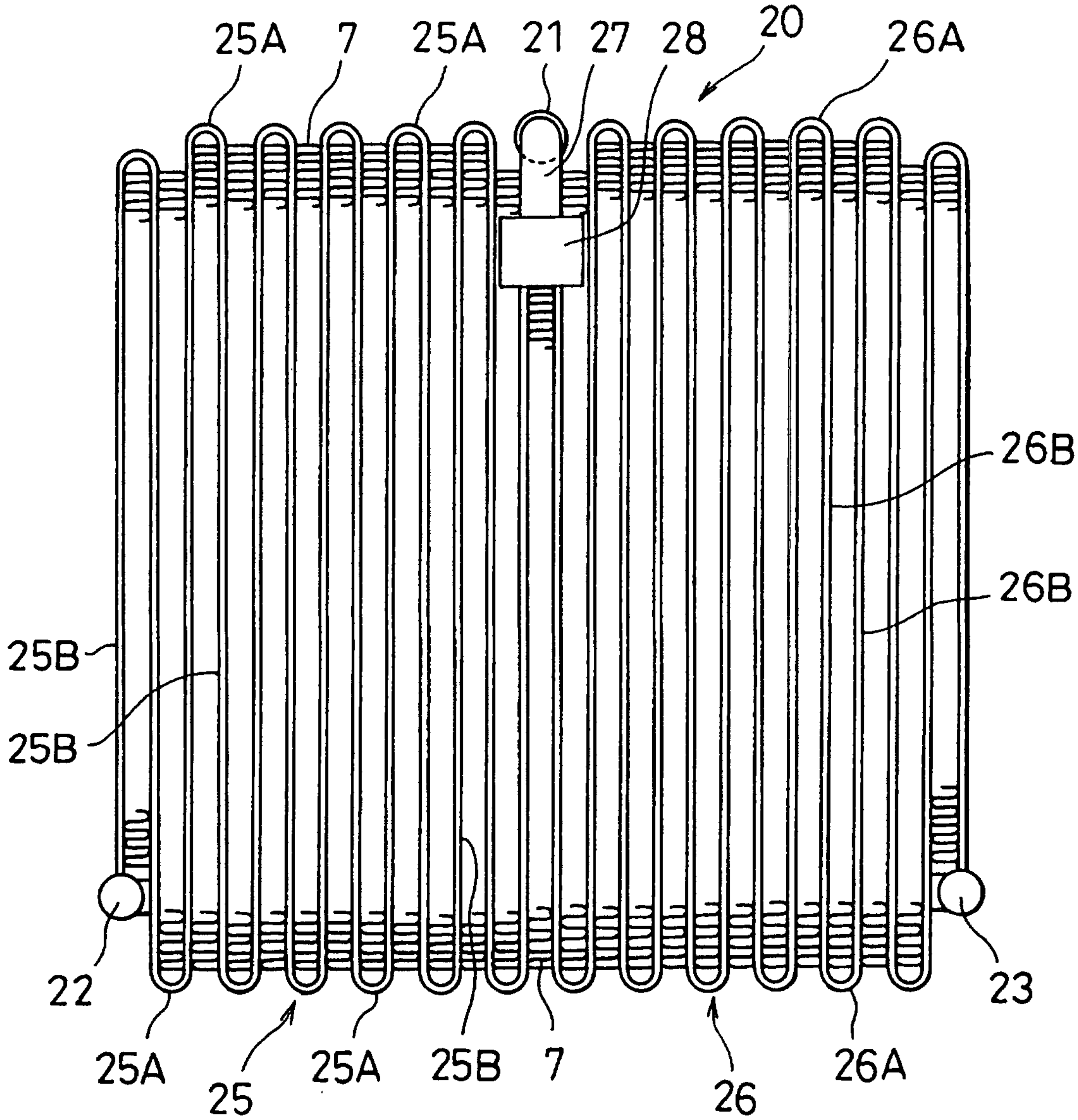

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FIG.11

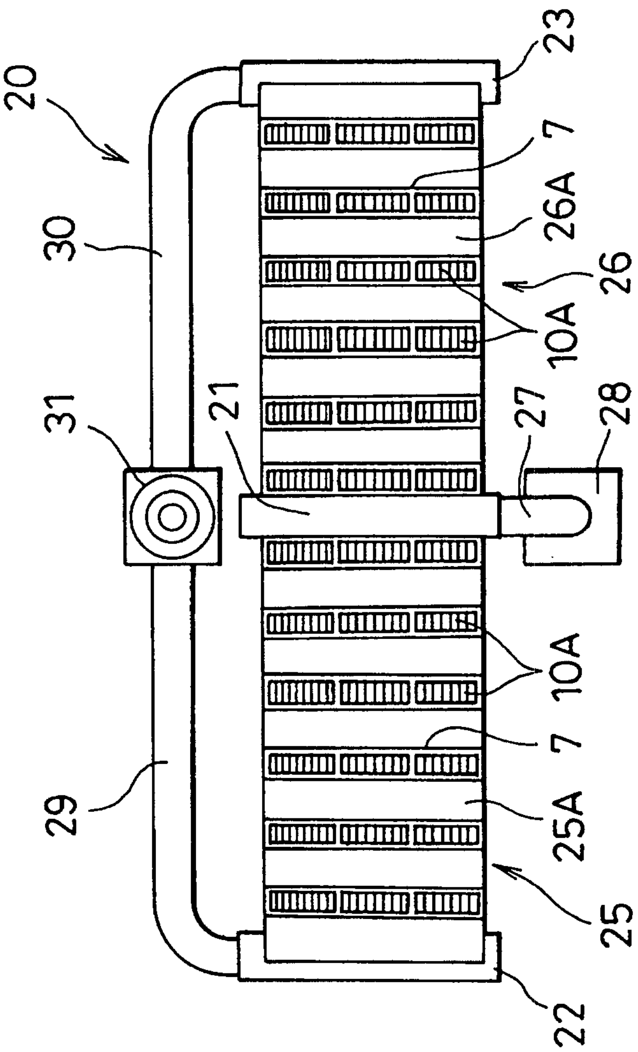
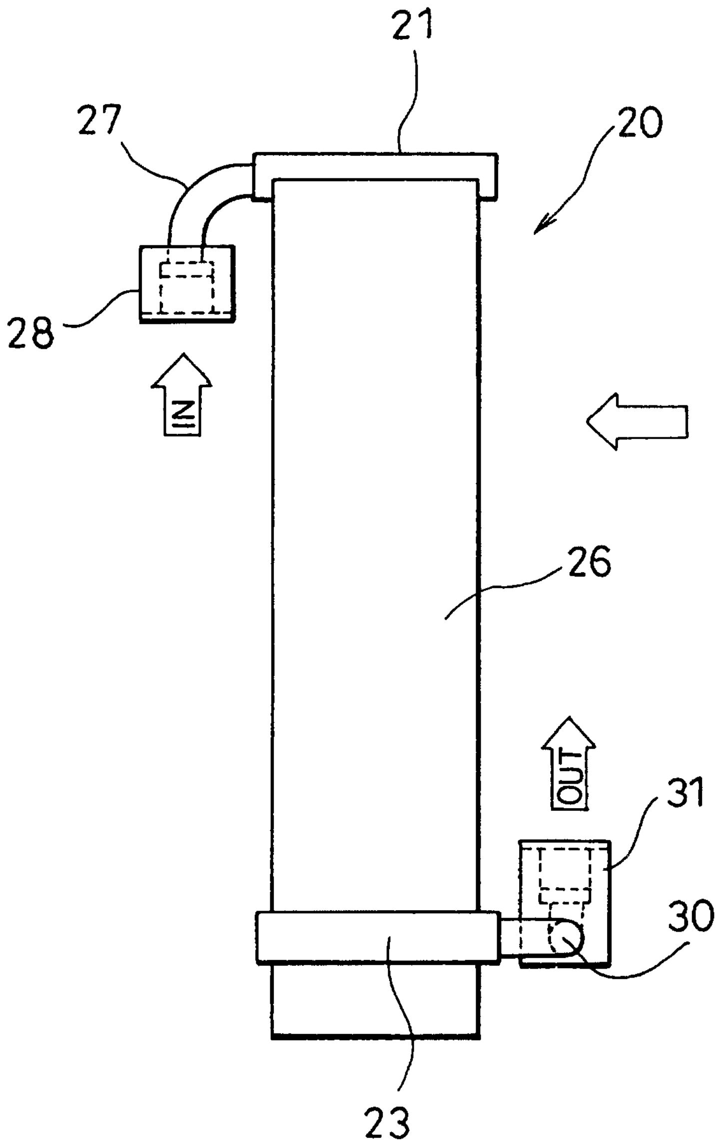


FIG.12



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/02262

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^7 F28D1/047

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.Cl^7 F28D1/047

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	1994-2000
Kokai Jitsuyo Shinan Koho	1971-2000	Jitsuyo Shinan Toroku Koho	1996-2000

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.
A	JP, 2-109178, U (Sanden Corp.), 30 August, 1990 (30.08.90), Full text	1-7
A	JP, 3-102193, A (SHOWA ALUMINUM CORPORATION), 26 April, 1991 (26.04.91), Full text (Family: none)	1-7
A	JP, 63-134267, U (Toyo Radiator K.K.), 02 September, 1988 (02.09.88), Full text	1-7
A	JP, 59-170783, U (Matsushita Refrig. co., Ltd.), 15 November, 1984 (15.11.84), Full text	1-7
A	JP, 64-19290, A (Hitachi, Ltd.), 23 January, 1989 (23.01.89), Full text (Family: none)	1-7

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

* Special categories of cited documents:
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Date of the actual completion of the international search 30 June, 2000 (30.06.00)	Date of mailing of the international search report 18 July, 2000 (18.07.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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