



US 20060157233A1

(19) **United States**(12) **Patent Application Publication**
Ozaki et al.(10) **Pub. No.: US 2006/0157233 A1**(43) **Pub. Date: Jul. 20, 2006**(54) **HEAT EXCHANGER****Publication Classification**(75) Inventors: **Tatsuo Ozaki**, Okazaki-city (JP);
Takaki Okochi, Chiryu-city (JP)(51) **Int. Cl.**
F28D 1/02 (2006.01)(52) **U.S. Cl.** 165/152

Correspondence Address:

HARNES, DICKEY & PIERCE, P.L.C.**P.O. BOX 828****BLOOMFIELD HILLS, MI 48303 (US)**(57) **ABSTRACT**(73) Assignee: **DENSO Corporation**, Kariya-city (JP)(21) Appl. No.: **11/331,439**(22) Filed: **Jan. 12, 2006**(30) **Foreign Application Priority Data**

Jan. 19, 2005 (JP) 2005-011466

A heat exchanger with louvers twisted by a predetermined angle with respect to flat parts of fins and with louver passages formed between adjoining louvers, wherein step differences projecting out to the louver passage side are provided at the louvers. According to this, when cooling air flows through the louver passages, the flow of the cooling air is disrupted by the step differences and temperature boundary layers are destroyed, so the local heat conductivity is again raised at the locations of the step differences.

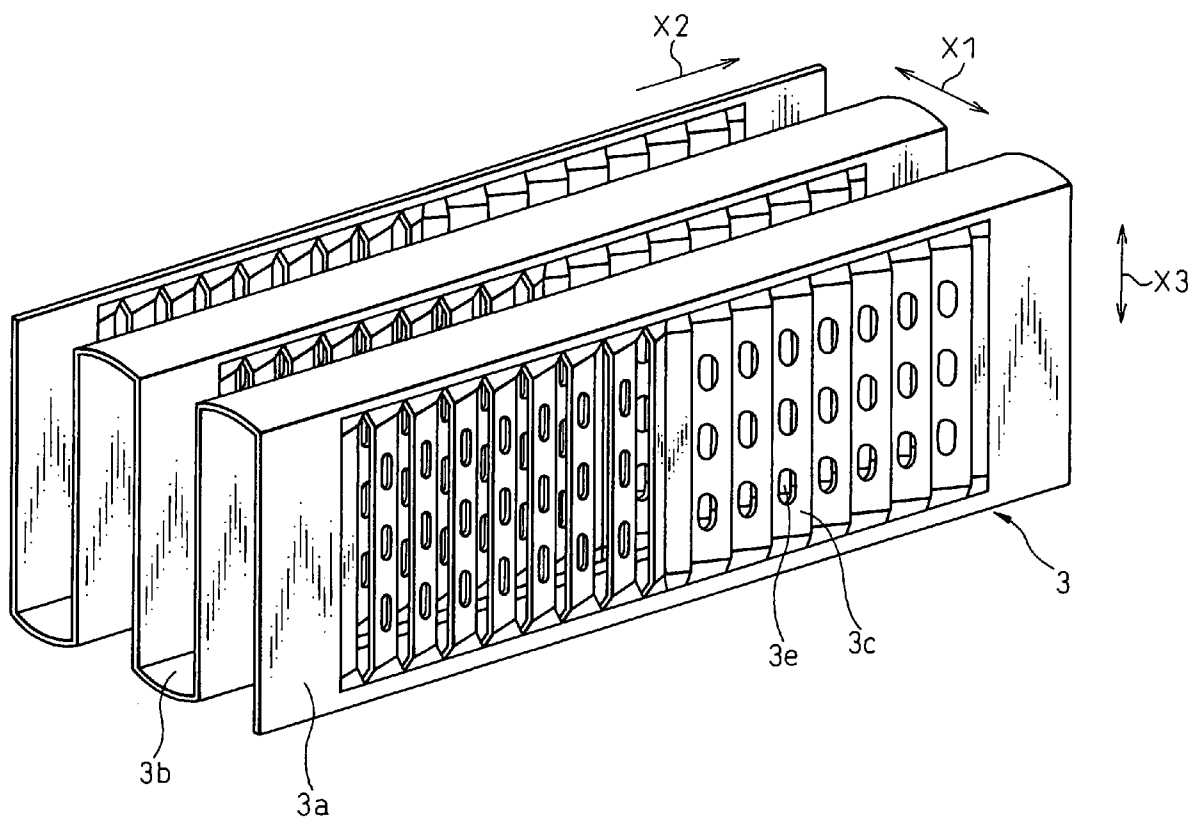
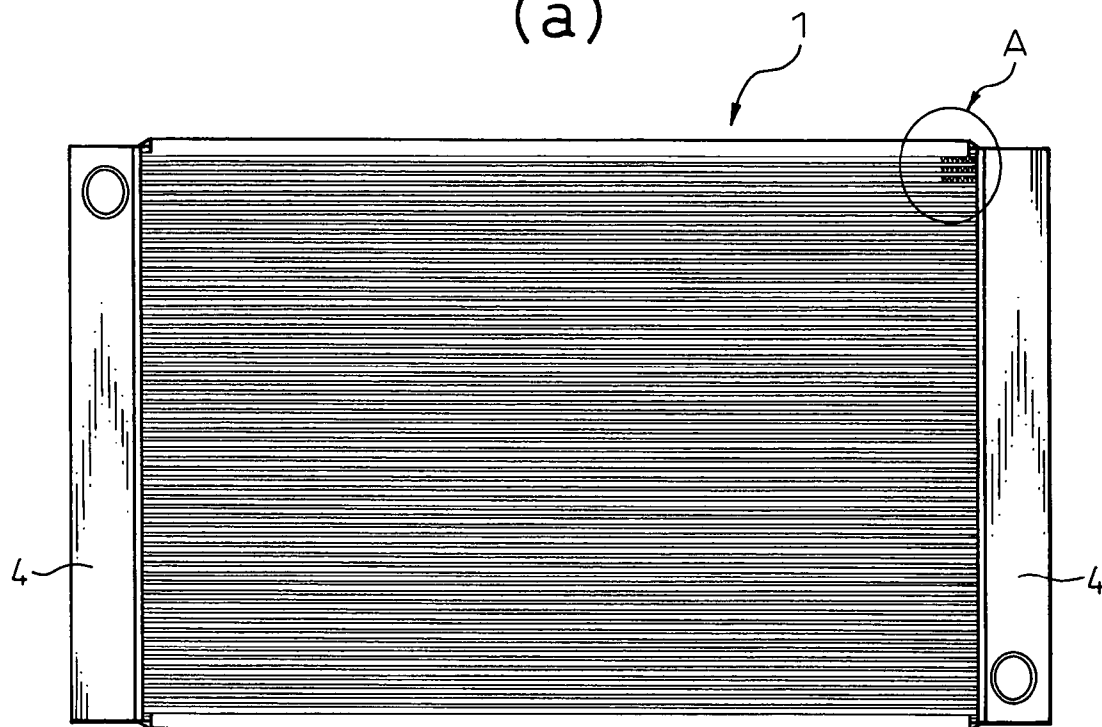


Fig.1

(a)



(b)

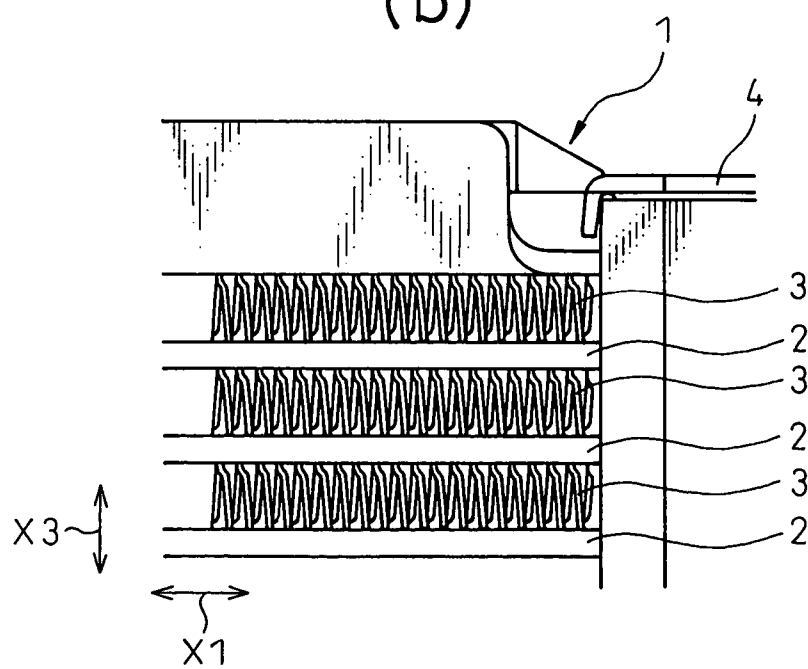


Fig.2

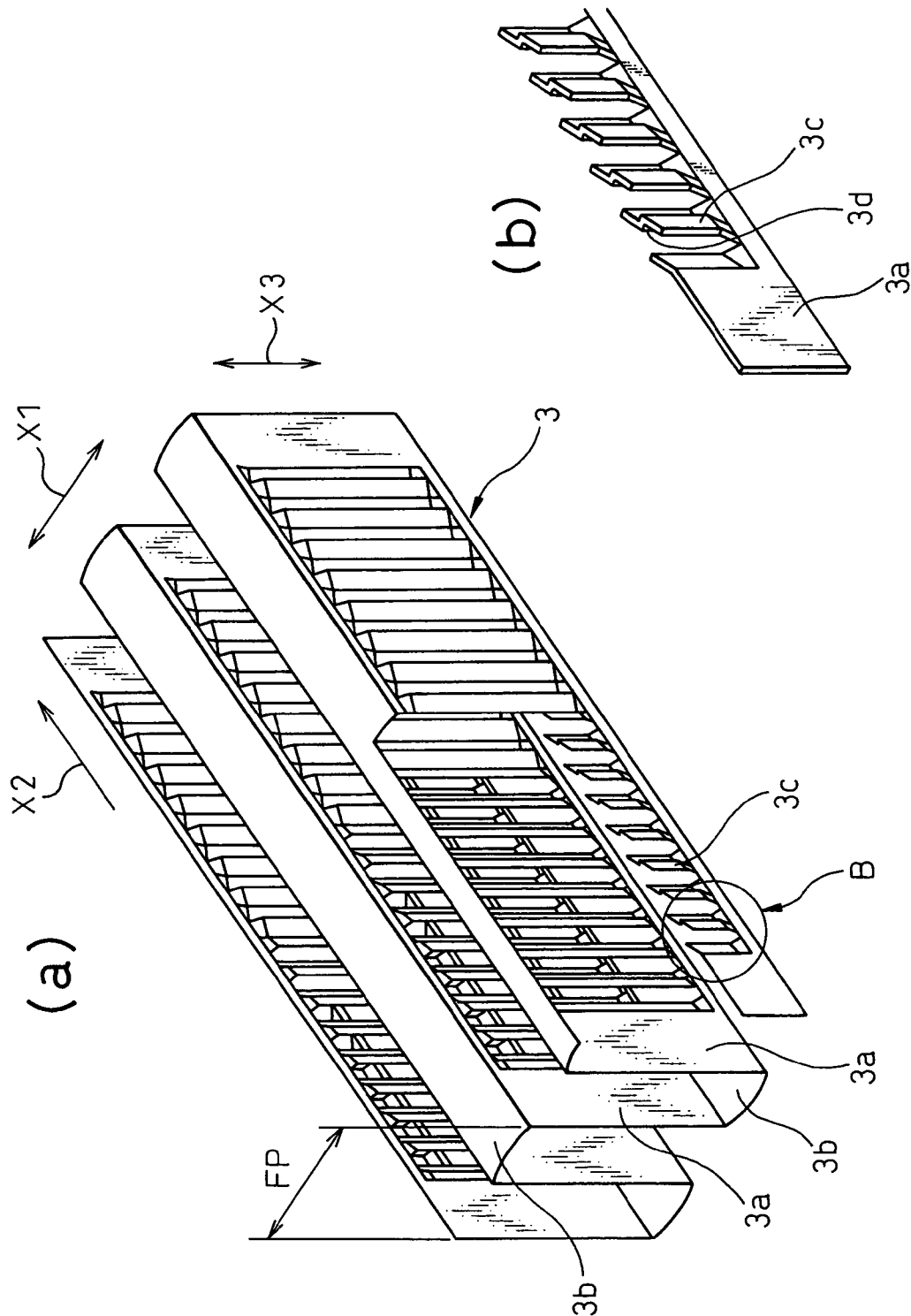


Fig. 3

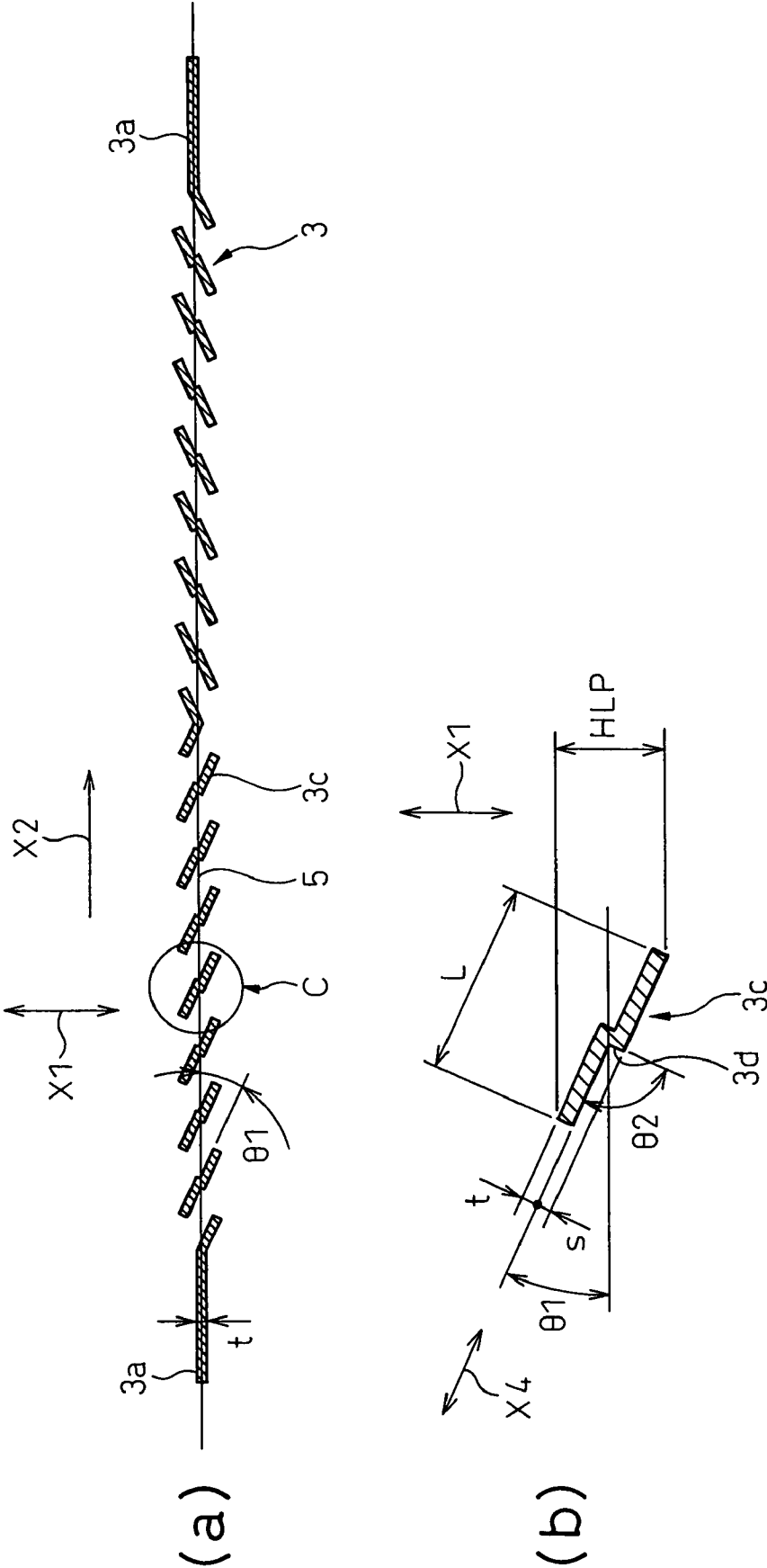
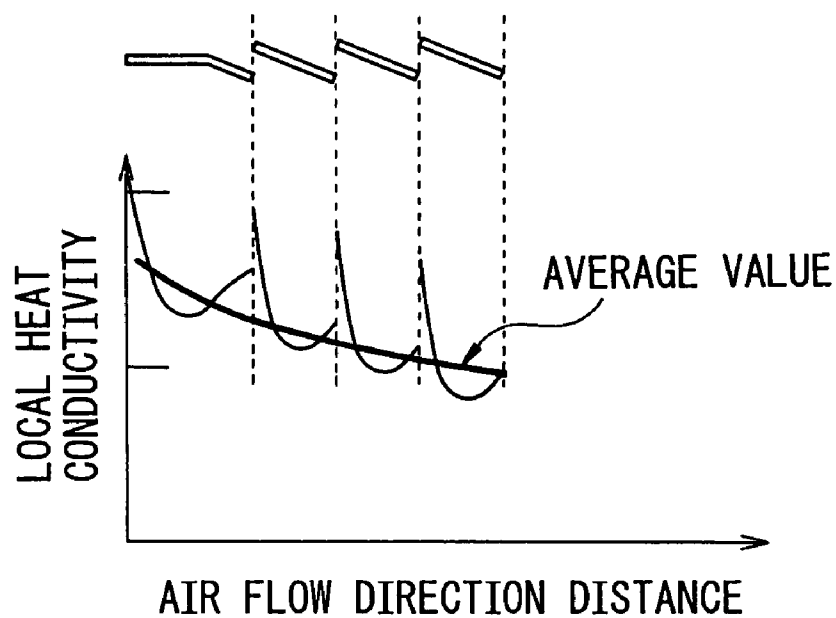


Fig.4

(b)



(a)

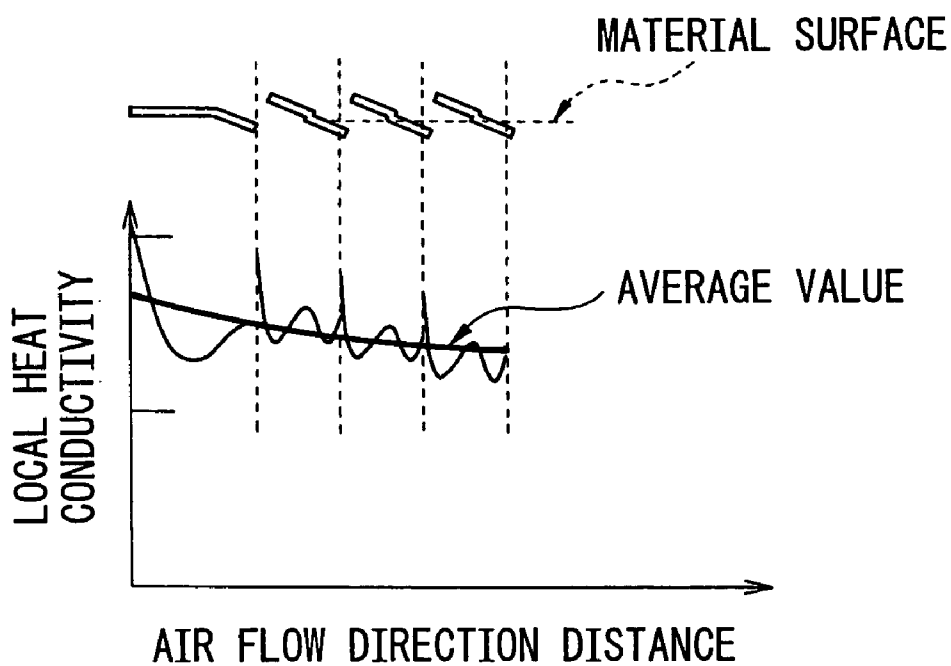


Fig.5

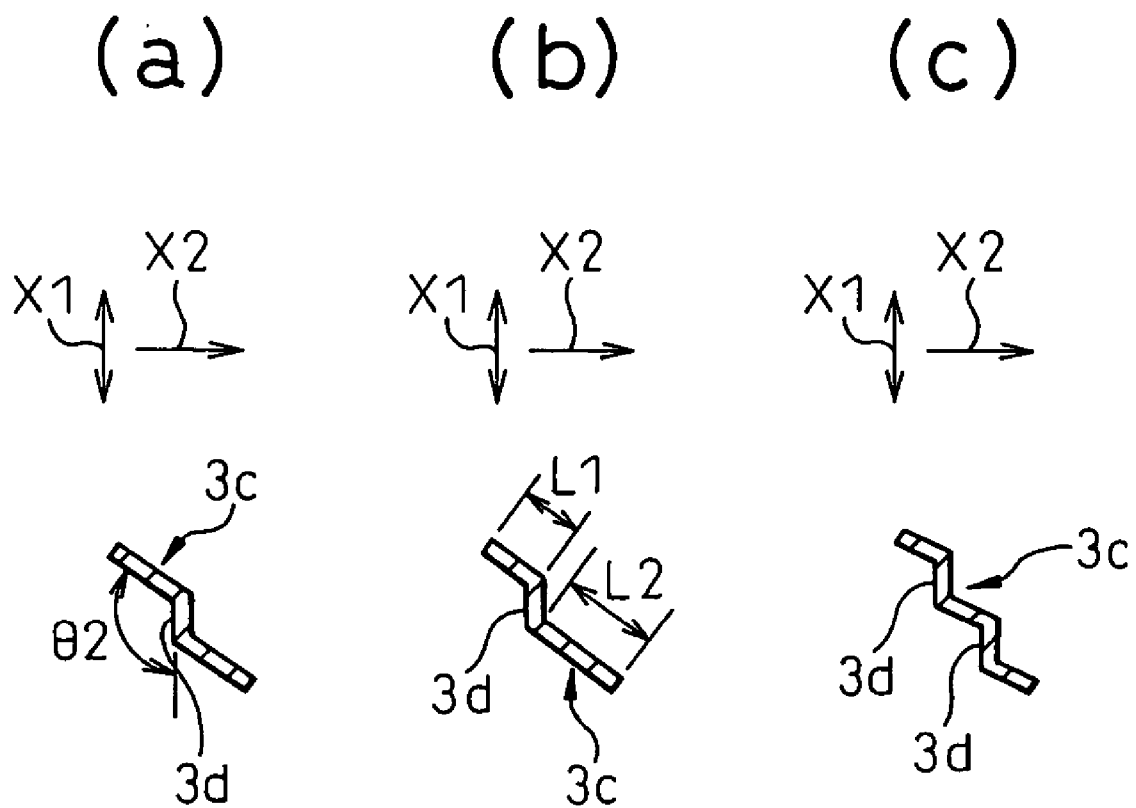


Fig.6

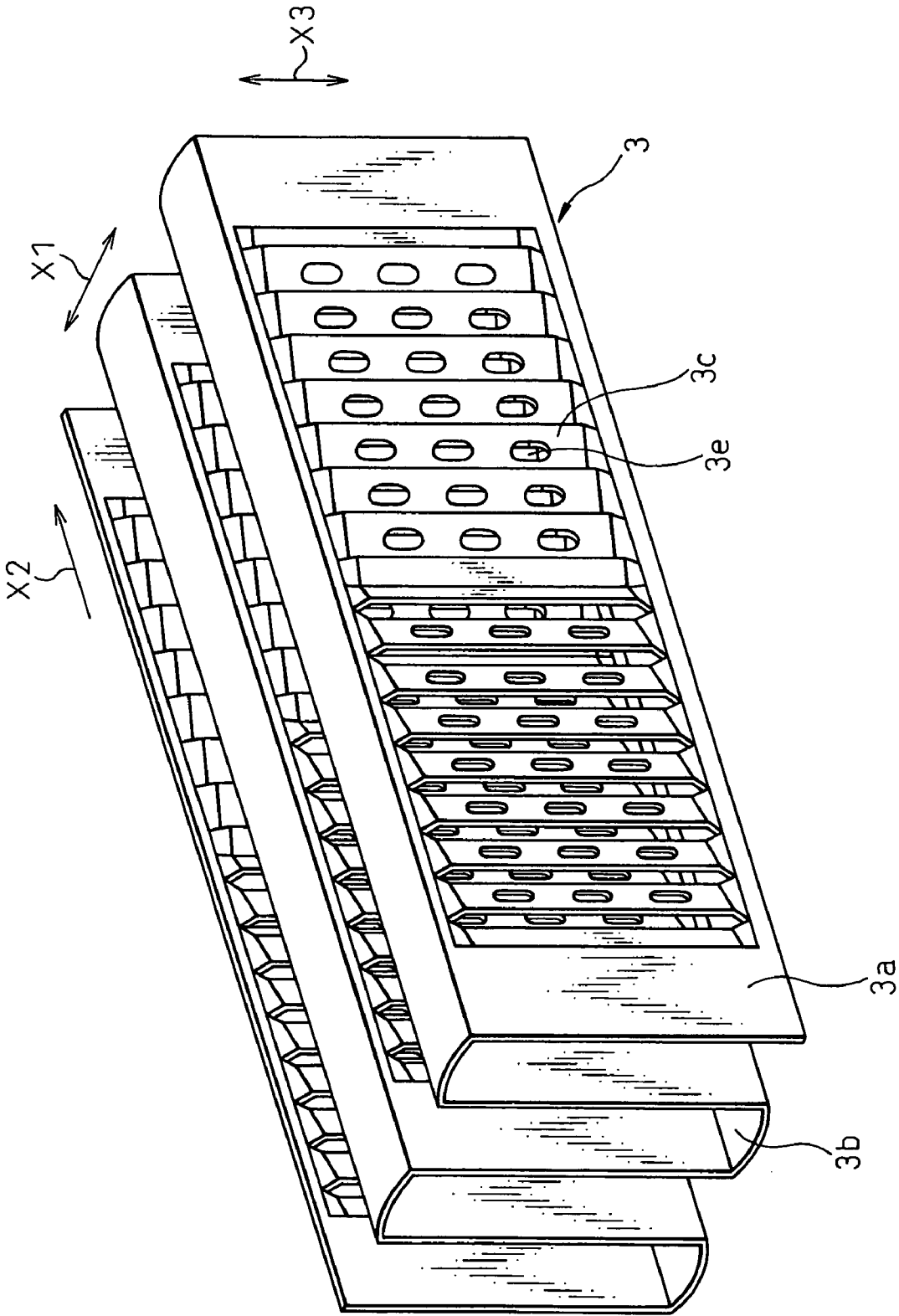
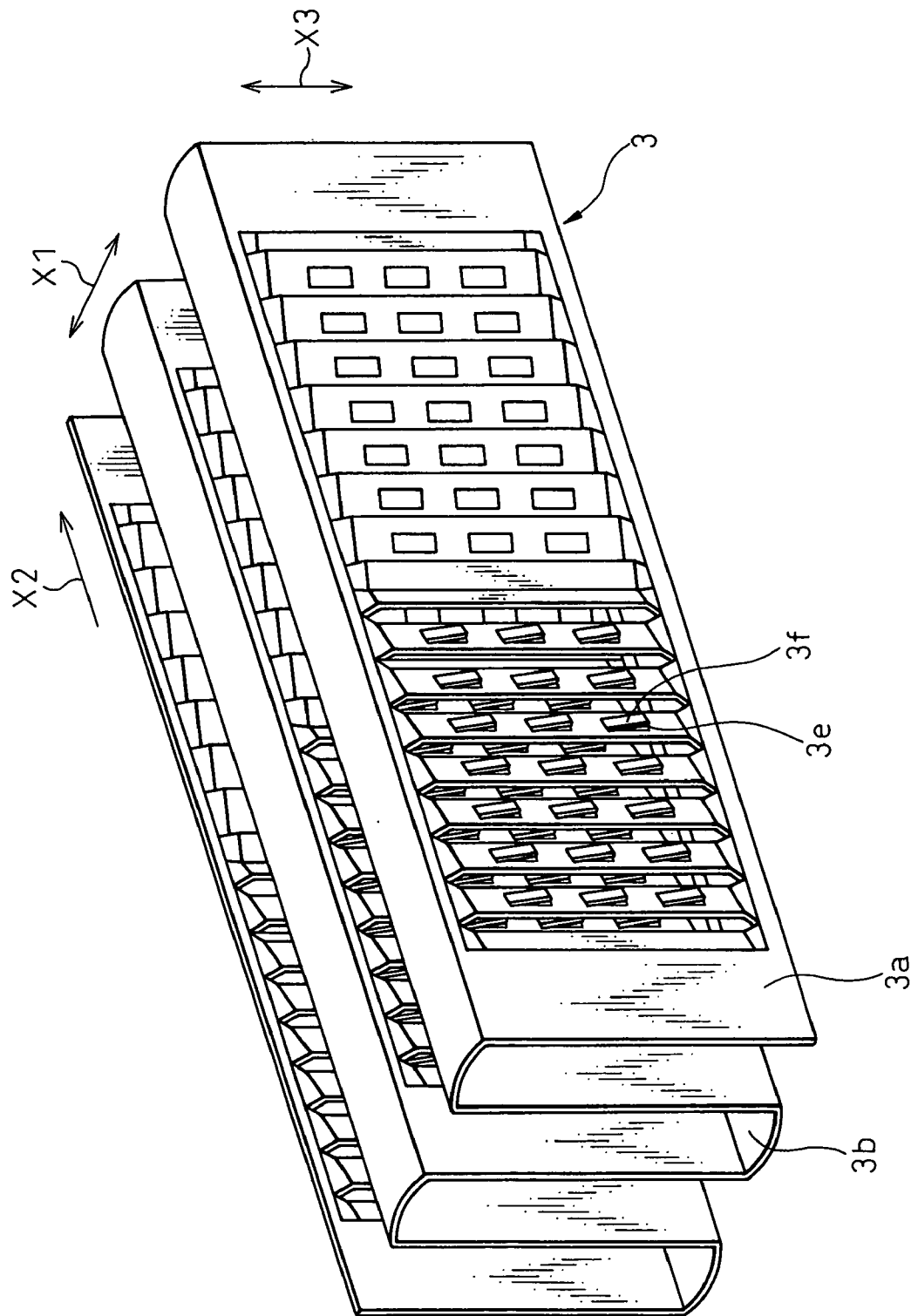


Fig.7



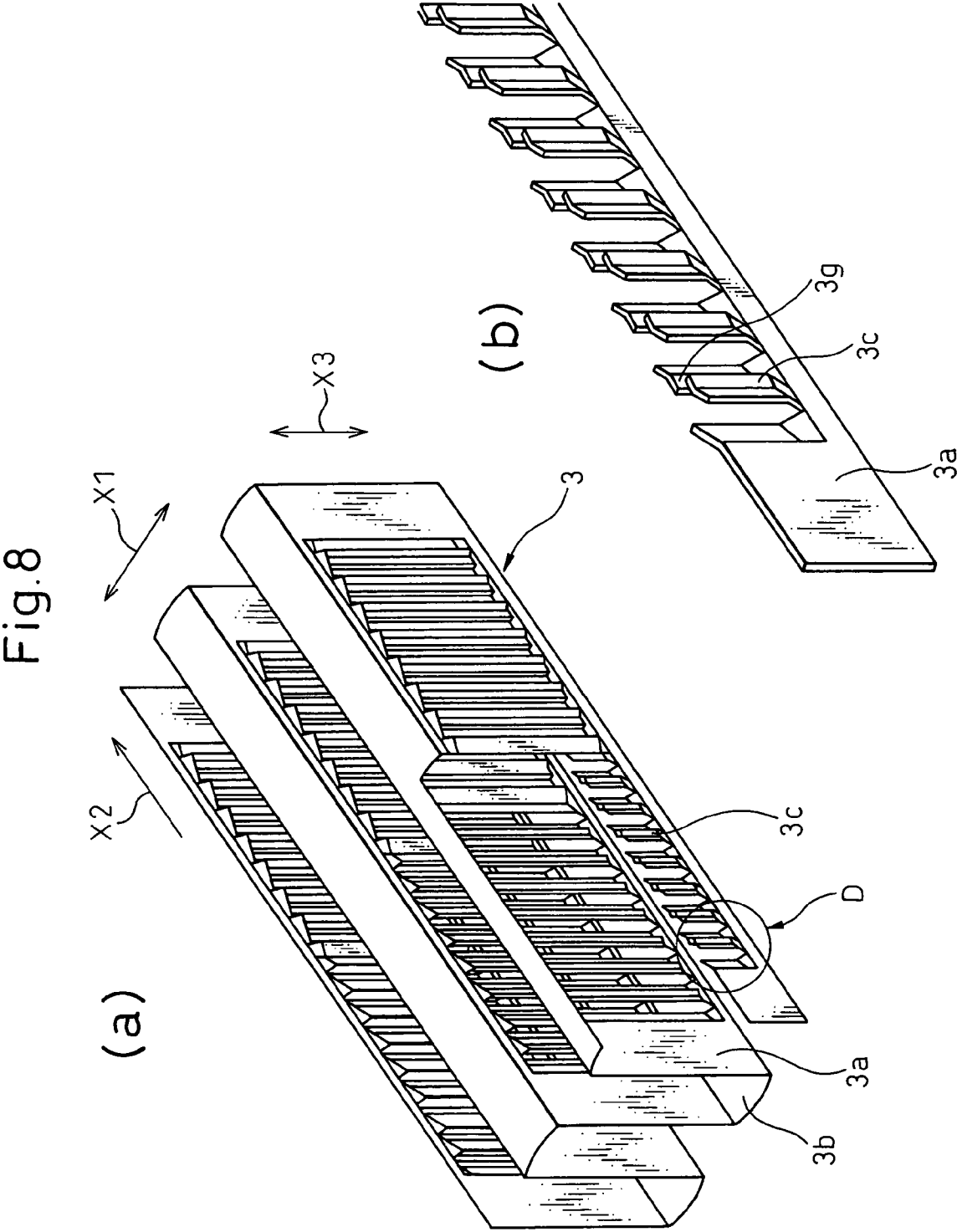
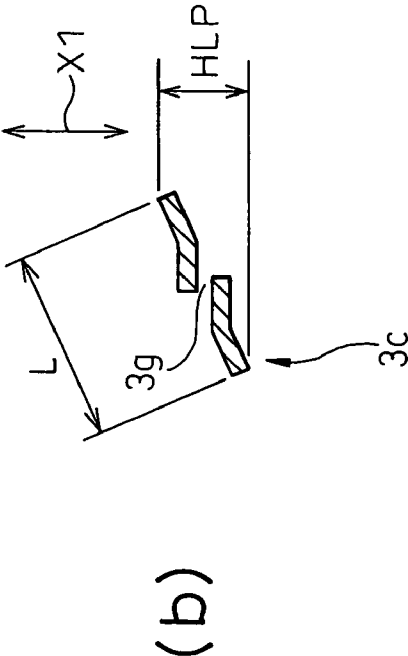
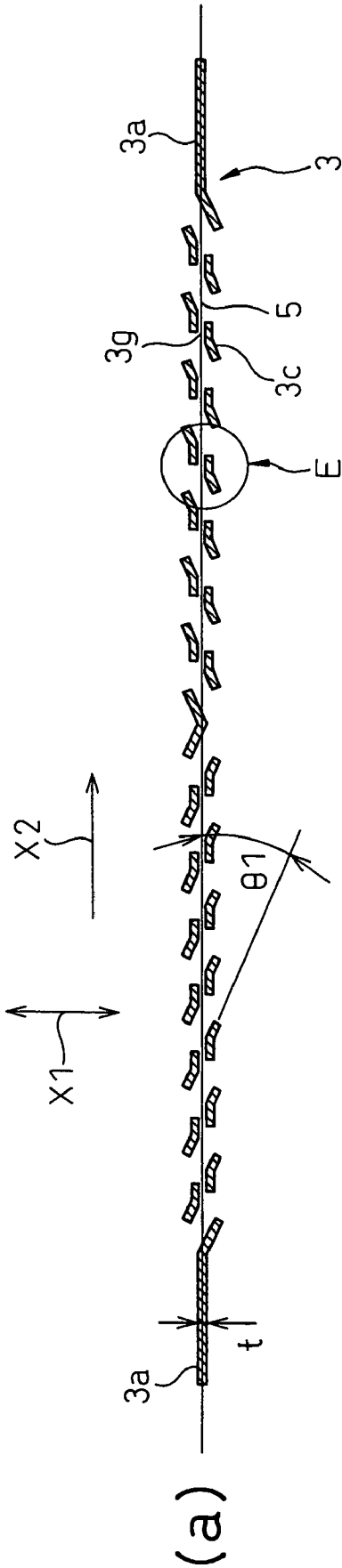


Fig.9



HEAT EXCHANGER

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger which is effective when applied to a radiator etc. for heat exchange between cooling water and air of an internal combustion engine.

BACKGROUND ART

[0002] The fins in a conventional heat exchanger have louvers. The edge effect of the louvers enables the heat conductivity of the fins to be improved. Further, by tilting the louvers with respect to the flat parts by a predetermined angle, the flow of the cooling air is changed to guide the cooling air to the louver passages between the adjoining louvers and thereby improve the heat conductivity of the fins (for example, see Japanese Patent Publication (A) No. 2003-83690).

[0003] However, in the above conventional heat exchanger, if the louver pitch is shortened to further improve the performance, there was the problem that the cooling air ended up no longer being guided to the louver passages, the edge effect was not improved, and as a result the heat conductivity of the fins could not be improved.

DISCLOSURE OF THE INVENTION

[0004] The present invention, in consideration of the above points, has as its object the improvement of the heat conductivity of the fins without shortening the louver pitch.

[0005] To achieve the above object, in the present invention, there is provided a heat exchanger provided with a plurality of tubes through the inside of which an inside fluid is circulated and arranged stacked over each other and fins arranged between the tubes and having flat parts substantially parallel to the direction of circulation of the outside fluid flowing between the tubes, a plurality of louvers twisted by a predetermined angle with respect to the flat parts being provided at the flat parts along the direction of circulation of the outside fluid and louver passages being formed between the adjoining louver, characterized in that when the direction along a predetermined angle is made the louver width direction, a step difference projecting out to the louver passage side is provided at an intermediate part of each louver in the louver width direction.

[0006] According to this, when the outside fluid flows through the louver passages, the flow of the outside fluid is disrupted by the step difference and the temperature boundary layer is destroyed, so at the location of the step differences, the local heat conductivity is again improved. Therefore, it is possible to improve the heat conductivity of the fins without shortening the louver pitch.

[0007] Further, in the present invention, the step difference is provided at the louver passage side positioned at the upstream side in the direction of circulation of the outside fluid in the louver passages positioned at the two sides of the louvers.

[0008] According to this, the flow of the outside fluid is strongly disrupted, so the heat conductivity of the fins can be further improved.

[0009] Further, in the present invention, there is provided a heat exchanger provided with a plurality of tubes through the inside of which an inside fluid is circulated and arranged stacked over each other and fins arranged between the tubes and having flat parts substantially parallel to the direction of circulation of the outside fluid flowing between the tubes, a plurality of louvers twisted by a predetermined angle with respect to the flat parts being provided at the flat parts along the direction of circulation of the outside fluid and louver passages being formed between the adjoining louver, characterized in that when the direction along a predetermined angle is made the louver width direction, a communicating passage for communicating the louver passages positioned at the two sides of each louver is provided at an intermediate part of the louver in the louver width direction.

[0010] According to this, when the outside fluid flows through the louver passages, the outside fluid passes through the communicating passages whereby the development of temperature boundary layers is suppressed. Therefore, it is possible to improve the heat conductivity of the fins without shortening the louver pitch.

[0011] Further, in the present invention, the communicating passages are long slits extending in the stacking direction of the tubes formed by making cuts along the stacking direction of the tubes, then deforming the two sides of the cuts.

[0012] According to this, it is possible to form communicating passages without generating waste material.

[0013] Further, in the present invention, the heat exchanger may use fins formed to corrugated shapes so as to have a plurality of flat parts arranged along the direction of circulation of the inside fluid and curved parts connecting the adjoining flat parts.

[0014] Below, the present invention will be able to be more sufficiently understood from the attached drawings and the preferred embodiments of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1(a) is a front view of a heat exchanger according to a first embodiment of the present invention, while FIG. 1(b) is an enlarged view of part A of FIG. 1(a).

[0016] FIG. 2(a) is a partially cutaway perspective view of the fins 3 of FIG. 1, while FIG. 2(b) is an enlarged view of part B of FIG. 2(a).

[0017] FIG. 3(a) is a sectional view of the fins 3 of FIG. 1 seen from the tube stacking direction X3, while FIG. 3(b) is an enlarged view of part C of FIG. 3(a).

[0018] FIG. 4(a) is a graph showing the local heat conductivity and average heat conductivity of fins 3 in a heat exchanger according to a first embodiment, while FIG. 4(b) is a graph showing the local heat conductivity and average heat conductivity of fins 3 in a conventional heat exchanger.

[0019] FIG. 5 gives sectional views of principal parts showing modifications of the fins 3 in the heat exchanger according to the first embodiment.

[0020] FIG. 6 is a perspective view of fins 3 in a heat exchange according to a second embodiment of the present invention.

[0021] FIG. 7 is a perspective view of fins 3 in a heat exchange according to a third embodiment of the present invention.

[0022] FIG. 8(a) is a partially cutaway perspective view of fins 3 in a heat exchange according to a fourth embodiment of the present invention, while FIG. 8(b) is an enlarged view of a part D of FIG. 8(a).

[0023] FIG. 9(a) is a sectional view of the fins 3 of FIG. 8 as seen from the tube stacking direction X3, while FIG. 9(b) is an enlarged view of a part E of FIG. 9(a).

BEST MODE FOR WORKING THE INVENTION

First Embodiment

[0024] The present embodiment applies the heat exchanger according to the present invention to a radiator 1 for heat exchange between cooling water of a running engine (internal combustion engine) and air so as to cool the cooling water. FIG. 1(a) is a front view of the radiator 1, FIG. 1(b) is an enlarged view of part A of FIG. 1(a), FIG. 2(a) is a partially cutaway perspective view of the fins 3 of FIG. 1, FIG. 2(b) is an enlarged view of part B of FIG. 2(a), FIG. 3(a) is a sectional view of the fins 3 of FIG. 1 seen from the tube stacking direction X3, and FIG. 3(b) is an enlarged view of part C of FIG. 3(a).

[0025] As shown in FIG. 1, the radiator 1 has tubes 2 through the inside of which engine cooling water flows, corrugated-shaped fins 3 bonded to the outside surfaces of the tubes 2, header tanks 4 provided at the ends of the tubes 2 in the direction of circulation X1 of the cooling water (hereinafter referred to as the "cooling water circulation direction X1") and communicating with the tubes 2, etc. Note that the engine cooling water corresponds to the inside fluid of the present invention.

[0026] The tubes 2 are made of metal (in the present embodiment, aluminum alloy). Cooling water passages through which the cooling water flows are formed inside them and are formed as flat shapes. Further, a plurality of the tubes 2 are stacked over each other. The fins 3 are arranged between the adjoining tubes 2. Cooling air is designed to be able to flow between the adjoining tubes 2. Note that the cooling air corresponds to the outside fluid of the present invention.

[0027] The fins 3 promote the heat exchange between the cooling air and the cooling water and are comprised of a metal (in the present embodiment, aluminum alloy) and produced by press forming or rolling.

[0028] These fins 3, as shown in FIG. 2 and FIG. 3, have flat parts 3a having surfaces substantially parallel with the direction of circulation X2 of the cooling air flowing between the tubes 2 (hereinafter referred to as the "air flow direction X2") and curved parts 3b connecting the adjoining flat parts 3a and are formed to corrugated shapes seen from the air flow direction X2. A plurality of these flat parts 3a are arranged along the cooling water circulation direction X1.

[0029] Further, the flat parts 3a are formed integrally with louvers 3c by cutting and raising the flat parts 3a. The louvers 3c, when seen from the stacking direction X3 of the tubes 3 (hereinafter referred to as the "tube stacking direction X3"), are twisted from the flat parts 3a by a predeter-

mined angle $\theta 1$ (hereinafter referred to as the "twist angle $\theta 1$ "). A plurality are provided at the flat parts 3a along the air flow direction X2. Further, louver passages 5 are formed between the adjoining louvers 3c. The twist direction of the louvers 3c positioned at the upstream side in the air flow direction X2 and the twist direction of the louvers 3c positioned at the downstream side in the air flow direction X2 differ. Note that the twist angle $\theta 1$ is, in the present embodiment, made 23° .

[0030] Here, when the direction along the angle $\theta 1$ is made the louver width direction X4, the intermediate part of each louver 3c in louver width direction X4 is provided with a step difference 3d extending in the tube stacking direction X3 and projecting out to the louver passage 5 side.

[0031] One step difference 3d is provided at each louver 3c. The step difference 3d is provided at the louver passage 5 side positioned upstream in the air flow direction X2 among the louver passages 5 positioned at the two sides of each louver 3c. Further, the bending angle $\theta 2$ when viewing the step difference 3d from the tube stacking direction X3 is, in the present embodiment, made 90° .

[0032] Note that in the present embodiment, the fins 3 are made of aluminum alloy, the thickness t of the fins 3 is 0.05 mm, the length L of the louvers 3c in the louver width direction X4 (hereinafter referred to as the "louver width L") is 0.8 mm, and the amount of projection S of the step differences 3d is made 0.05 mm.

[0033] Further, the amount of projection S of the step differences 3d is preferably at least the thickness t of the fins 3. Further, when the length of one period of the fins 3 formed in the corrugated shape is the fin pitch FP and the dimension of the cooling water circulation direction X1 in the louvers 3c is the louver pitch height HLP, it is preferable that FP/HLP be 10 or less.

[0034] Next, the actions and effects of the present embodiment will be explained.

[0035] FIG. 4(a) shows the change in the local heat conductivity of the fins 3 according to the present embodiment, while FIG. 4(b) shows the change in the local heat conductivity of the fins having configurations similar to that described in Patent Publication 1.

[0036] As shown in FIG. 4(a), the upstream ends of the louvers 3c in the air flow direction X2 become higher in local heat conductivity due to the edge effect. Next, when the cooling air flows through the louver passages 5, the temperature boundary layers develop and the local heat conductivity gradually falls.

[0037] However, the radiator 1 of the present embodiment has step differences 3d projecting out to the louver passage 5 sides. By the cooling air striking these step differences 3d, the flow of the cooling air is disrupted by the step differences 3d and the temperature boundary layers are destroyed, so at the locations of the step differences 3d, the local heat conductivity again rises and the average heat conductivity is improved. Therefore, it is possible to improve the heat conductivity of the fins 3 without shortening the louver pitch.

[0038] Further, since the step differences 3d are provided at the louver passage 5 side positioned at the upstream side in the air flow direction X2, compared even with the case of

providing the step differences **3d** at the louver passage **5** side positioned at the downstream side of the air flow direction **X2**, the flow of the cooling air is strongly disrupted. Therefore, the heat conductivity of the fins **3** can be further improved.

[0039] Note that **FIG. 5** shows modifications of the fins **3** of the present embodiment and gives views of the step differences **3d** seen from the tube stacking direction **X3**.

[0040] **FIG. 5(a)** shows a step difference **3d** with a blunted bending angle $\theta 2$. **FIG. 5(b)** shows a step difference **3d** with a louver width **L1** at one end and a louver width **L2** at the other end made different. **FIG. 5(c)** shows a plurality of step differences **3d** provided at a louver **3c**.

Second Embodiment

[0041] A second embodiment of the present invention will be explained next. **FIG. 6** is a perspective view of fins **3** in a heat exchanger according to a second embodiment.

[0042] The present embodiment is provided with, in place of the step differences **3d** in the first embodiment, holes **3e** in the louvers **3c**. The other points are common with the first embodiment.

[0043] The holes **3e** pass through the louvers **3c** so as to communicate the louver passages **5** positioned at the two sides. Further, the holes **3e** are oval in shape. A plurality are provided at the intermediate parts of the louvers **3c** in the louver width direction **X4** and at the louvers **3c** along the tube stacking direction **X3** (in this example, three). Note that the holes **3e** correspond to the communicating passages of the present invention.

[0044] According to this, when the cooling air flows through the louver passages **5**, part of the cooling air passes through the holes **3e** and flow to the adjoining louver passages **5**, whereby the development of temperature boundary layers is suppressed and therefore the average heat conductivity is improved. Therefore, it is possible to improve the heat conductivity of the fins **3** without shortening the louver pitch.

Third Embodiment

[0045] A third embodiment of the present invention will be explained next. **FIG. 7** is a perspective view of fins **3** in a heat exchanger according to the third embodiment.

[0046] In the second embodiment, the holes **3e** were formed by punching, but in the present embodiment, the holes **3e** are formed by cutting and raising up parts of the louvers **3c**. Due to this, it is possible to form holes **3e** without generating waste material. Note that the **3f** is a piece which is cut and raised up.

Fourth Embodiment

[0047] A fourth embodiment of the present invention will be explained next. **FIG. 8(a)** is a partially cutaway perspective view of the fins **3** in a heat exchanger according to the fourth embodiment, **FIG. 8(b)** is an enlarged view of the part D of **FIG. 8(a)**, **FIG. 9(a)** is a sectional view of the fins **3** of **FIG. 8** seen along the tube stacking direction **X3**, and **FIG. 9(b)** is an enlarged view of the part E of **FIG. 9(a)**.

[0048] In the second embodiment, each louver **3c** was provided with a plurality of holes **3e** to communicate the louver passages **5** positioned at the two sides of the louver **3c**, but the present embodiment each louver **3c** is provided with one long slit **3g** extending in the tube stacking direction **X3** so as to communicate the louver passages **5** positioned at the two sides of the louver **3c**. Note that the slits **3g** correspond to the communicating passages of the present invention.

[0049] The slits **3g** are formed as follows: That is, a cut is made in the intermediate part of each louver **3c** in the louver width direction **X4** along the tube stacking direction **X3**, then the two sides of the cut are deformed. Due to this, it is possible to form the slits **3g** without generating any waste material.

Other Embodiments

[0050] In the above embodiments, the twist direction of the louvers **3c** positioned at the upstream side in the air flow direction **X2** and the twist direction of the louvers **3c** positioned at the downstream side in the air flow direction **X2** were made different, but it is also possible to make the twist directions of all of the louvers **3** the same.

[0051] Note that the present invention was explained in detail based on specific embodiments, but a person skilled in the art could make various changes, modifications, etc. without departing from the claims and idea of the present invention.

1. A computer-implemented method for communication within a network, said method comprising the steps of:

transmitting a data packet as a broadcast signal from a first application node of a first subnetwork to a first gateway node of the first subnetwork;

transmitting the data packet as a point-to-point signal from the first gateway node to a second gateway node of a second subnetwork;

transmitting the data packet as a broadcast signal from the second gateway node of the second subnetwork to at least one application node of the second subnetwork; and

simulating war games between two remote geographic sites.

2. The computer-implemented method as set forth in claim 1 further comprising the steps of:

transmitting another data packet as a broadcast signal from the at least one application node of the second subnetwork to the second gateway node of the second subnetwork;

transmitting the other data packet as a point-to-point signal from the second gateway node to the first gateway node of the first subnetwork; and

transmitting the data packet as a broadcast signal from the first gateway node of the first subnetwork to the first application node of the first subnetwork.

3. The computer-implemented method as set forth in claim 1 wherein said transmitting the data packet as a point-to-point signal is conducted across an undedicated communication network.

4. The computer-implemented method as set forth in claim 3 wherein the undedicated communication network is the Internet.

5. (canceled)

6. The computer-implemented method as set forth in claim 1 wherein the broadcast signals each comprise an Ethernet Protocol Data Unit.

7. The computer-implemented method as set forth in claim 1 wherein the point-to-point signal includes an IP address.

8. The computer-implemented method as set forth in claim 1 further including the step of transmitting the data packet as a broadcast signal to a second application node of the first subnetwork.

9. A system comprising:

a first device for transmitting a data packet as a broadcast signal from a first application node of a first subnetwork to a first gateway node of the first subnetwork;

a second device for transmitting the data packet as a point-to-point signal from the first gateway node to a second gateway node of a second subnetwork; and

a third device for transmitting the data packet as a broadcast signal from the second gateway node of the second subnetwork to at least one application node of the second subnetwork,

the broadcast signals each comprising an Ethernet Protocol Data Unit.

10. The system as set forth in claim 9 wherein said third device transmits another data packet as a broadcast signal from the at least one application node of the second subnetwork to the second gateway node of the second subnetwork; said second device transmits the other data packet as a point-to-point signal from the second gateway node to the first gateway node of the first subnetwork; and said third device transmits the data packet as a broadcast signal from the first gateway node of the first subnetwork to the first application node of the first subnetwork.

11. The system as set forth in claim 9 wherein said first device is a computer.

12. The system as set forth in claim 11 wherein the first gateway node converts the data packet from the broadcast signal to the point-to-point signal by adding an IP address to the broadcast signal.

13. The system as set forth in claim 9 wherein said third means is a computer.

14. The system as set forth in claim 9 wherein said second means is an undedicated intranet.

15. The system as set forth in claim 9 wherein said first device transmits the data packet as a broadcast signal from the first application node to a second application node of the first subnetwork.

16. An apparatus for simulating a war game, said apparatus comprising:

a first means for transmitting a data packet as a broadcast signal from a first application node of a first subnetwork to a first gateway node of the first subnetwork;

a second means for transmitting the data packet as a point-to-point signal from the first gateway node to a second gateway node of a second subnetwork; and

a third means for transmitting the data packet as a broadcast signal from the second gateway node of the second subnetwork to at least one application node of the second subnetwork,

said first, second, and third transmitting means simulating the war game between two remote geographic sites.

17. The apparatus as set forth in claim 16 wherein said third means transmits another data packet as a broadcast signal from the at least one application node of the second subnetwork to the second gateway node of the second subnetwork; said second means transmits the other data packet as a point-to-point signal from the second gateway node to the first gateway node of the first subnetwork; and said third means transmits the data packet as a broadcast signal from the first gateway node of the first subnetwork to the first application node of the first subnetwork.

18. A computer program product containing executable instructions for communicating within a network, said product comprising:

a first subnetwork having a first application node and a first gateway node; and

a second subnetwork having a second application node and a second gateway node,

said first application node transmitting a data packet as a broadcast signal to said first gateway node of said first subnetwork;

said first gateway node transmitting said data packet as a point-to-point signal from said first gateway node to said second gateway node of said second subnetwork,

said second gateway node transmitting said data packet as a broadcast signal from said second gateway node of said second subnetwork to said second application node of said second subnetwork,

the broadcast signals each comprising an Ethernet Protocol Data Unit.

19. The computer program product as set forth in claim 18 wherein said second application node transmits another data packet as a broadcast signal to said second gateway node, said second gateway node transmits said other data packet as a point-to-point signal to said first gateway node, and said first gateway node transmits said other data packet as a broadcast signal to said first and second application nodes.

20. The computer program product as set forth in claim 18 wherein said first application node transmits said data packet as a broadcast signal to another application node of said first subnetwork simultaneously to the transmission of said data packet to said first gateway node.

* * * * *