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(54) **HEAT EXCHANGER**

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(57) **ABSTRACT**

Disclosed is a heat exchanger. The heat exchanger includes a plurality of plates superimposed on one another, and a plurality of heat transfer fins formed on the plurality of plates, and shaped into an airfoil, wherein a channel of a fluid between the superimposed plates is formed to perform a heat exchange.

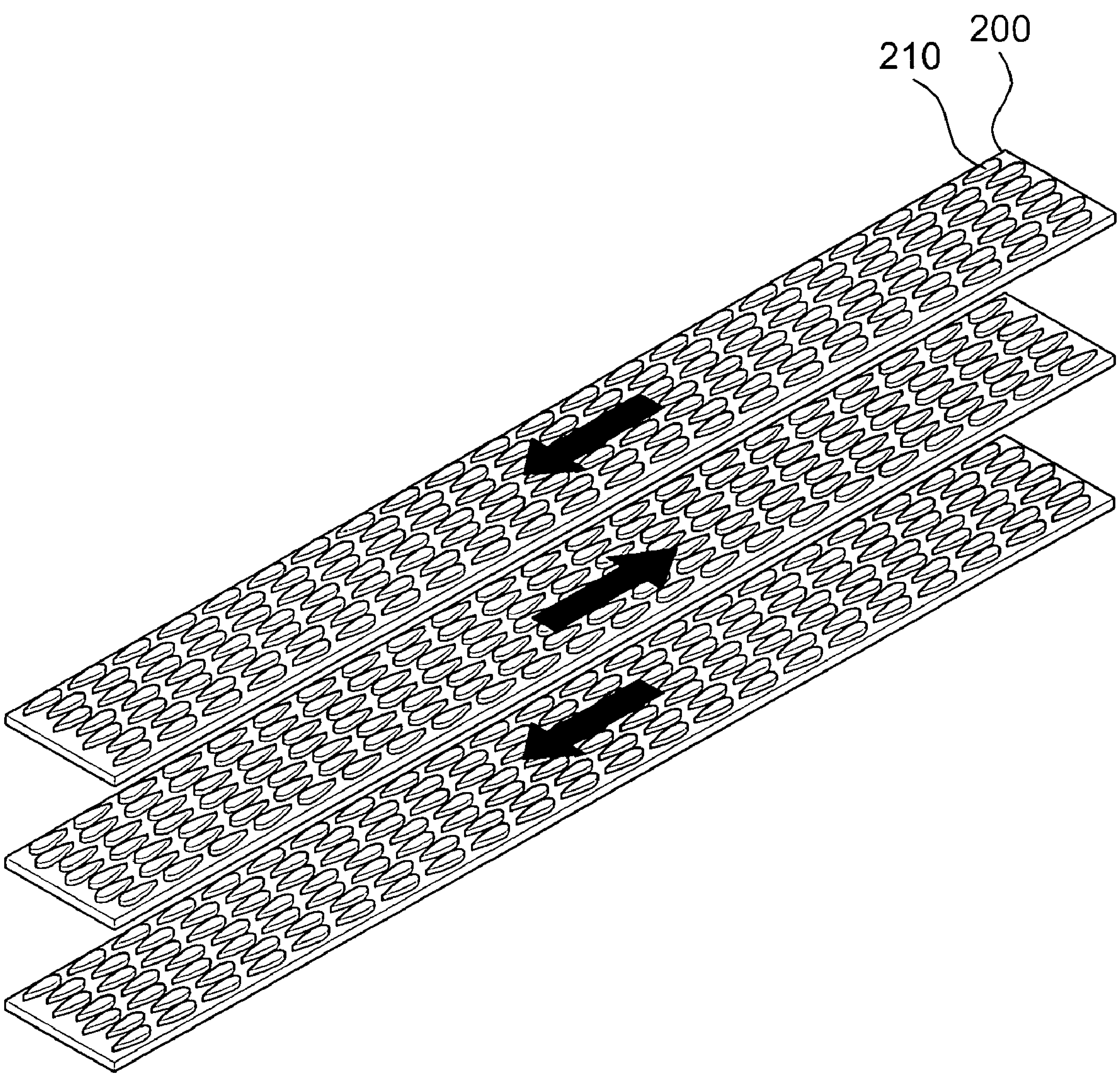


FIG. 1 (RELATED ART)

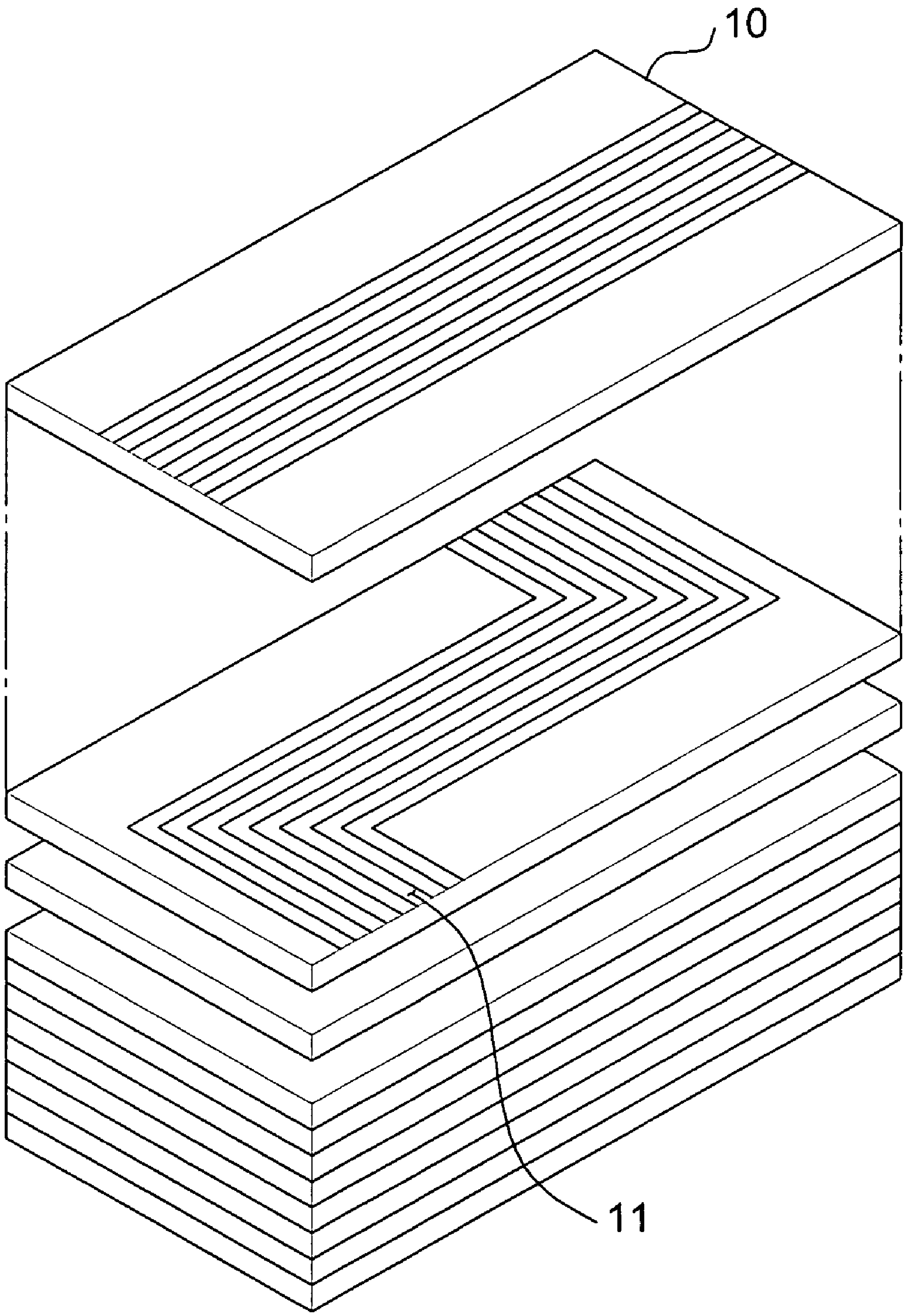


FIG. 2

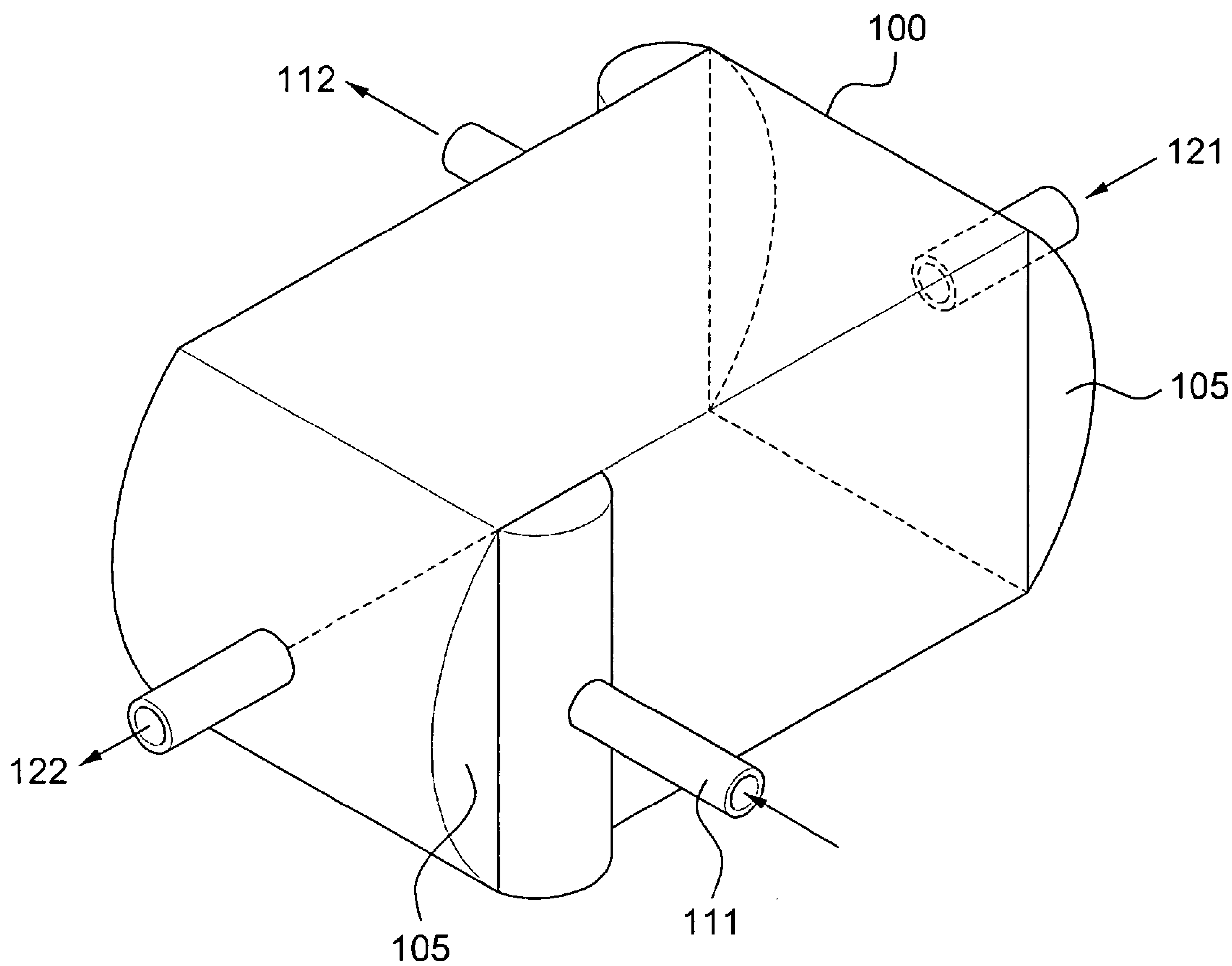


FIG. 3

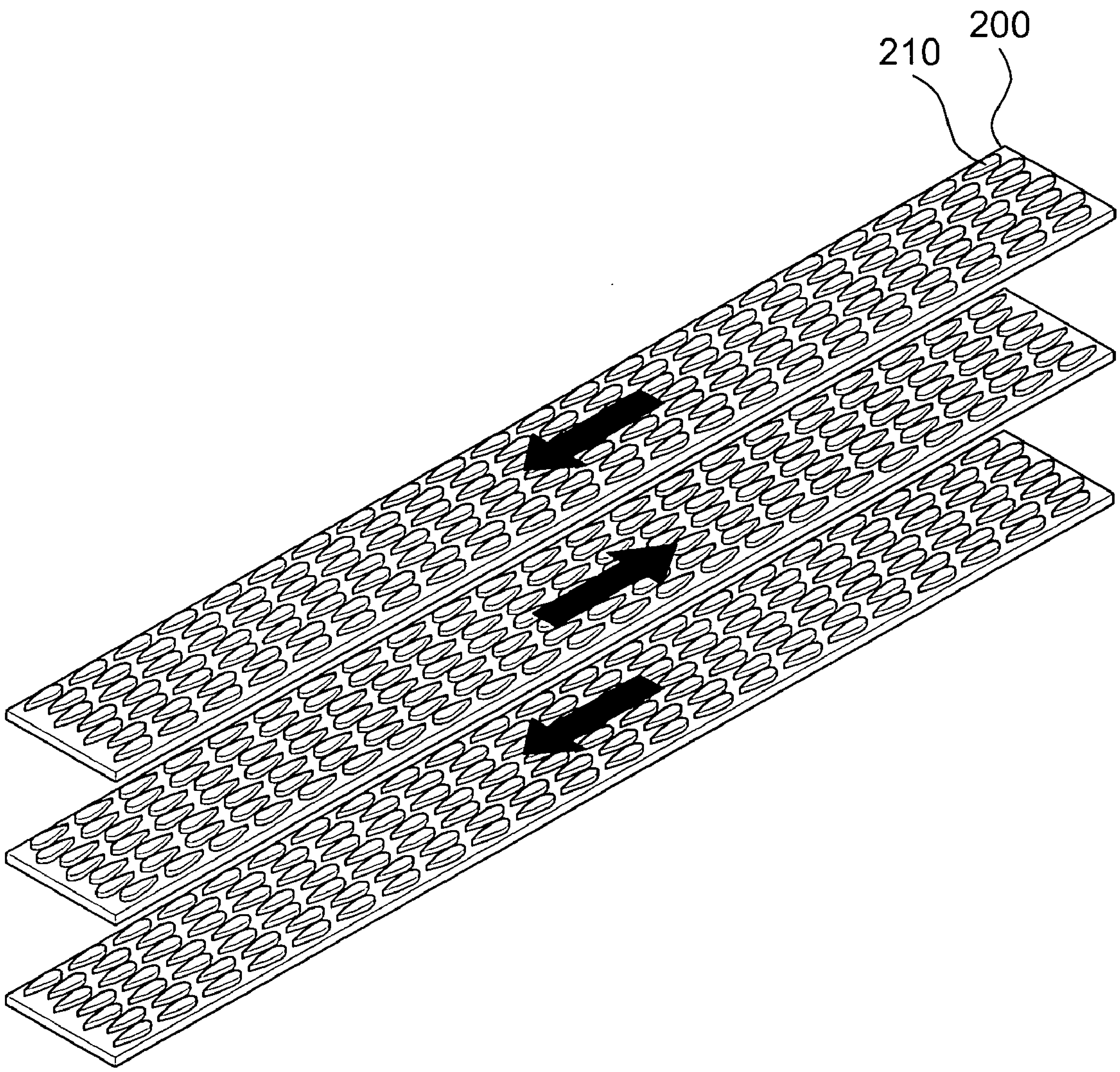


FIG. 4

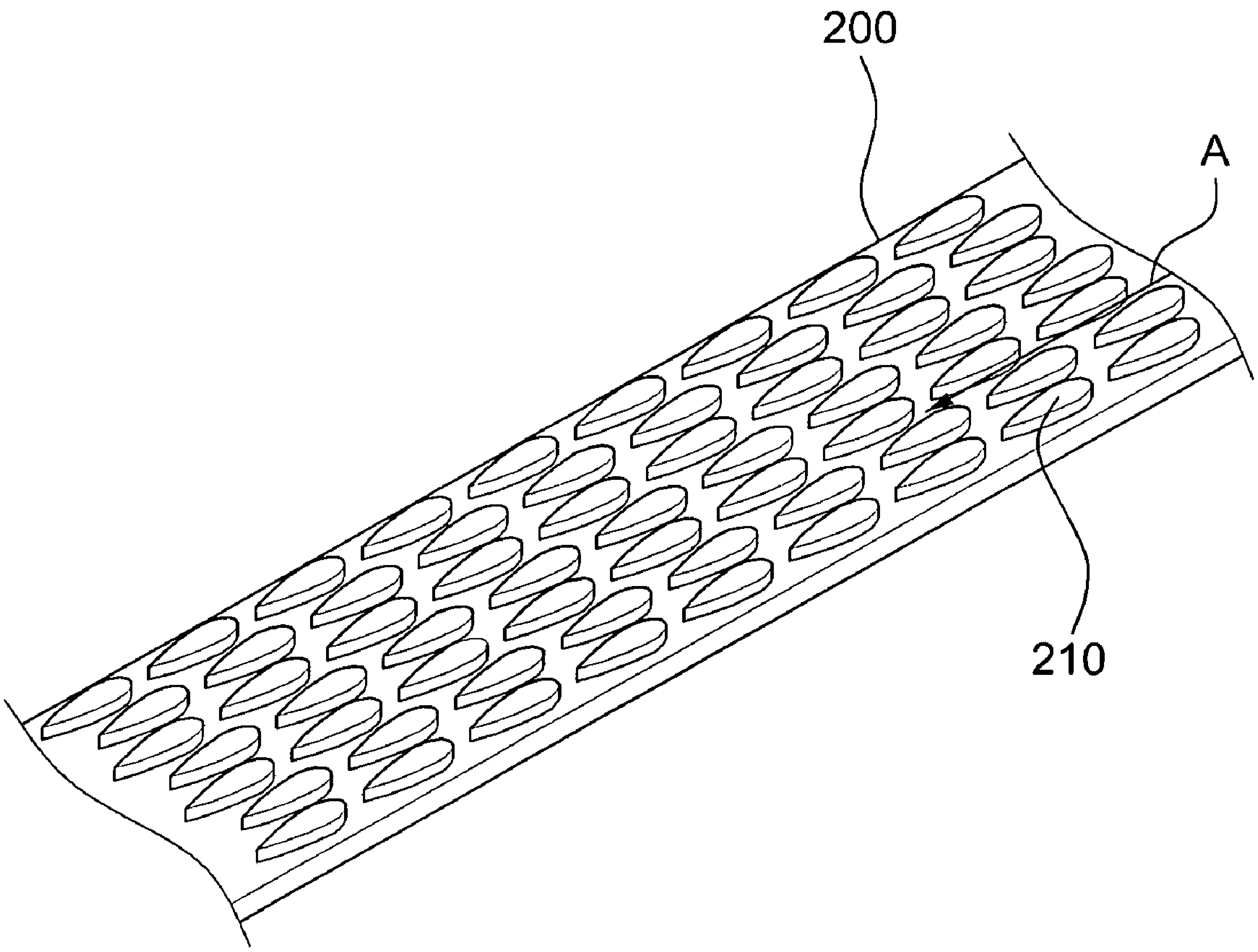


FIG. 5 (RELATED ART)

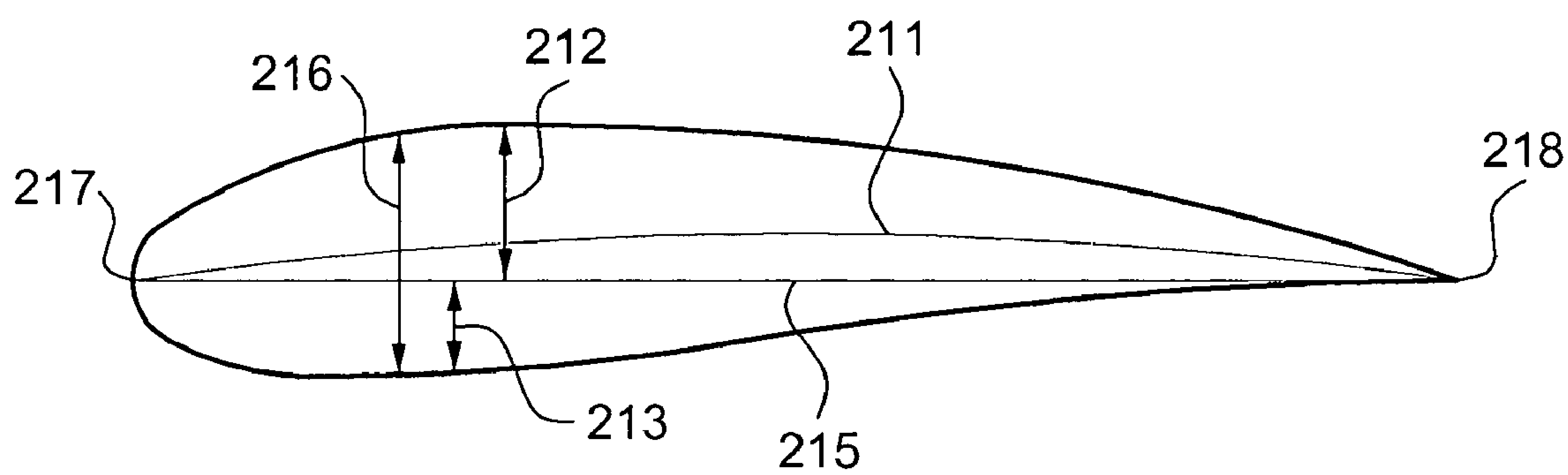


FIG. 6

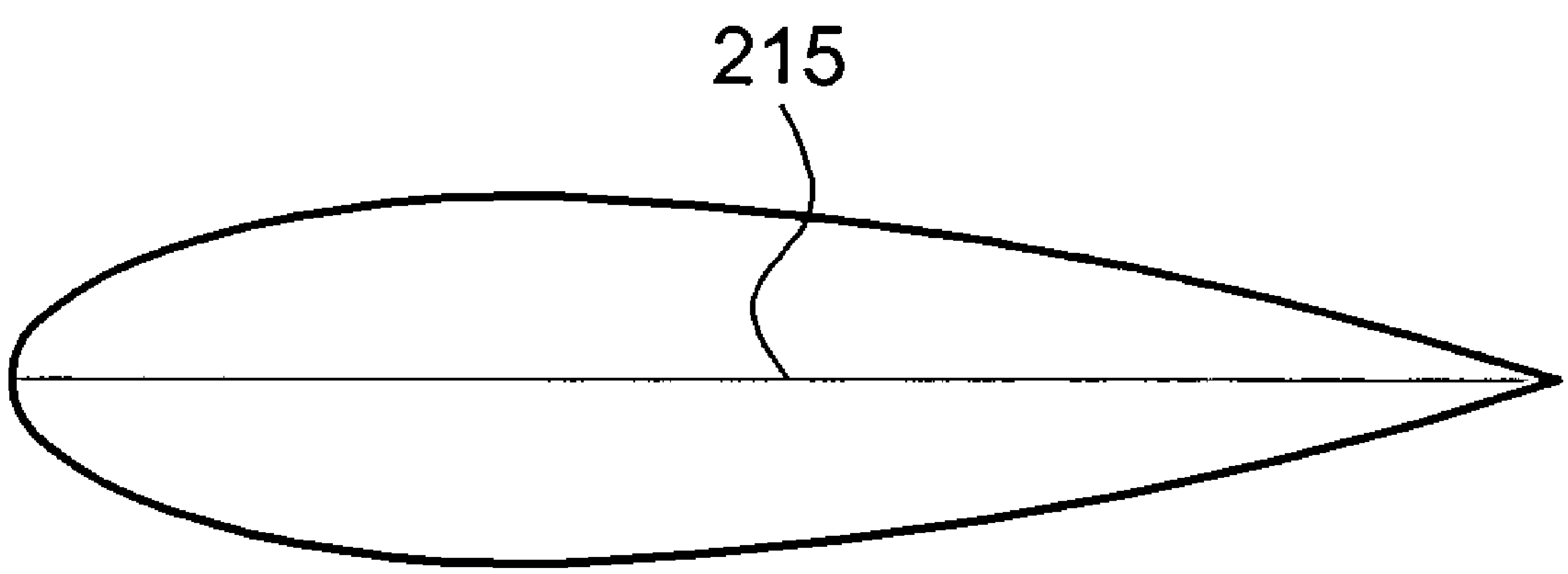


FIG. 7

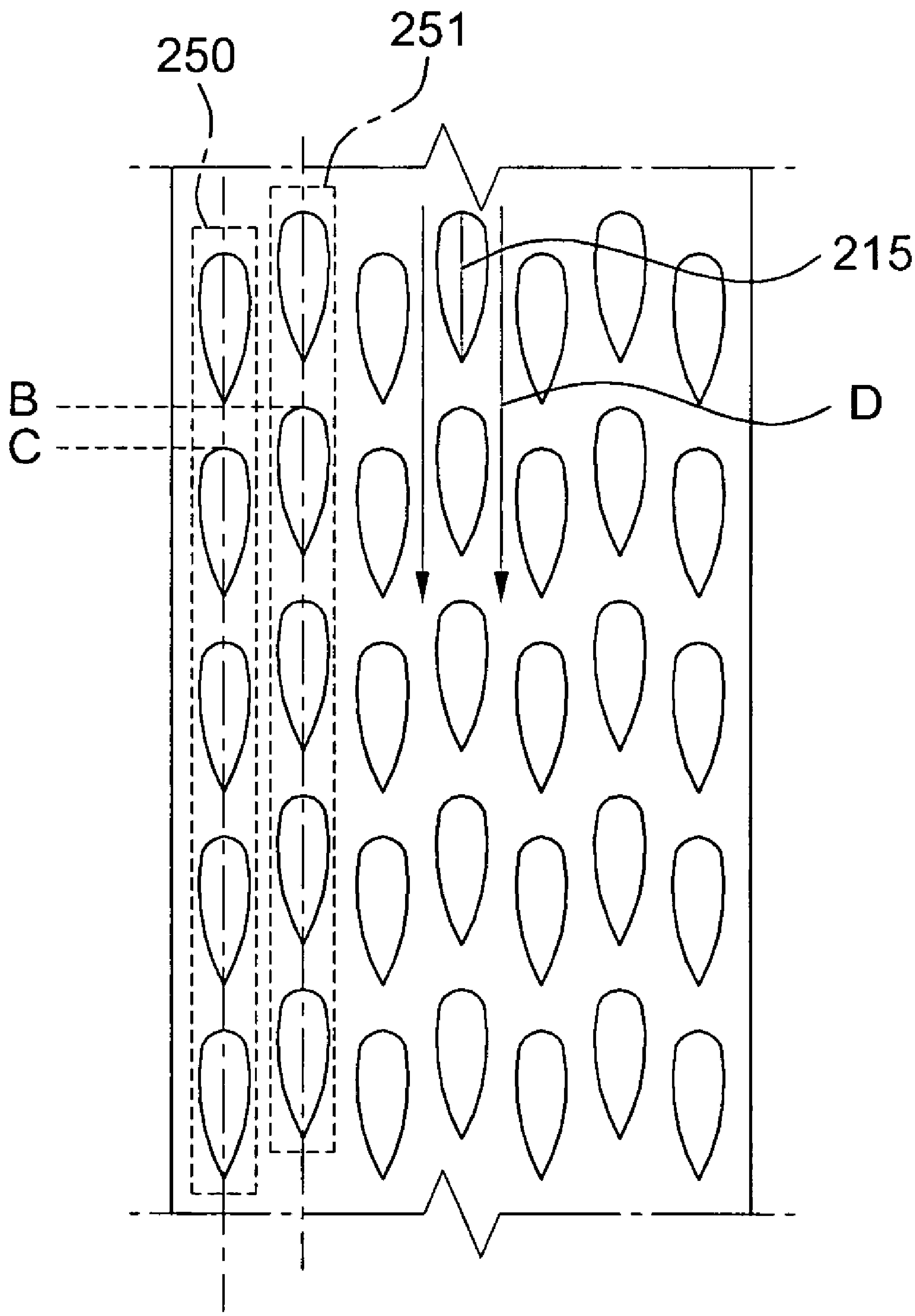


FIG. 8

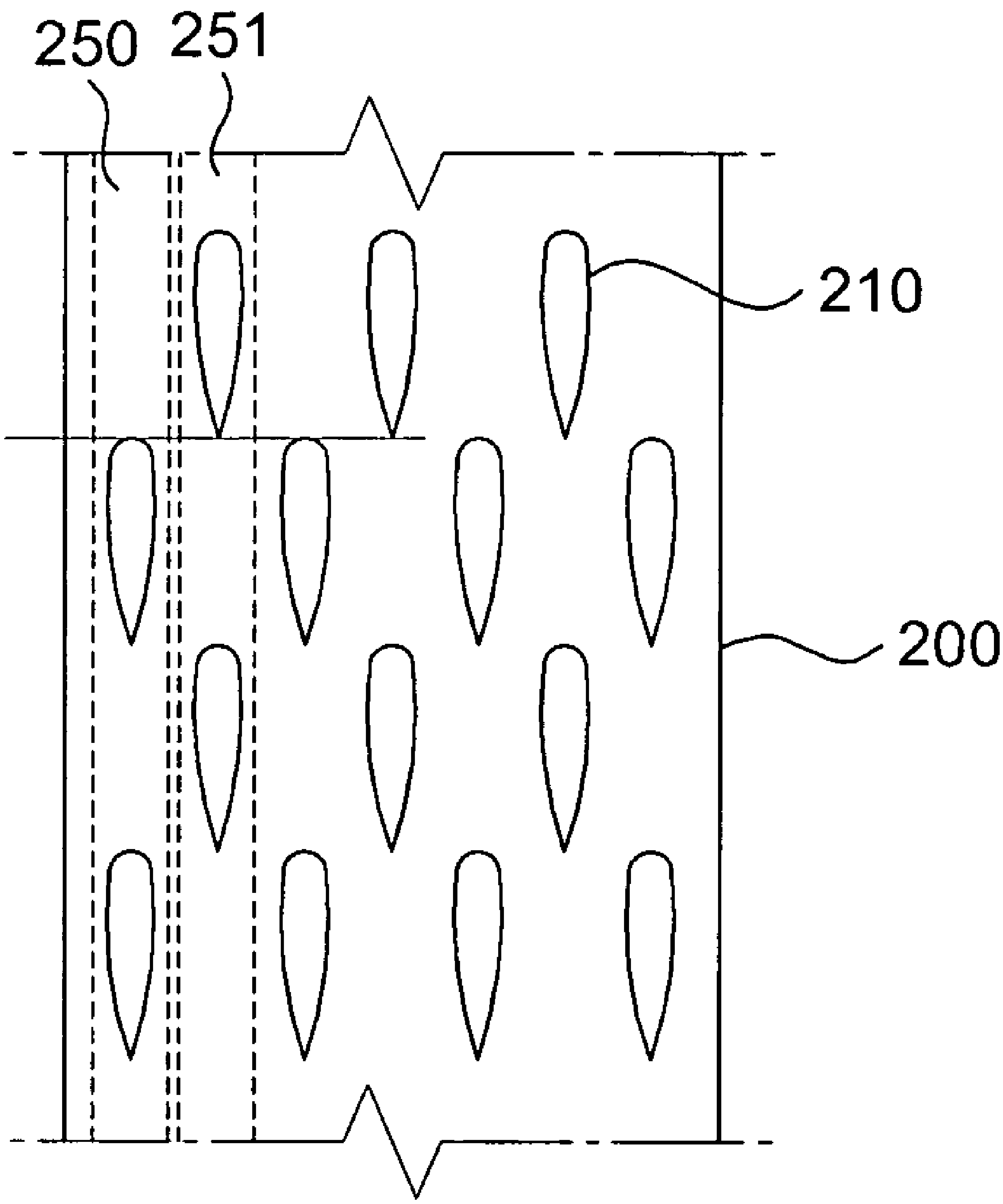


FIG. 9

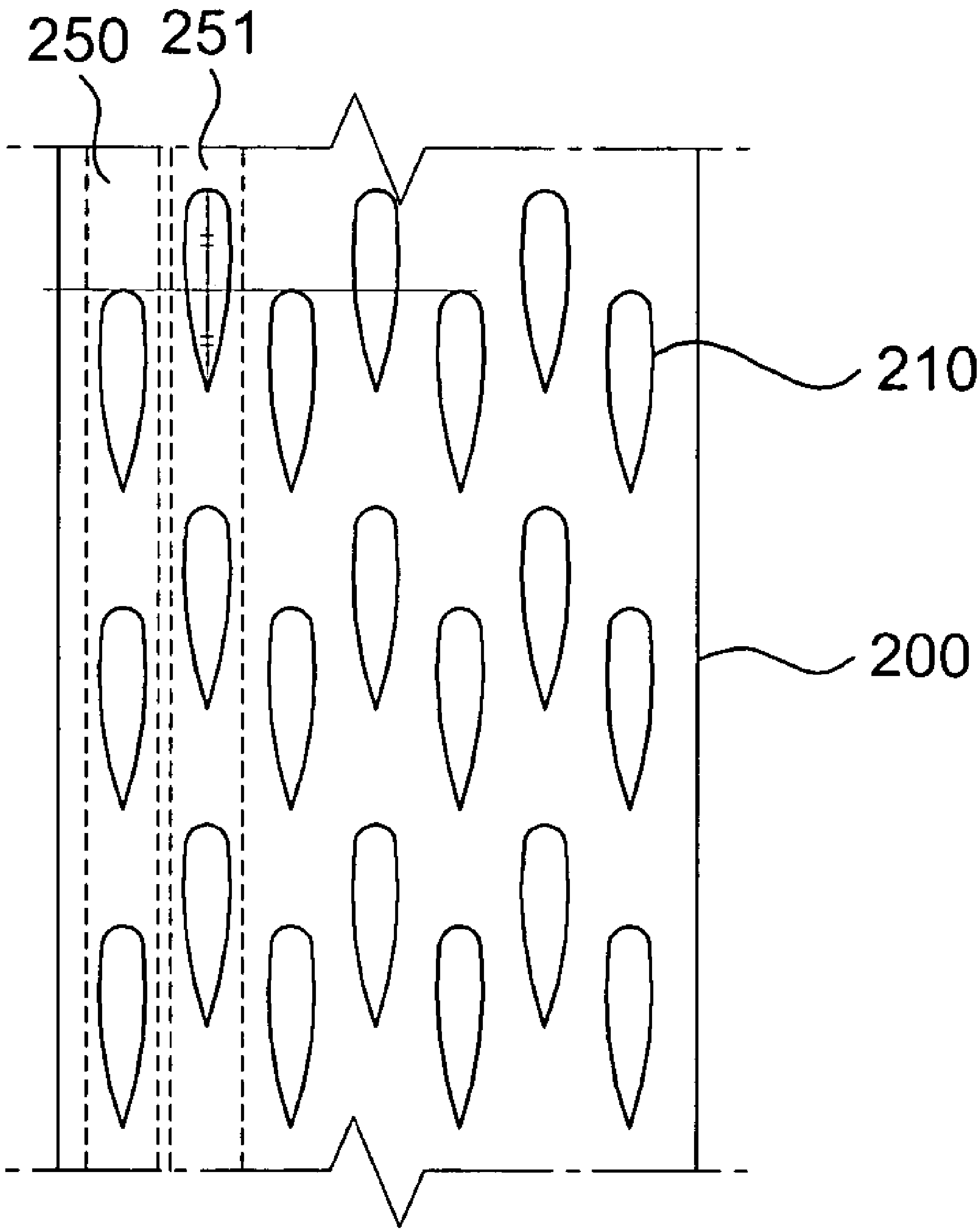


FIG. 10

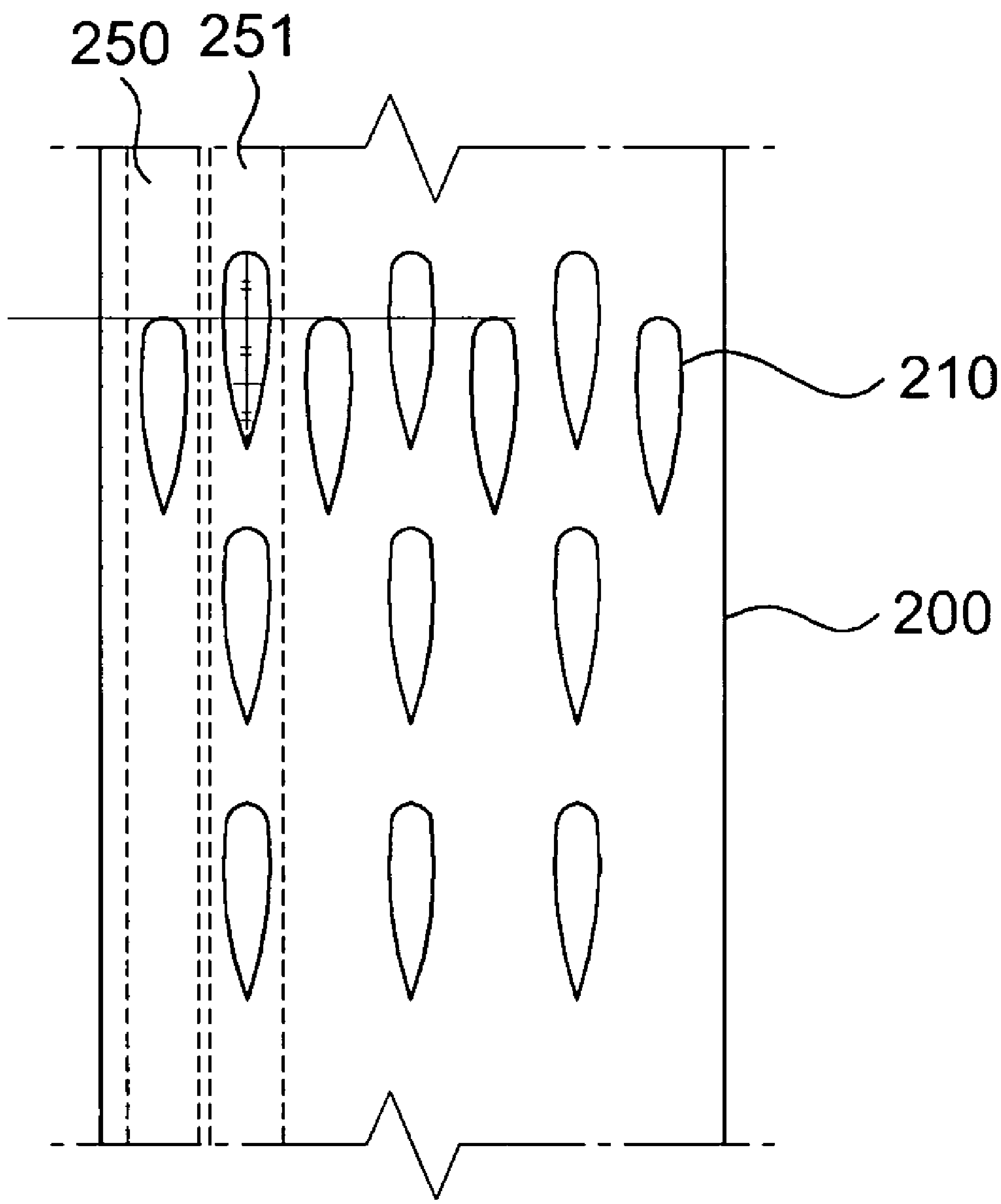
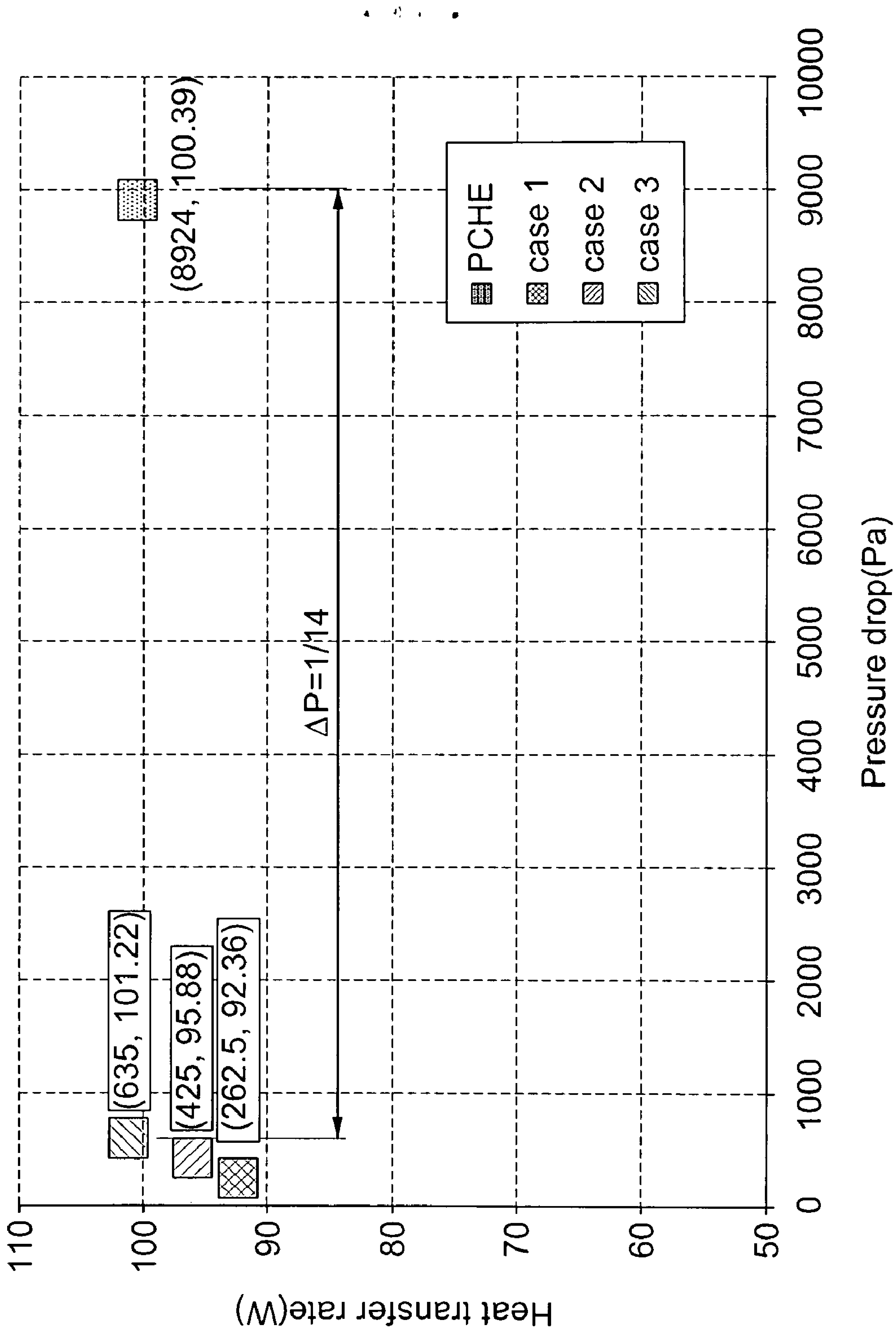


FIG. 11


Heat transfer rate(W)
Pressure drop(Pa)
110
100
90
80
70
60
50
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
(635, 101.22)
(425, 95.88)
(262.5, 92.36)
(8924, 100.39)
ΔP=1/14
PCHE
case 1
case 2
case 3

HEAT EXCHANGER

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Korean Patent Application No. 10-2008-0051931, filed on Jun. 3, 2008, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND

[0002] 1. Field of the Invention

[0003] The present invention relates to a heat exchanger, and more particularly, to a heat exchanger in which a channel type is changed into a fin structure to increase a heat transfer area, and the fin is formed into an airfoil shape to minimize a pressure drop due to the fin structure, thereby increasing a heat flowing performance.

[0004] 2. Description of the Related Art

[0005] In the Republic of Korea, with an economical and social change due to a switchover to a highly industrialized society, energy consumption and emission of greenhouse gases such as carbon dioxide have been rapidly increased. Currently, advanced countries have strongly requested that the Republic of Korea, that is, one of Organisation for Economic Co-operation and Development (OECD) members and a front-runner in developing countries, reduce greenhouse gas emission. Accordingly, there arises a need for actively attempting a method of reducing the greenhouse gas emission. A heat exchanger having a concept of a heat transfer device such as a condenser, an evaporator, a radiator, and the like may be utilized in various fields such as industry, transportation, households, and the like. In France, a huge amount of energy is consumed whereby in one year about 80% to 90% of primary energy has been circulated through a heat exchanger. Accordingly, when increasing efficiency of the heat exchanger, consumed energy may be significantly reduced, and at the same time generation of carbon dioxide may be reduced.

[0006] Therefore, there arises a need for an intensive heat exchanger that reduces an overall volume of the heat exchanger while maintaining a required heat flowing performance. A method of increasing convective heat transfer to promote heat transfer of the heat exchanger may be roughly classified into a passive method and an active method. The active method in which a pulsation is applied to a working fluid or an additive is applied to a fluid may be effective in all flowing areas, however, may be restrictively used because separate equipment is additionally needed, and energy requiring for driving the separate equipment is required to be supplied.

[0007] Conversely, the passive method may be an ordinary method of increasing efficiency through a slight change in an existing design such as manipulation of a heat transfer surface. In the most general method of operating a fluid channel and the heat transfer surface, and using a fin, an offset fin, a louvered fin, a serrated fin, and the like have been used, and also a technique in which a rib is attached on the heat transfer surface or the heat exchanger surface formed into a groove or corrugate shape is used to promote generation of turbulence has been introduced.

[0008] A conventional heat exchanger will be herein briefly described. FIG. **1** is a perspective view illustrating heat transfer members of the conventional heat exchanger, which are superimposed for heat exchange.

[0009] As illustrated in FIG. **1**, the conventional heat exchanger is formed such that a plurality of metal plate-heat exchange members **10** are superimposed on one another to be combined with each other, and fluid channels **11** are formed between the plurality of metal plate-heat exchange members **10**.

[0010] In the conventional heat exchanger, the fluid channels shaped into a zigzag shape are formed on the metal plate-heat exchange members **10** to increase a heat transfer area, and a heat exchange is performed between two heat exchange fluids of a high temperature side and a low temperature side between the metal plate-heat exchange members **10**.

[0011] In this instance, to maintain a heat flowing performance and reduce a volume, a size of the fluid channels **11** for heat exchange is reduced to be about 1 mm, and the fluid channels **11** are disposed in a zigzag type to thereby enable a heat transfer to be performed.

[0012] However, the conventional heat exchanger has problems which will be described in detail as below.

[0013] First, a pressure drop may significantly increase within the heat exchanger due to a reduction in the size of the fluid channel.

[0014] Second, a channel through which a heat exchange fluid flows may be lengthened due to the zigzag shape, and a pressure drop of the heat exchange fluid may increase due to a vortex flow generated in a curved part made for mixing the fluid.

[0015] Third, an energy loss may occur due to the above-mentioned pressure drop, the vortex, and a swirl.

[0016] Fourth, a power of a pump may increase when replenishing the pressure drop, and an installation cost or operation cost may increase as a result.

SUMMARY

[0017] An aspect of the present invention provides a heat exchanger that may prevent a pressure drop while increasing a thermal efficiency regardless of a size of a channel.

[0018] An aspect of the present invention provides a heat exchanger that may change a disposition of a heat transfer fin to prevent a pressure drop of a fluid.

[0019] An aspect of the present invention provides a heat exchanger that may minimize an energy loss.

[0020] An aspect to the present invention provides a heat exchanger that may minimize a pressure drop, and enable a heat exchange fluid to flow using relatively less power of a pump, thereby reducing an installation cost and operation cost.

[0021] According to an aspect of the present invention, there is provided a heat exchanger, including: a plurality of plates superimposed on one another; and a plurality of heat transfer fins formed on the plurality of plates, and shaped into an airfoil, wherein a channel of a fluid between the superimposed plates is formed to perform a heat exchange.

[0022] In this instance, the airfoil may be symmetrical with respect to a chord line of the heat transfer fins, and the chord line of the plurality of heat transfer fins may be positioned on a straight line being parallel with a flowing direction of the fluid.

[0023] Also, the plurality of heat transfer fins may form a fin column included on a single straight line being parallel with the flowing direction of the fluid. In this instance, a plurality of fin columns may be formed.

[0024] Also, a leading edge of the heat transfer fin included in the single fin column and another leading edge of another fin column adjacent to the single fin column may be disposed on different straight lines each being perpendicular to the flowing direction of the fluid.

[0025] Also, the plurality of plates may be combined with each other in a diffusion bonding.

[0026] Also, chord lines of the plurality of heat transfer fins disposed on different plates being adjacent to each other may be disposed at a predetermined angle, and the heat transfer fins disposed on different plates being adjacent to each other may be disposed in an opposite direction to each other.

[0027] Additional aspects, features, and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] These and/or other aspects, features, and advantages of the invention will become apparent and more readily appreciated from the following description of exemplary embodiments, taken in conjunction with the accompanying drawings of which:

[0029] FIG. **1** is a perspective view illustrating heat transfer members of a conventional heat exchanger, which are superimposed for heat exchange;

[0030] FIG. **2** is a perspective view illustrating a heat exchanger according to example embodiments of the present invention;

[0031] FIG. **3** is an exploded perspective view illustrating a plurality of plates of a heat exchanger according to example embodiments of the present invention;

[0032] FIG. **4** is a perspective view illustrating a plate of FIG. **3**;

[0033] FIG. **5** illustrates a general airfoil;

[0034] FIG. **6** illustrates a heat transfer fin according to example embodiments of the present invention;

[0035] FIG. **7** illustrates a disposition of heat transfer fins according to example embodiments of the present invention;

[0036] FIG. **8** illustrates a heat exchanger including a heat transfer fin shaped into an airfoil of a case **1**;

[0037] FIG. **9** illustrates a heat exchanger including a heat transfer fin shaped into an airfoil of a case **2**;

[0038] FIG. **10** illustrates a heat exchanger including a heat transfer fin shaped into an airfoil of a case **3**; and

[0039] FIG. **11** illustrates an analysis result of three-dimensional numerical values of a heat transfer and a pressure drop with respect to a conventional printed circuit heat exchanger and a heat exchanger with heat transfer fins according to example embodiments of the present invention.

DETAILED DESCRIPTION

[0040] Reference will now be made in detail to exemplary embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. Exemplary embodiments are described below to explain the present invention by referring to the figures.

[0041] FIG. **2** is a perspective view illustrating a heat exchanger according to example embodiments of the present invention, FIG. **3** is an exploded perspective view illustrating a plurality of plates **200** of a heat exchanger according to example embodiments of the present invention, and FIG. **4** is a perspective view illustrating a plate of FIG. **3**.

[0042] The heat exchanger includes a housing **100** receiving the plurality of plates **200** therein, a header portion **105** disposed on both sides of the housing **100**, inflow pipes **111** and **121** of a heat exchange fluid, and outflow pipes **112** and **122** of the heat exchange fluid. In this instance, the plurality of plates **200** includes a heat transfer fin **210** formed thereon.

[0043] In the heat exchanger, the heat exchange fluid enters the inflow pipes **111** and **121** by a pump (not shown), a heat transfer is performed by means of the plurality of plates **200** and the heat transfer fin **210**, and the heat exchange fluid flows out from the outflow pipes **112** and **122**. Here, the heat exchange fluid may be preferably supercritical carbon dioxide, however the present invention is not limited thereto.

[0044] A plurality of plates **200** are provided, and superimposed on one another as illustrated in FIG. **3**. In this instance, the plurality of plates **200** may be made of a stainless steel plate or a metal material being several millimeters thick, and combined with each other using a diffusion bonding scheme.

[0045] Specifically, due to a principle in that atoms are moved in a bonding surface between the plurality of plates **200** by means of a high pressure generated by an exerted external power to thereby enable the bonding between the plurality of plates to be performed, the plurality of plates **200** are combined with each other, and easily used due to its relatively high tolerance to a high temperature and high pressure.

[0046] A plurality of heat transfer fins **210** are formed on the plurality of plates **200**, and shaped into an airfoil. Also, the heat transfer fin **210**is protrusively formed on the plurality of plates **200**, and thereby a channel between the plurality of plates **200** is formed, when the plurality of plates **200** are combined with each other. The channel is disposed to enable the heat exchange fluid to flow in other parts of the plate other than the heat transfer fin **210**, so that a heat transfer is performed through the plurality of plates **200** and the heat transfer fin **210** to thereby enable a heat exchange to be preformed. Specifically, a channel (A) is formed by means of the plurality of plates **200** and the heat transfer fin **210**, and the heat exchange fluid is guided to flow along the channel A.

[0047] In this instance, another heat transfer fin **210** formed on another plate being adjacent to the plurality of plates **200** is disposed in a different direction. That is, the heat exchange fluids interposing the plurality of plates **200** are required to flow in different directions from each other, and a more effective heat exchange is performed as a result. However, the heat transfer fin **210** is required to be disposed in a direction capable of minimizing a pressure drop with respect to flowing of the heat exchange fluid. Accordingly, preferably, a leading edge **217** (see FIG. **5**) of the heat transfer fin **210** is disposed to correspond to a flowing direction of the heat exchange fluid, and a chord line **215** (see FIG. **5**) of the heat transfer fin **210** is arranged in an identical direction to the flowing direction of the heat exchange fluid.

[0048] According to the present example embodiment, the leading edge **217** of the heat transfer fin **210** on a plate and another leading edge of the heat transfer fin on another plate adjacent to the plate are disposed in opposite directions with a difference of **180** degrees. Specifically, when the heat exchange fluids interposing the single plate flow in opposite directions, the heat transfer fin **210** may be disposed along the flowing direction of the heat exchange fluid.

[0049] According to the present example embodiment, the heat exchange fluids interposing the single plate flow in opposite directions with the difference of **180** degrees, however the present invention is not limited thereto. For example, the flowing directions of the heat exchange fluids may be provided at a predetermined angle with respect to the plate, and the heat transfer fin **210** may be disposed to correspond to the flowing direction.

[0050] In this instance, the airfoil may be shaped into a cross-sectional area of a wing, and used in academically defining any cross-sectional area such as a wing, an aileron, an elevator, and a rudder of an aircraft. The airfoil may need aerodynamic effects to lift a heaver than air aircraft, that is, the airfoil may need a great upward force and a less reaction. To increase the upward force, the airfoil may be formed into a streamline having a round upper surface and a sharp tip, however, according to the present invention, the heat transfer fin **210** may be formed into the airfoil shape capable of reducing the reaction without generation of the upward force.

[0051] Here, the heat transfer fin **210** shaped into the airfoil will be described in detail with reference to FIGS. **5** to **6**.

[0052] FIG. **6** illustrates a heat transfer fin according to example embodiments of the present invention, and FIG. **7** illustrates a disposition of heat transfer fins according to example embodiments of the present invention.

[0053] As illustrated in FIG. **5**, the airfoil includes the leading edge **217**, a trailing edge **218** the chord line **215**, a lower camber **213**, an upper camber **212**, and an average camber line **211**.

[0054] The chord line **215** may designate a straight line connecting the leading edge **217** and the trailing edge **218**, the lower camber **213** may designate a distance from the chord line **215** to a lower surface, and the upper camber **212** may designate a distance from the chord line **215** to an upper surface.

[0055] In this instance, the average camber line may designate a center line of a thickness, that is, an average line between the upper camber **212** and the lower camber **213**. A front end of the average camber line **211** may designate the leading edge **217** and a rear end thereof may designate the trailing edge **218**.

[0056] In general, the airfoil may be expressed in a naming method such as NACA XXXX, wherein NACA designates a National Advisory Committee for Aeronautics-series airfoil, a first numeral of X is a value in which a size of a maximum average camber is expressed using a percentage of the chord, a second numeral of X is a value in which a location of the maximum average camber is expressed using a percentage of tens of the chord, and third and fourth numerals of XX are values in which a size of a maximum thickness **216** is expressed using a percentage of the chord.

[0057] In this instance, the shape of the airfoil of the heat transfer fin **210** may be preferably symmetrical with respect to the chord line **215**. More specifically, when the upper camber **212** and lower camber **213** of the airfoil are the same, the airfoil may be referred to as a symmetrical airfoil. In the symmetrical airfoil having the same upper camber **212** and lower camber **213**, the average camber line may be the same as the chord line. Specifically, only a concept of the maximum thickness **216** may exist without concepts of the camber and maximum average camber. Thus, the symmetrical airfoil may be expressed as NACA 00XX, which is referred to as NACA 00-series, and an NACA 00-series airfoil may designate the symmetrical airfoil as a result. For example, NACA 0009 and NACA 0012 as the symmetrical airfoil may respectively express an airfoil with a maximum thickness of 9% of the chord, and an airfoil with a maximum thickness of 12% of the chord.

[0058] Here, a direction and disposition of the heat transfer fin **210** will be described in detail with reference to FIG. **7**. FIG. **7** illustrates a disposition of a heat transfer fin according to example embodiments of the present invention.

[0059] The chord line **215** of the heat transfer fin **210** is disposed on a straight line being parallel with a flowing direction (D) of the heat exchange fluid. That is, the heat transfer fin **210** is disposed in a direction capable of minimizing a resistance with respect to the flowing of the heat exchange fluid. As a result, a heat exchange is effectively performed by means of the heat exchange fluid, and a pressure drop is minimized.

[0060] Also, the heat transfer fin **210** may form a plurality of fin columns **250** disposed in a row with respect to the flowing direction of the heat exchange fluid. In this instance, the heat transfer fin **210** included in the fin column **250** is disposed on a straight line being parallel with the flowing direction of the heat exchange fluid.

[0061] In this instance, the leading edge **217** of the heat transfer fin **210** included in the single fin column **250** and another leading edge of another heat transfer fin **210** included in another fin column **250** adjacent to the single fin column **250** may be disposed on straight lines B or C different from each other each being perpendicular to the flowing direction (D) of the heat exchange fluid. Specifically, leading edges of other heat transfer fins being adjacent to and parallel with the heat transfer fin **210** may be disposed on different straight lines being perpendicular to the flowing direction of the heat exchange fluid, thereby minimizing a pressure drop of the heat exchange fluid and effectively performing a heat exchange.

[0062] Here, the pressure drop and the heat transfer rate may be adjusted according to a number of the heat transfer fins **210** and a disposition density of the heat transfer fins **210**, which will be described in detail with reference to FIGS. **8** to **10**.

[0063] FIG. **8** illustrates a heat exchanger including a heat transfer fin shaped into an airfoil of a case **1**, FIG. **9** illustrates a heat exchanger including a heat transfer fin shaped into an airfoil of a case **2**, FIG. **10** illustrates a heat exchanger including a heat transfer fin shaped into an airfoil of a case **3**, and FIG. **11** illustrates an analysis result of three-dimensional numerical values of a heat transfer and a pressure drop with respect to a conventional printed circuit heat exchanger and a heat exchanger with heat transfer fins according to example embodiments of the present invention.

[0064] In the case **1** of FIG. **8**, the leading edge **217** of the heat transfer fin **210** included in a fin column **250** is disposed on a straight line on which a trailing edge of a heat transfer fin included in a fin column **251** adjacent to the fin column **250** is located.

[0065] In the case **2** of FIG. **9**, the leading edge **217** of the heat transfer fin **210** included in a fin column **250** is disposed on a straight line through which a point of ½ of the chord line **215** of a heat transfer fin **210** included in a fin column **251** adjacent to the fin column **250** passes.

[0066] In the case **3** of FIG. **10**, the leading edge **217** of the heat transfer fin **210** included in a fin column **250** is disposed on a straight line through which a point of ⅓ of the chord line **215** of a heat transfer fin **210** included in a fin column **251**

adjacent to the fin column **250**, starting from the leading edge of the heat transfer fin **210**, passes.

[0067] Specifically, in FIG. **8** to FIG. **10**, the disposition density of the heat transfer pin **210** becomes denser. That is, locations of leading edges of the heat transfer fins **210** included in different fin columns are adjusted to change a degree of density of the heat transfer fin **210**, and Table 1 below shows an obtained analysis result of the heat exchanger as a result. For reference, according to the present invention, three plates are superimposed on one another.

TABLE 1

classification	Pressure drop	Heat transfer rate	Note
Case 1	262.5 Pa	92.36	
Case 2	425 Pa	95.88	
Case 3	635 Pa	101.22	
PCHE	8924 Pa	100.39	Conventional printed circuit heat exchanger

[0068] As shown in Table 1, in the heat exchangers including the heat transfer fin **210** shaped into the airfoils of the cases **1** and **2**, the pressure drop is significantly reduced and a total heat transfer rate is relatively low in comparison with that in the conventional printed circuit heat exchanger. The heat exchanger including the heat transfer fin **210** shaped into the airfoil of the case **3** shows nearly the same heat transfer amount as that in the conventional printed circuit heat exchanger, and also shows a low pressure drop corresponding to 1/14 of the pressure drop in the conventional printed circuit heat exchanger.

[0069] That is, the degree of density of the heat transfer fin **210** may be adjusted to enable the heat exchanger to control the pressure drop while maintaining the heat transfer amount.

[0070] As described above, according to the present invention, there is provided a heat exchanger that may change a channel type into a fin structure to increase a thermal efficiency regardless of a size of a channel, and may include a fin shaped into an airfoil to prevent a pressure drop.

[0071] According to the present invention, there is provided a heat exchanger that may change a direction or shape of a heat transfer fin to correspond to a channel of a fluid, thereby preventing a pressure drop of the fluid.

[0072] According to the present invention, there is provided a heat exchanger that may reduce occurrence of a pressure drop, a vortex flow, and a turning flow in a channel of a fluid, thereby minimizing an energy loss.

[0073] According to the present invention, there is provided a heat exchanger that may minimize a pressure drop, thereby enabling a heat exchange fluid to flow using relatively less pump power, and reducing an installation cost and operation cost as a result.

[0074] According to the present invention, there is provided a heat exchanger that may control a pressure drop while maintaining a heat transfer amount through a simple change in a disposition of a heat transfer fin.

[0075] Although a few exemplary embodiments of the present invention have been shown and described, the present invention is not limited to the described exemplary embodiments. Instead, it would be appreciated by those skilled in the art that changes may be made to these exemplary embodiments without departing from the principles and spirit of the invention, the scope of which is defined by the claims and their equivalents.

What is claimed is:

1. A heat exchanger, comprising:

a plurality of plates superimposed on one another; and

a plurality of heat transfer fins formed on the plurality of plates, and shaped into an airfoil, wherein a channel of a fluid between the superimposed plates is formed to perform a heat exchange.

2. The heat exchanger of claim **1**, wherein the airfoil is symmetrical with respect to a chord line of the heat transfer fins.

3. The heat exchanger of claim **2**, wherein the chord line of the plurality of heat transfer fins is positioned on a straight line being parallel with a flowing direction of the fluid.

4. The heat exchanger of claim **3**, wherein the plurality of heat transfer fins forms a fin column included on a single straight line being parallel with the flowing direction of the fluid, a plurality of fin columns being formed.

5. The heat exchanger of claim **4**, wherein a leading edge of the heat transfer fin included in the single fin column and another leading edge of another fin column adjacent to the single fin column are disposed on different straight lines each being perpendicular to the flowing direction of the fluid.

6. The heat exchanger of claim **1**, wherein the plurality of plates are combined with each other in a diffusion bonding.

7. The heat exchanger of claim **1**, wherein chord lines of the plurality of heat transfer fins disposed on different plates being adjacent to each other are disposed at a predetermined angle.

8. The heat exchanger of claim **1**, wherein the heat transfer fins disposed on different plates being adjacent to each other are disposed in an opposite direction to each other.

* * * * *