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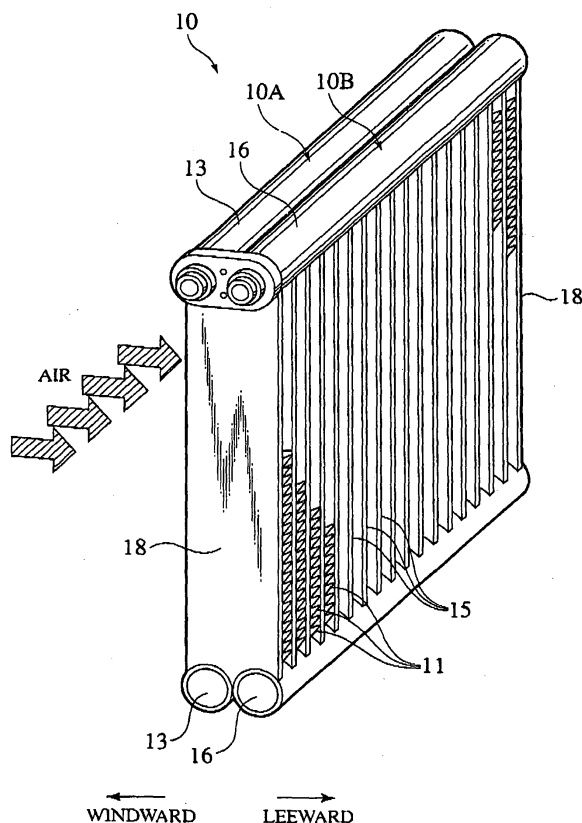
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(54) **Evaporator**

(57) An evaporator (10) has at least one core (10A, 10B). The core (10A, 10B) has tubes (15) and a pair of tanks (13). The tube (15) is configured to internally pass coolant, each of the tubes (15) formed by bending a plate material and joining both edges of the bent plate

material to each other. The pair of header tanks (13) is connected to and communicating with each open end of the tubes (15). In the most windward core (10A), the jointed edge (21) of the tubes (15) is arranged on the windward side.

FIG. 1



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Description

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2003-057354 filed on March 4, 2003; the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to an evaporator, and particularly, to an evaporator installed in an air conditioner for a vehicle.

2. Description of Related Art

[0003] An evaporator evaporates coolant inside the evaporator to thereby cool air passing outside the evaporator. An example of an evaporator includes a pair of header tanks and a plurality of tubes, as heat exchange tubes, that are arranged between and connected to the header tanks. Between the tubes, corrugated outer fins are arranged. In recent years, there has been a request to reduce the weight of the evaporator as well as other vehicle-mounted devices. In the evaporator, the tubes occupy a large part of the volume of the evaporator, and therefore, it is particularly required to reduce the weight of the tubes.

[0004] The tubes are structurally classified into the following two types:

Type-1 tube: comprise two metal plates joined together into a tube-shape

Type-2 tube: having a tube-shape formed by extrusion

[0005] In terms of weight reduction, the type-2 tube that does not have a joint is more preferable than the type-1 tube having joints between the two metal plates.

[0006] The tubes of the evaporator tend to condense moisture in the air passing around the tubes. Accordingly, compared with tubes of other heat exchangers, the tubes of the evaporator easily get foreign matter, such as dust, passing around the tubes. Such foreign matter adhering to the tubes may be the starting point for corrosion. In particular, the type-2 tube is susceptible to corrosion when the tube is made thinner for weight reduction.

SUMMARY OF THE INVENTION

[0007] The inventor of the present invention found that the windward side of a tube easily gets foreign matter to start corrosion. As a result, the present application

relates to an evaporator employing light and corrosion-resistant (durable) tubes.

[0008] An aspect of the present invention provides an evaporator having at least one core. The core has tubes and a pair of tanks. The tube is configured to internally pass coolant, each of the tubes formed by bending a plate material and joining both edges of the bent plate material to each other. A pair of header tanks is connected to and communicates with each open end of the tubes. In the most windward side core, the jointed edge of the tubes is arranged on the windward side. According to this aspect, the tube having only one joint can achieve weight reduction comparable to the type-2 tube made by extrusion. Additionally the joint of the tube is arranged on the windward side to further improve corrosion resistance as compared to the type-2 tube made by extrusion. In short, the tubes of this aspect of the invention can achieve weight reduction and high corrosion resistance, to thereby provide an evaporator that is light and corrosion resistant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Figure 1 is a perspective view showing an evaporator according to a first embodiment of the present invention;

Fig. 2 is a sectional view showing tubes and outer fins arranged one upon another in the evaporator of the first embodiment;

Fig. 3 is a sectional view showing the details of the tube of the first embodiment;

Fig. 4 is a model view showing a structure of the tube of the first embodiment;

Figs. 5A, 5B, and 5C are model views showing a method of forming the tube of the first embodiment; Figs. 6A and 6B are schematic views showing foreign matter adhering to a windward end of a tube; Fig. 7 is a sectional view partly showing an evaporator according to a second embodiment of the present invention;

Fig. 8 is a sectional view partly showing an evaporator according to a third embodiment of the present invention;

Figs. 9A, 9B, and 9C are enlarged sectional views showing examples of tube structures according to the present invention;

Fig. 10 is a view showing an evaporator as a comparison example having the type-1 tubes each made of two metal plates joined together; and Fig. 11 is a view showing an evaporator as a comparison example having the type-2 tubes each made by extrusion.

DETAILED DESCRIPTION OF THE INVENTION

[0010] Evaporators according to the embodiments of

the present invention will be explained with reference to the accompanying drawings.

First embodiment

[0011] Figures 1 to 6 show an evaporator according to the first embodiment of the present invention. The evaporator 10 is installed in an air conditioner for a vehicle and is arranged downstream from a fan and upstream of a heater core in a casing of the air conditioner. The evaporator 10 exchanges heat between coolant flowing through tubes and air passing outside the tubes, to thereby dehumidify and cool air sent from the fan.

[0012] In Fig. 1, the evaporator 10 has a core 10A and a core 10B arranged inline in an airflow direction. The first core 10A is on the windward side and the second core 10B is on the leeward side. In Fig. 1, a reference numeral 18 represents a reinforcing side plate.

[0013] The first core 10A includes corrugated outer fins 11, tubes 12 alternated with the fins 11 for internally passing coolant, and a pair of header tanks 13 connected to and communicating with each open end of the tubes 12. Like the first core 10A, the second core 10B includes the corrugated outer fins 11, tubes 15 alternated with the fins 11 and internally passing coolant, and a pair of header tanks 16 connected to and communicating with each open end of the tubes 15.

[0014] In Fig. 2, the outer fins 11 extend along the cores 12 and 15 through the first core 10A and second core 10B in the airflow direction. As another way of explaining, each outer fin 11 is shared by the first and second cores 10A and 10B.

[0015] The structure of the tube 12 will be explained in detail with reference to Figs. 2 to 6. The tubes 12 of the first core 10A and the tubes 15 of the second core 10B have an identical structure, and therefore, the tube 12 will be explained representatively. The tube 12 is made of a long aluminum plate. In Fig. 4, the aluminum plate has a core material (aluminum alloy having a relatively high melting point) 12A and brazing materials (aluminum alloy having a relatively low melting point) 12B and 12C that are on each face of the core material 12A. The aluminum plate may be replaced with any material having a good heat transfer characteristic.

[0016] In Figs. 5A, 5B, and 5C, the tube 12 is formed by bending a metal plate in the width direction and joining both edges 21 of the bent plate to each other. More precisely, in Fig. 5A, a metal plate is formed by rolling or pressing the metal plate into a depressed shape with two flat edges 21. In Fig. 5B, the metal plate is bent along a center bend line 22, indicated by a dotted line, into a tube-shape having a roundness of a given radius along the center bend line 22. At this time, the edges 21 are fitted or joined to each other. A corrugated inner fin 25 (Fig. 3) is inserted into the tube 12. The tube 12 is heated to fix or join the edges 21 to each other by brazing, to complete the long flat tube 12 shown in Fig. 5C.

[0017] In Figs. 2 and 3, the completed tube 12 has a

flat tube body 20, the joint 21 protruding from the tube body 20, and the inner fin 25 arranged in the tube body 20. In Fig. 2, the joint 21 of the most windward side tubes 12 are oriented windward. The tube 12 having the thick joint 21 on the windward side has improved corrosion resistance compared with the type-2 tube made by extrusion, and due to this, the tube body 20 of the tube 12 may be made thinner, to make the tube 12 light and corrosion resistive.

[0018] In Fig. 6A, a windward end face 12a of the tube 12 and a windward end face 11a of the outer fin 11 is flush with each other facing an airflow direction. Figure 6B shows a comparison example with a windward end face 12a (end face of a joint 21) of a tube 12 being displaced from a windward end face 11a of an outer fin 11 in an airflow direction. When foreign matter traveling in the air flow from the fan adheres to the windward end face, a distance $d3 (> d4)$ between the foreign matter and the tube body 20 of the first embodiment of Fig. 6A is longer than any other arrangements, including the arrangement of Fig. 6B. Accordingly, the first embodiment can effectively prevent corrosion of the tube body 20.

[0019] The inner fin 25 has a corrugated shape. More precisely, the inner fin 25 comprises first parallel sections 26 that are substantially parallel to and connected to a first side wall 23 of the tube 12, second parallel sections 27 that are substantially parallel to and connected to a second side wall 24 of the tube 12, and orthogonal sections 28 that are substantially orthogonal to the first and second side walls 23 and 24 and link the first and second parallel sections 26 and 27 with each other. In this structure, the orthogonal sections 28 function as supports of the tube 12 to improve the pressure resistance of the tube 12. A plate thickness $d5$ of the inner fin 25 is thinner than a plate thickness $d1$ of the tube 12 as shown in Fig. 3.

[0020] Effects of the evaporator 10 according to the first embodiment will be explained.

[0021] First, the tubes 12 (Figs. 3 and 5) are each formed by bending a metal plate 19 and joining both edges 21 of the bent plate 19 to each other, to reduce the number of joints to less than that of the type-1 tube made by joining two metal plates together. The thick joint 21 of the tube 12 of the most windward side core 10A is arranged on the windward side (Figs. 2 and 6) where corrosion may start. This structural arrangement improves corrosion resistance of the tube 12 and 15 compared with the type-2 tube made by extrusion.

[0022] The improved corrosion resistance of the tube 12 (15) enables the tube body 20 to be thinned. As a result, the tube 12 (15) can achieve weight reduction and improved corrosion resistance. Therefore, the evaporator 10 according to the first embodiment employing the tubes 12 and 15 is light and corrosion resistive.

[0023] Second, the windward end face 12a of each tube 12 is substantially made flush with the windward end face 11a of each outer fin 11 in an airflow direction

(Fig. 6A). As a result, foreign matter may adhere to the windward end of the tube 12 that is farthest from the tube body 20. An erosion of the tube 12 from the windward takes more time. This structural arrangement effectively prevents the tube body 20 from corroding.

[0024] Third, the cores 10A and 10B are arranged in line in an airflow direction, to greatly improve the heat exchange efficiency of the evaporator 10 per unit airflow area. In addition, the outer fins 11 are extended along the tubes 12 and 15 that are arranged in line in the airflow direction. Alternating the outer fins 11 with the tubes 12 and 15 enables easy assembling of the evaporator 10.

[0025] Fourth, each of the tubes 12 and 15 has the inner fin 25 to improve the heat exchange efficiency and pressure resistance of the tube. The plate thickness d5 of the inner fin 25 is thinner than the plate thickness d1 of the tube 12 (Fig. 3). This configuration helps reduce the weight of the tubes 12 and 15.

[0026] Fifth, the inner fin 25 has the orthogonal sections 28 that are substantially orthogonal to the first and second side walls 23 and 24 of the tube 12 (15) and link the first and second parallel sections 26 and 27 of the inner fin 25 with each other. The orthogonal sections 28 function as supports of the tube 12 (15) to improve the pressure resistance of the tube 12 (15).

Second embodiment

[0027] Figure 7 is a sectional view partly showing an evaporator according to the second embodiment of the present invention. The same parts as those of the first embodiment are represented with like reference numerals and will not be explained in detail.

[0028] A difference from the first embodiment is that the second embodiment orients joints 21 of the most leeward tubes 15 leeward. That is, in the evaporator 30, joints 21 of the most windward tubes 12 are oriented windward and the joints 21 of the most leeward tubes 15 are oriented leeward. Since the joints 21 are present at windward and leeward ends, the evaporator 30 can provide the same effects as the first embodiment even if the evaporator 30 is turned around in the airflow direction. This provides a greater degree of freedom in positioning the evaporator 30.

Third embodiment

[0029] Figure 8 shows an evaporator 40 according to the third embodiment of the present invention. The evaporator 40 has a single core 10A instead of a plurality of cores (two or more cores) arranged in line in an airflow direction.

Other examples of tubes

[0030] The structure of a joint of a tube used for an evaporator according to the present invention is not limited

to the above embodiments. Other tube structures such as those shown in Figs. 9A to 9C are also possible according to the present invention. In terms of reducing weight of an evaporator, the most preferable structure for the joint 21 of the tube 12 (15) is that explained in any one of the first to third embodiments.

[0031] In Fig. 9A, a tube 50 has edges 51 and 52 where the edge 51 (upper edge in Fig. 9A) is longer than the edge 52 (lower edge in Fig. 9A) and is folded along the edge 52 into a U-shape to cover the edge 52.

[0032] In Fig. 9B, a tube 60 has edges 61 and 62 that are inwardly folded in advance and are joined together. Instead of folding each of the edges 61 and 62 inwardly, each may be folded outwardly.

[0033] In Fig. 9C, a tube 70 has edges 71 and 72 with each of their ends 71a and 72a being outwardly bent in an L-shape to form an inverted T-shape joint in an airflow direction.

[0034] Figure 10 shows an evaporator serving as a comparison example. The evaporator of Fig. 10 employs tubes 100, each being the type-1 tube made by joining two metal plates 101 together. Numeral 102 represents an inner fin and 103 an outer fin arranged between the adjacent tubes 100. Figure 11 shows an evaporator serving as another comparison example. The evaporator of Fig. 11 employs tubes 200, each being the type-2 tube made by extrusion.

[0035] Although the present invention has been explained in connection with the embodiments, the present invention should not be limited to them as is apparent for those skilled in the art. The embodiments may allow many modifications and alterations without departing from the spirit and scope of the present invention defined in claims. The descriptions in this specification are only for explanatory purposes and are not intended to restrict the present invention.

Claims

1. An evaporator comprising:

a core;
tubes configured to internally pass a coolant therethrough, each of the tubes formed by a bent plate material and in which edges of the bent plate material are joined to each other; and
a pair of header tanks connected to and communicating with open ends of the tubes,

wherein the joined edges of the tubes are oriented windward.

2. An evaporator comprising:

a plurality of cores in which a core located at a position closest to windward includes:

tubes configured to internally pass coolant, each of the tubes formed by bending a plate material and joining both edges of the bent plate material to each other; and a pair of header tanks connected to and communicating with each open end of the tubes,

wherein the joined edges of the tubes being oriented windward.

3. An evaporator comprising:

a plurality of cores, each of said cores comprising:

tubes configured to internally pass a coolant therethrough, each of the tubes formed by a bent plate material and in which edges of the bent plate material are joined to each other; and a pair of header tanks connected to and communicating with open ends of the tubes,

wherein the joined edges of the tubes are oriented in a windward direction with a core thereof located in a position closest to windward.

4. The evaporator of claim 3, further comprising:

outer fins alternating with the tubes, wherein a windward end face of each of the tubes is substantially aligned with a windward end face of each of the outer fins in the core located to the closest windward position.

5. The evaporator of claim 3, further comprising:

outer fins alternating with the tubes,

wherein the outer fins are extended along the tubes through the cores.

6. The evaporator of claim 3, wherein:

the joined edge of the tubes of in the core located closest to windward are oriented windward; and the joined edges of the tubes of the core located closest to leeward are oriented leeward.

7. The evaporator of claim 3, further comprising:

an inner fin arranged in each of the tubes, a material thickness of the inner fin being thinner than a material thickness of the tube.

8. The evaporator of claim 7, wherein the inner fin comprises:

first parallel sections substantially parallel to and connected to a first side wall of the tube; second parallel sections substantially parallel to and connected to a second side wall of the tube; and orthogonal sections substantially orthogonal to the first and second side walls of the tube and linking the first and second parallel sections with each other.

FIG. 1

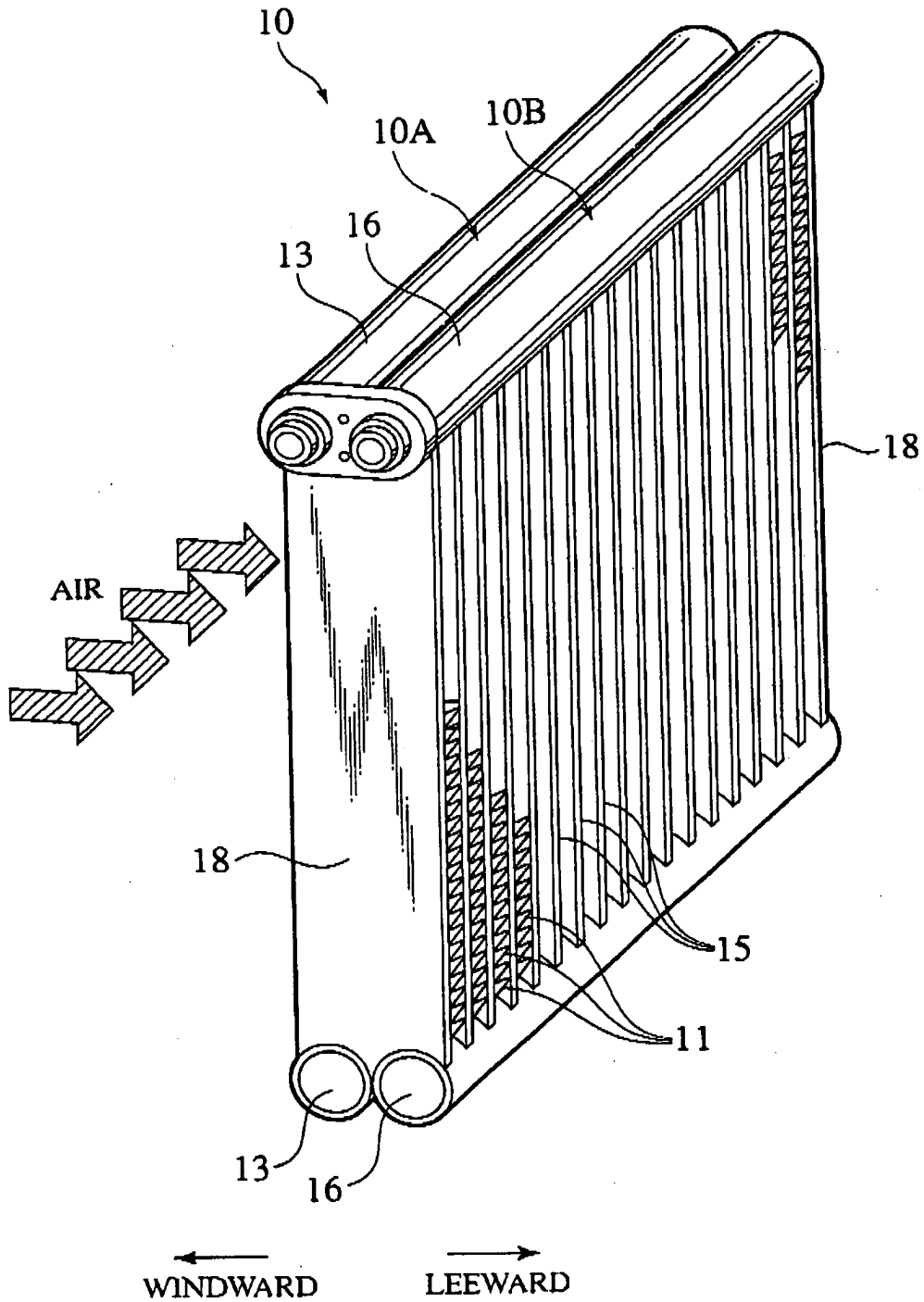


FIG. 2

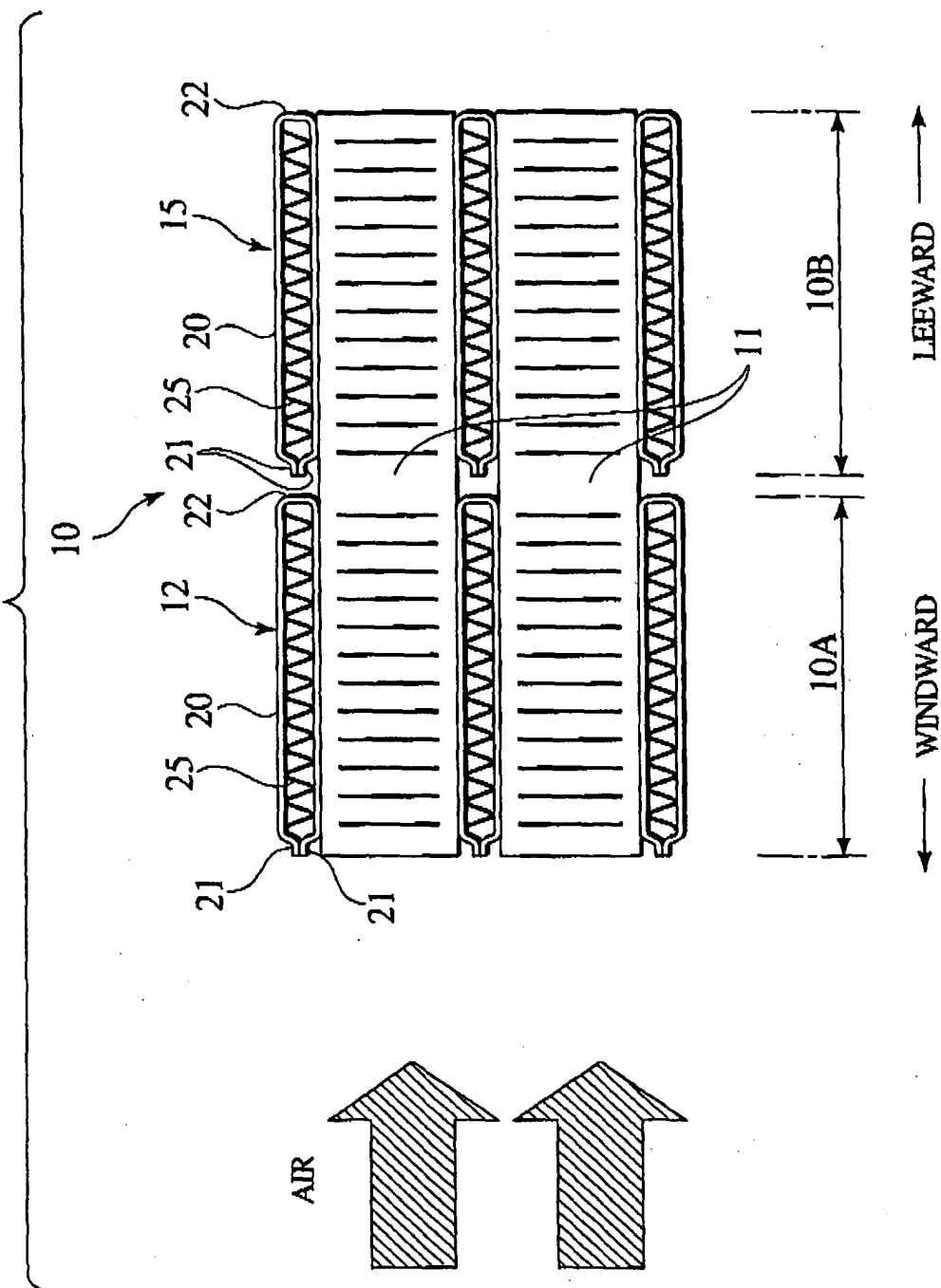


FIG. 3

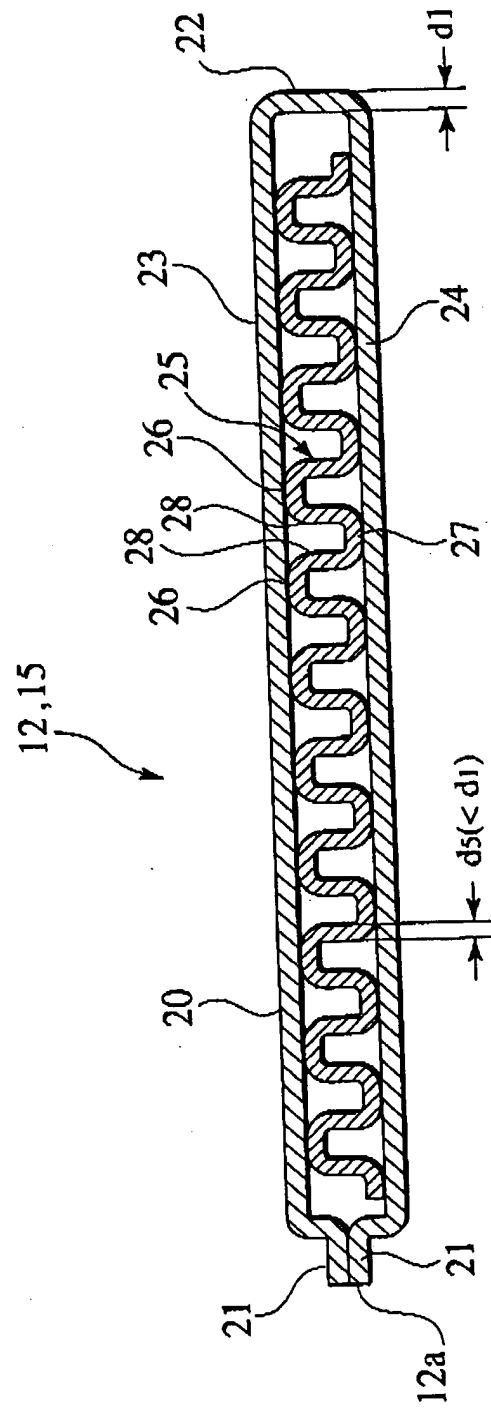


FIG. 4

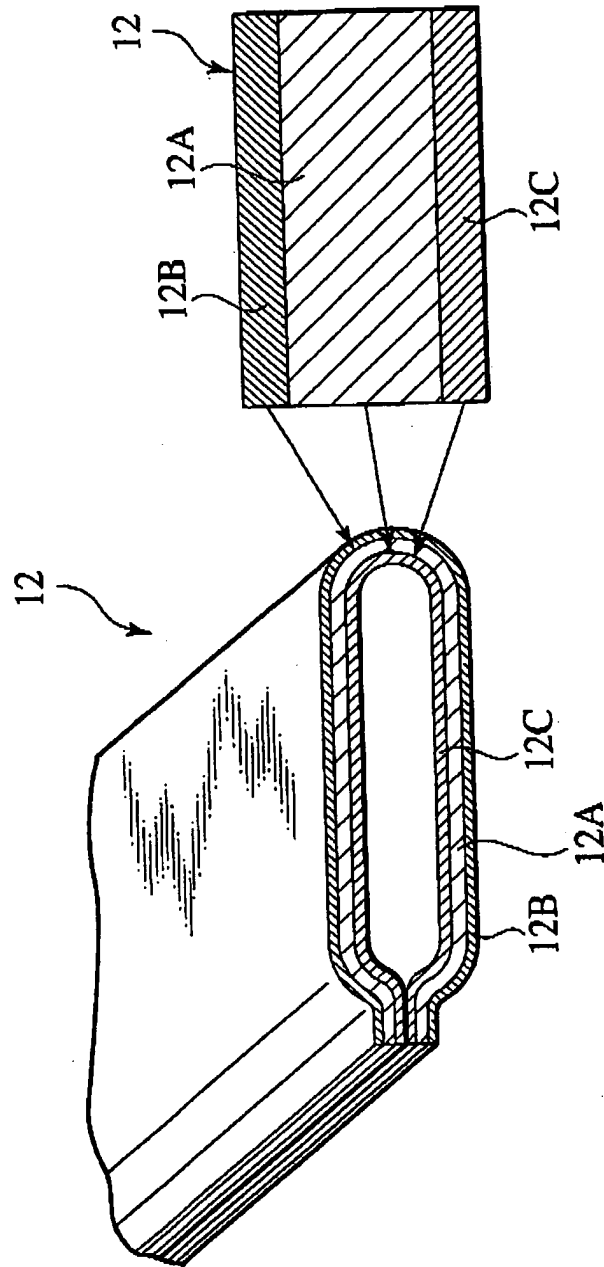


FIG. 5A

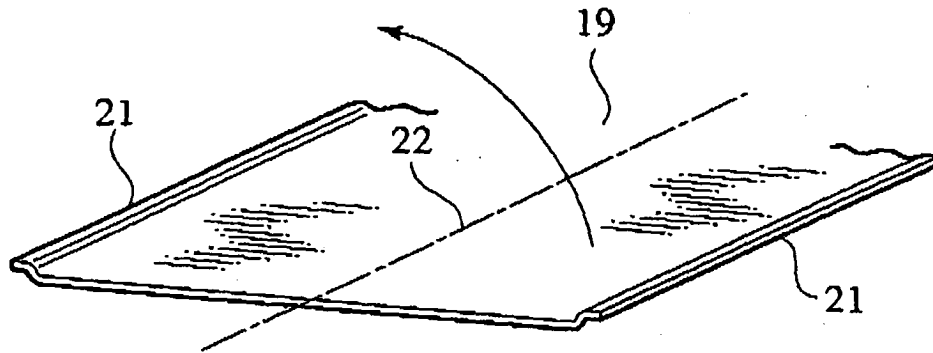


FIG. 5B

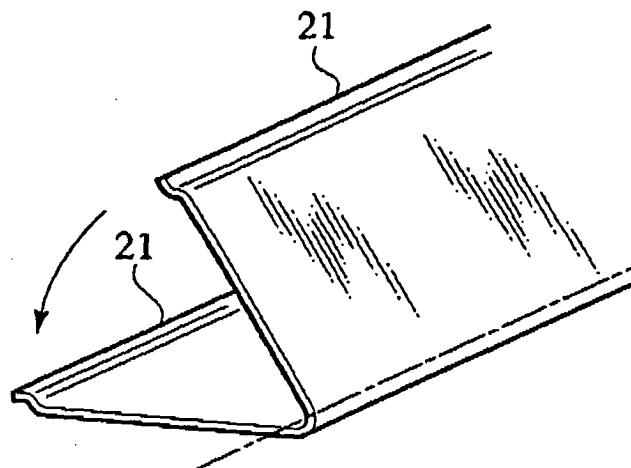


FIG. 5C

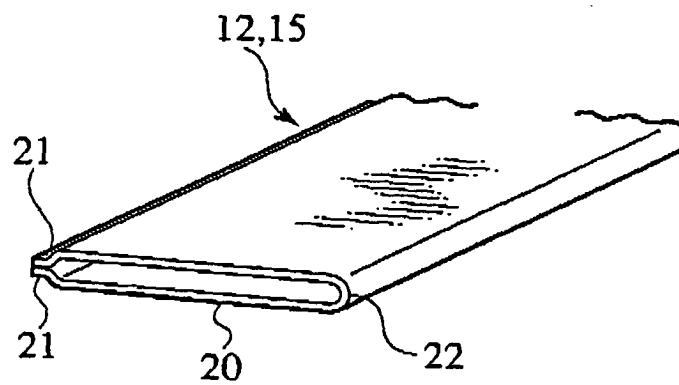


FIG. 6A

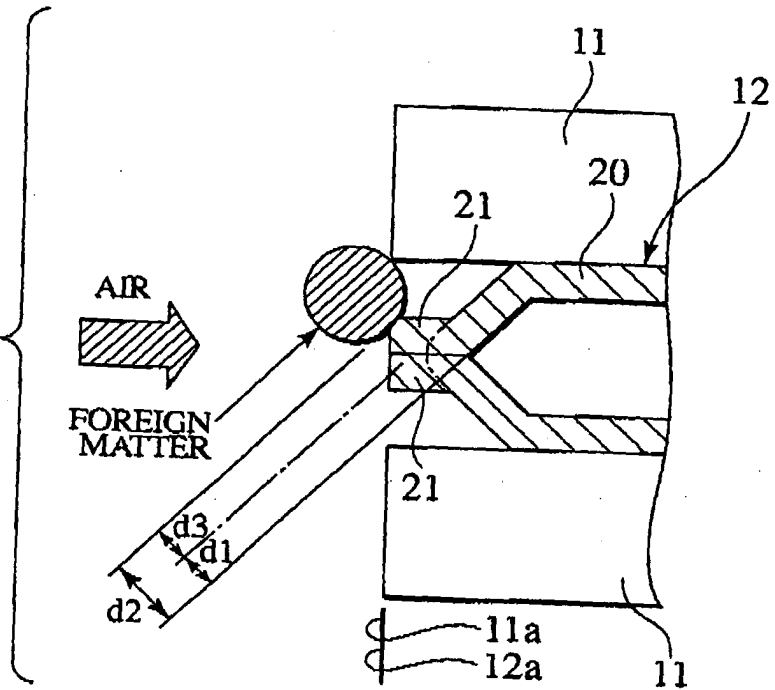


FIG. 6B

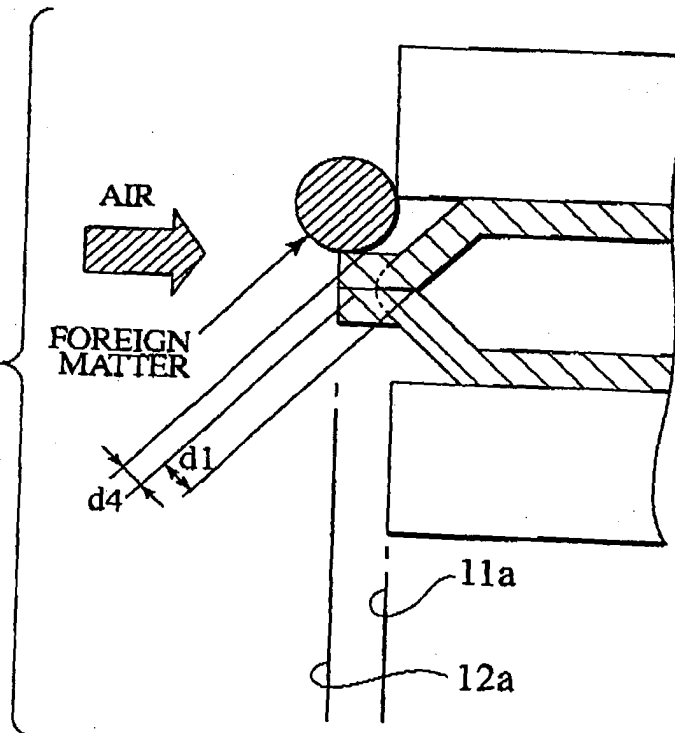


FIG. 7

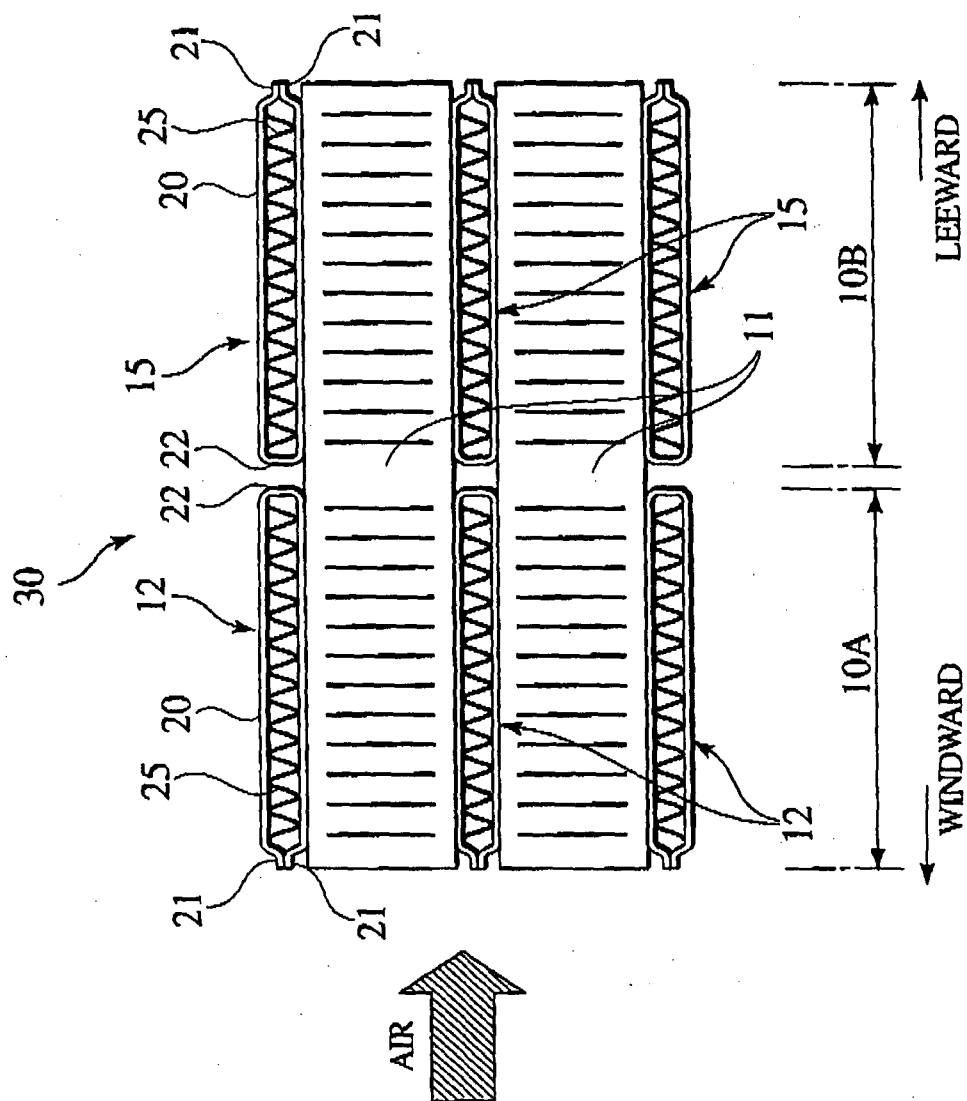
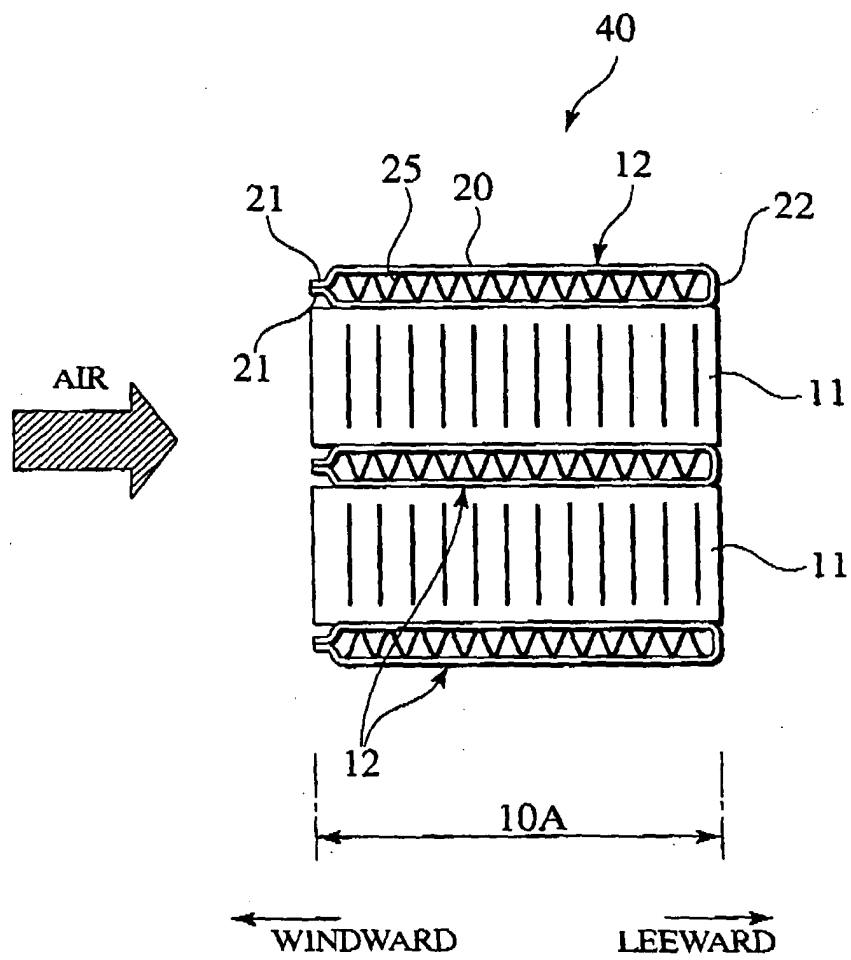


FIG. 8



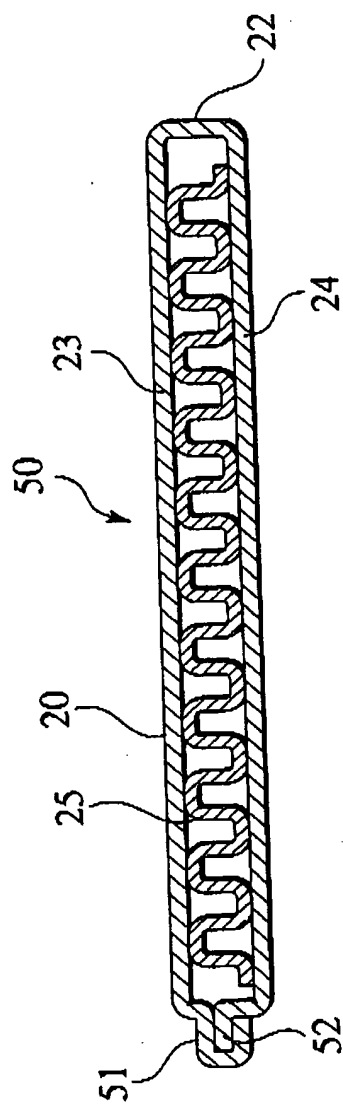


FIG. 9A

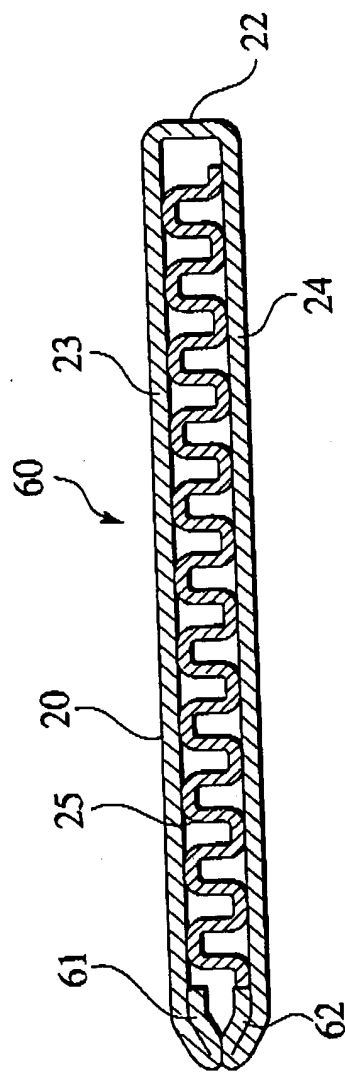


FIG. 9B

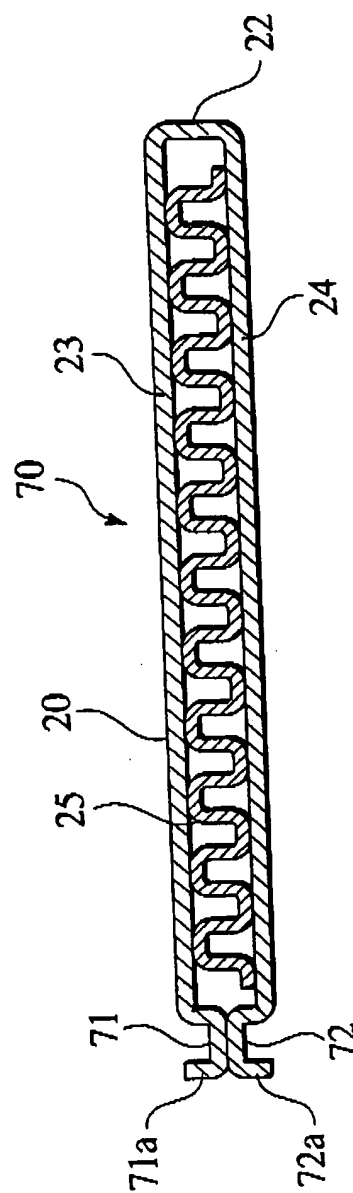


FIG. 9C

FIG. 10

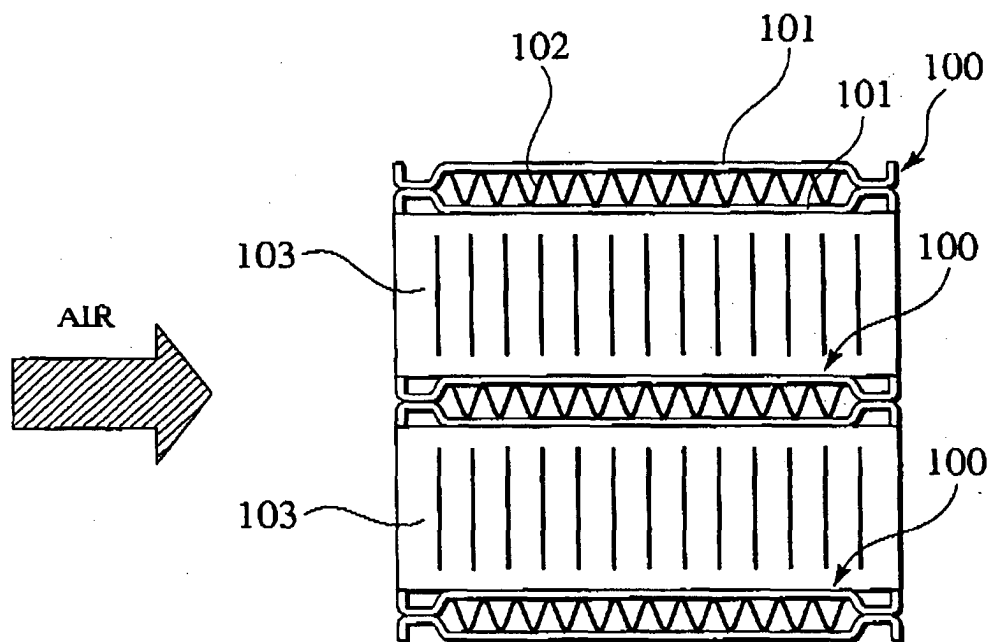


FIG. 11

