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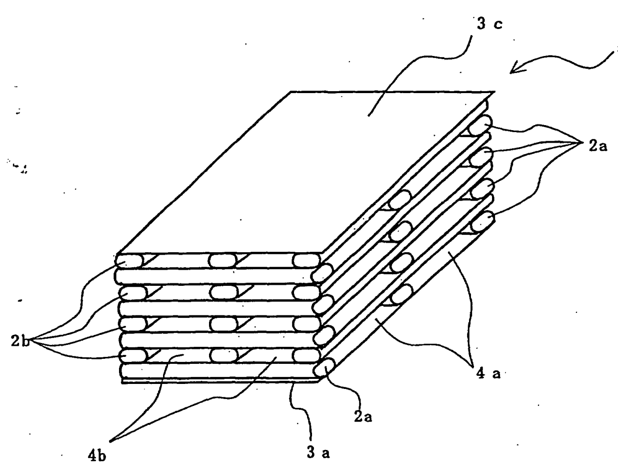
(54) AIR-TO-AIR HEAT-EXCHANGE ELEMENT

(57) A gas-to-gas heat exchange element 5 is constructed by superposing heat exchange segments of the same type. Heat exchanging gases are supplied to gas flow channels 4a extending in one direction, and other gas flow channels 4b extending perpendicular thereto. Each heat exchange segment has heat exchange sheets bonded to upper and lower surfaces of hollow resin spacers 2a of compressed elliptical shape arranged equidistantly to form the gas flow channels 4a. Second hollow resin spacers 2 of compressed elliptical shape are arranged equidistantly and boned to the upper heat exchange sheet.

Fig.3



EP 1 136 781 A1

Description

TECHNICAL FIELD

[0001] This invention relates to heat exchange segments, and a gas-to-gas heat exchange element having a superposition of the segments.

BACKGROUND ART

[0002] Conventionally, as is widely known, an air-conditioning and ventilating fan apparatus used in a house, office or the like has an air-to-air heat exchanger mounted therein.

[0003] Thus, various types of heat exchange elements therefor are already known. For example, as a typical example, as disclosed in "Japanese Patent Publication (Unexamined) H6-101988" or "Japanese Patent Publication (Unexamined) H5-288488", a heat exchange element has a plurality of heat exchange segments, with a plurality of hollow resin spacers secured at predetermined intervals to one surface of a heat exchange sheet, superposed with directions of total lengths of the hollow resin spacers staggered alternately by 90 degrees.

[0004] However, this known heat exchange element has drawbacks. The hollow resin spacers of the heat exchange segments, since they are in the form of commercially available circular straws such as of polypropylene (hereinafter simply called PP), easily roll and therefore are troublesome to handle when manufacturing the heat exchange segments, for example. When bonding the hollow resin spacers to the heat exchange sheet, the bonding areas are insufficient and it is difficult to secure them with sufficient strength. Therefore, to increase the strength of the segments, an increased number of hollow resin spacers must be bonded, which results in an increases material cost. A disposal of used heat exchange elements results in an increased quantity of waste.

[0005] It is also known to form the hollow resin spacers in other shapes than circular, that is to say angular such as square or triangular, or elliptical (as disclosed in "Japanese Patent Publication (Unexamined) S62-29898", for example). Such angular hollow resin spacers are custom-made and expensive. Elliptical hollow resin spacers may be obtained by appropriately deforming commercially available circular straws such as of PP, but fail to eliminate the above-noted drawback of bonding area shortage.

[0006] This invention has been made having regard to the state of the art noted above, and its object is to provide a heat exchange element, which uses compressed elliptical hollow spaces to facilitate handling in time of manufacturing exchange segments, and secures sufficient boding strength with bonding areas increased when the spacers are bonded to heat exchange sheets.

DISCLOSURE OF THE INVENTION

[0007] To fulfill the above object, this invention employs the following construction.

[0008] A gas-to-gas heat exchange element comprising a superposition of heat exchange segments each having a plurality of hollow resin spacers secured at predetermined intervals to either surfaces of heat exchange sheets, wherein

said hollow resin spacers have a compressed elliptical shape, and arranged with flat portions thereof contacting said heat exchange sheets.

[0009] According to the heat exchange element of this invention, the hollow resin spacers of compressed elliptical shape, not possible to roll, are easy to handle when manufacturing the heat exchange element. The bonding areas between the hollow resin spacers and heat exchange sheets are increased to obtain sufficient bonding strength. Based on this, a reduced number of hollow resin spacers may be secured. The hollow resin spacers of compressed elliptical shape may be obtained by deforming commercially available straws, for example.

[0010] In the gas-to-gas heat exchange element according to this invention, a plurality of first hollow resin spacers may be secured at predetermined intervals to the heat exchange sheets to form gas flow channels opening in one direction only longitudinally of said first hollow resin spacers, and a plurality of second hollow resin spacers may extend in a direction crossing a longitudinal direction of said first hollows resin spacers and secured at predetermined intervals to the heat exchange sheets. This construction has the following function and effect. Gases may be supplied for heat exchange to the gas flow channels formed between the first hollow resin spacers, and to the gas flow channels formed between the second hollow resin spacers extending in the direction crossing the longitudinal direction of the first hollow resin spacers.

[0011] Further, the first hollow resin spacers may have a dimension between flat surfaces of the compressed elliptical shape different from a dimension between flat surfaces of the compressed elliptical shape of said second hollow resin spacers. This construction achieves an excellent heat exchange where an inflow resistance of one gas and an outflow resistance of the other gas are in an unbalanced relationship.

[0012] In the gas-to-gas heat exchange element according to this invention, the heat exchange sheets may have patterns of embosses formed thereon. Then, the heat exchange sheets have an increased rigidity and are difficult to deform. Where a heat exchange is effected between gases supplied to the gas flow channels formed between the hollow resin spacers, a situation in which the lower heat exchange sheet and heat exchange sheet are deformed to contact one another is prevented. The heat exchange sheets have increased surface areas, and the gases may be caused to flow as divided or meandering in the gas flow channels, thereby extending flow paths. As a result, an improvement is made in heat transfer and moisture transfer properties.

[0013] Preferably, one end of each heat exchange sheet is secured only to a flat portion of one of the hollow resin spacers, or to a flat portion and a curved portion (r-portion) of one of the hollow resin spacers. The former is advantageous from the viewpoint of reducing the amount of use of the heat exchange sheets. The latter is advantageous in securing strength and in heat-exchange performance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a perspective view of a heat exchange segment in a first embodiment;
Fig. 2 is a sectional view of a hollow resin spacer;
Fig. 3 is a perspective view of a heat exchange element in the first embodiment;
Fig. 4 is a cross-sectional view of an air-conditioning and ventilating fan apparatus;
Fig. 5 is a view showing a way in which heat exchange sheets are secured a first hollow resin spacer of compressed elliptical shape;
Fig. 6 is a view showing another way in which the heat exchange sheets are secured to the first hollow resin spacer of compressed elliptical shape;
Fig. 7 is a perspective view of a heat exchange segment in a second and a third embodiments;
Fig. 8 is a perspective view of a heat exchange element in the second and third embodiments;
Fig. 9 is a plan view showing an emboss pattern formed on an upper heat exchange sheet;
Fig. 10 is a plan view showing an emboss pattern formed on a lower heat exchange sheet;
Fig. 11 is a view showing a height of an emboss formed on the lower heat exchange sheet;
Fig. 12 is a view showing gas currents;
Fig. 13 is a plan view showing another emboss pattern formed on the lower heat exchange sheet;
Fig. 14 is a plan view showing another emboss pattern formed on the lower heat exchange sheet;
Fig. 15 is a view showing a contact between embosses;
Fig. 16 is a view showing gas currents in a location having no emboss;
Fig. 17 is a view showing gas currents in a location having embosses;
Fig. 18 is a view showing first and second hollow resin spacers superposed in the third embodiment; and
Fig. 19 is a plan view of an air-conditioning and ventilating fan apparatus in the third embodiment.

BEST MODE FOR CARRYING OUT THE INVENTION

[0015] Preferred embodiments of this invention will be described in detail hereinafter with reference to the drawings.

First Embodiment

[0016] In Fig. 1, a heat exchange segment 1 has three first hollow resin spacers 2a to which a lower heat exchange sheet 3a and an upper heat exchange sheet 3b are secured, and three second hollow resin spacers 2b secured to the upper heat exchange sheet 3b.

[0017] The first hollow resin spacers 2a are arranged equidistantly, and the second hollow resin spacers 2b also are arranged equidistantly. An appropriate adhesive is used to secure the first hollow resin spacers 2a and heat exchange sheets 3a and 3b, as well as the heat exchange sheet 3b and the second hollow resin spacers 2b.

[0018] Thus, as shown, gas flow channels 4a are formed that open in one direction only longitudinally of the first hollow resin spacers 2a (Y-direction in the figure). The second hollow resin spacers 2b have longitudinally opposite ends thereof disposed in the direction (X-direction in the figure) perpendicular to the longitudinal direction (Y-direction in the figure) of the first hollow resin spacers 2a.

[0019] The first and second hollow resin spacers 2a and 2b, with a sectional shape as shown in Fig. 2, are of compressed elliptical shape having a 6mm r surface-to-surface dimension La and a 2mm flat surface-to-surface dimension Lb, for example.

[0020] Generally, La/Lb is 2 to 5. Such first and second hollow resin spacers 2a and 2b of compressed elliptical shape may be obtained by deforming commercially available circular PP straws or polyethylene terephthalate (hereinafter called simply PET) straws.

[0021] As noted above, the heat exchange segment 1 according to this invention has the first and second hollow resin spacers 2a and 2b of compressed elliptical shape. Therefore, where, for example, heat exchange sheets 3a and 3b formed of a paper material such as paper impregnated with calcium chloride to have heat transfer property, moisture permeability and fire resistance are bonded to the first hollow resin spacers 2a, large bonding areas may be secured therebetween to obtain sufficient bonding strength.

[0022] Based on this, a reduced number of the first and second hollow resin spacers 2a and 2b are needed for production of each heat exchange segment. Thus, where a plurality of heat exchange segments 1 are superposed as shown in Fig. 3, relatively large gas flow channels 4a and 4b may be formed to realize a reduced pressure loss.

[0023] The first and second hollow resin spacers 2a and 2b of compressed elliptical shape, not possible to roll, are easy to handle when manufacturing the heat exchange segments 1. Further, where a heat exchange element 5 is formed by superposing the heat exchange segments 1, the compressed elliptical shape stabilizes the shape maintenance of heat exchange element 5. Thus, the heat exchange element 5 obtained has excellent shape stability, not easily collapsible.

[0024] The first hollow resin spacers 2a and second hollow resin spacers 2b have an excellent gastight feature at opposite ends thereof to prevent gas leakage. This completely prevents gas mixing between one gas flow channel and another gas flow channel.

[0025] In addition, the first and second hollow resin spacers 2a and 2b of compressed elliptical shape have a strong flexing resistance in the direction of width (direction La in Fig. 2), and therefore have characteristics similar to those of rigid spacers. Moreover, because of the small thickness (dimension Lb in Fig. 2), the heat exchange element 1 may be formed by superposing an increased number of heat exchange segments 1. Since the first hollow resin spacers 2a and second hollow resin spacers 2b are arranged in the relationship perpendicular to one another, the heat exchange segments 1 obtained have appropriate rigidity not easily deformable.

[0026] In superposing the heat exchange segments 1, a suitable adhesive is used to secure the heat exchange segments 1 together. Thus, the heat exchange element 5 of layer structure is obtained easily as seen in Fig. 3 showing a perspective view thereof. A heat exchange sheet 3c is bonded to the uppermost heat exchange segment 1.

[0027] With this heat exchange element 5, heat exchanging gases are supplied to the gas flow channels 4b extending in one direction and the other gas flow channels 4a formed perpendicular thereto. That is, for example, indoor air (unclean air) may be supplied to the gas flow channels 4b extending in one direction, and outdoor air (fresh air) to the other gas flow channels 4a for heat exchange.

[0028] This state is shown in Fig. 4. In this figure, an air-conditioning and ventilating fan apparatus 12 attached to an outer wall 11 of an office or the like has a heat exchanger 14 and a ventilator 15 mounted in a casing 13. The heat exchange element 5 is mounted in the heat exchanger 14.

[0029] Partitions 20-23 are arranged to define a passage 16 for supplying indoor air to the gas flow channels 4b extending in one direction and a passage 17 for discharging the air therefrom, and a passage 18 for supplying outdoor air to the other gas flow channels 4a and a passage 19 for discharging the air therefrom.

[0030] The heat exchange element 5 is expendable and is replaced with a new one as necessary. At this time, the heat exchange element, which is elastically deformable in the direction of superposition, may easily be detached from and attached to an element mounting portion of heat exchanger 14. An old heat exchange element 5 replaced is discarded.

[0031] Having described one embodiment hereinbefore, this invention allows two or more, i.e. a desired number, as necessary, of first and second hollow resin spacers 2a and 2b to be selected for the heat exchange segment 1.

[0032] The second hollow resin spacers 2b, apart from the arrangement in the direction (X-direction in the figure) perpendicular to the longitudinal direction (Y-direction in the figure) of the first hollow resin spacers 2a, may be arranged in a non-perpendicular direction as in a rhombic heat exchange segment, for example. In other words, the second hollow resin spacers may be arranged in a direction crossing the longitudinal direction (Y-direction in the figure) of the first hollow resin spacers 2a, depending on the shape of the heat exchange segment seen in plan view.

[0033] Apart from obtaining the first and second hollow resin spacers 2a and 2b of compressed elliptical shape by deforming commercially available circular PP straws or PET straws, the first and second hollow resin spacer 2a and 2b of compressed elliptical shape may be molded by other methods. In this case, CaO powder or $CaCO_3$ powder may be mixed into a molding material to improve fire resistance, adhesive property and strength. Adhesive property may be improved by mixing CaO powder or $CaCO_3$ powder since powder such as CaO powder or $CaCO_3$ powder can roughen the surfaces.

[0034] These exchange segments 1 may have any shape in plan view, such as square, rectangular, rhombic or the like. The heat exchange sheets 3a, 3b and 3c may be formed of other materials than the paper impregnated with calcium chloride. The dimensions of the compressed elliptical shape may be varied as appropriate.

[0035] In addition, the heat exchange sheets 3a and 3b are secured (usually bonded) to the first hollow resin spacers 2a of compressed elliptical shape, preferably as shown in Figs. 5 and 6.

[0036] Fig. 5 shows one end of each of the heat exchange sheets 3a and 3b secured only to a flat portion of a first hollow resin spacer 2a of compressed elliptical shape (the other end not shown being secured likewise). Fig. 6 shows one end of each of the heat exchange sheets 3a and 3b secured to a flat portion and an r-portion of a first hollow resin spacer 2a of compressed elliptical shape (the other end not shown being secured likewise). Instead of dividing into the heat exchange sheets 3a and 3b, one heat exchange sheet may be wrapped on and bonded to the first hollow resin spacers 2a.

[0037] The construction noted above in which the opposite ends of the heat exchange sheets 3a and 3b are completely secured to the first hollow resin spacers 2a can eliminate the drawbacks of the opposite ends of the heat exchange sheets 3a and 3b not being completely secured (the ends of the heat exchange sheets 3a and 3b being secured only to the flat portions and not secured to the r-portions as shown in Fig. 5, for example). Such drawbacks are that, where the heat exchange segments are superposed, the free ends of the sheets not secured become obstructive to gas currents to lower heat exchange performance, or the free ends of the sheets flap to generate an unpleasant sound (noise). It is thus preferable to secure the opposite ends of heat exchange sheets 3a and 3b completely.

[0038] The former (Fig. 5) is advantageous from the viewpoint of reducing the amount of use of heat exchange sheets 3a and 3b. However, the latter (Fig. 6) is advantageous in securing (usually bonding) strength.

Second Embodiment

[0039] As in the first embodiment, a heat exchange element 5 in the second embodiment is formed by superposing heat exchange segments 1. Further, in the second embodiment, as shown in Fig. 7, heat exchange sheets 3a and 3b constituting each heat exchange segment 1 have emboss patterns formed thereon. That is, the lower heat exchange sheet 3a has embosses 25a formed in a predetermined pattern thereon (see Fig. 10). The upper heat exchange sheet 3b has embosses 25b formed in a predetermined pattern thereon (see Fig. 9).

[0040] Consequently, the heat exchange sheets 3a and 3b have a further reinforced rigidity and are difficult to deform. Where a heat exchange is effected between gases supplied to gas flow channels 4a and 4b shown in Fig. 8, a situation in which the lower heat exchange sheets 3a and heat exchange sheets 3b are deformed to approach and contact one another is prevented substantially completely.

[0041] The heat exchange sheets 3a and 3b have increased surface areas for contacting the gases undergoing the heat exchange. As indicated by arrows in Figs. 9, 10 and 12, the gases may be caused to flow as divided or meandering in the gas flow channels 4a and 4b, thereby extending flow paths. As a multiplier effect of these, an improvement is made in heat transfer and moisture transfer properties.

[0042] Assuming that, in Fig. 11, the lower heat exchange sheet 3a and upper heat exchange sheet 3b have a spacing G therebetween, the embosses 25a and 25b have a height H in a range of at least 0.3G up to 0.7G. However, where necessary, the range may be at least 0.3G to less than 1.0G.

[0043] The embosses 25a and 25b divide the gas currents in the flow channels into branching or meandering gas currents and up and down gas currents flowing over the embosses (see Fig. 12), resulting in varied flow velocities and directions to generate turbulence in the flow channels. This breaks boundary layers caused by laminar flows occurring with flat paper.

[0044] Consequently, efficient counter currents are formed in the flow channels by various combinations of perpendicular currents along the gas flow channels 4a and 4b, branching or meandering currents, and up and down currents. This further improves the heat transfer and moisture transfer properties.

[0045] As in the first embodiment, the heat exchange segments 1 are superposed by securing the heat exchange segments 1 to one another with a suitable adhesive or adhesive tape.

[0046] Thus, the heat exchange element 5 of layer structure is obtained easily as seen in Fig. 8 showing a perspective view thereof. A heat exchange sheet 3c not having embosses formed thereon is bonded to the uppermost heat exchange segment 1.

[0047] As in the first embodiment, the heat exchange element 5, with the emboss patterns formed, is used in an air-conditioning and ventilating fan apparatus 12 attached to an outer wall 11 of an office or the like. The shape of heat exchange segment 1, securing of heat exchange sheets 3a and 3b to the first hollow resin spacers 2a and other aspects are the same as in the first embodiment. Further, apart from the above-noted aspects of the second embodiment, the following aspects may be cited regarding emboss pattern forms and emboss arrangements.

[0048] The embosses 25a on the lower heat exchange sheet 3a and the embosses 25b on the upper heat exchange sheet 3b may be formed in predetermined patterns as necessary. Fig. 13 and 14 show other patterns of embosses 25a. The embosses 25b also may be formed in the same patterns, but their phase may be shifted or the direction of the pattern may be varied.

[0049] The embosses 25a and 25b may have any shape in vertical section such as circular or truncated cone shaped, and any shape in plan such as point-shaped, linear, dashed or cross-shaped. The heat exchange sheets 3a, 3b and 3c may have uneven surfaces with a crepe (gathering) in creases.

[0050] The embosses 25a and 25b may be formed on opposite surfaces of both or one of the lower heat exchange sheet 3a and upper heat exchange sheet 3b as necessary. Further, where the embosses 25a are formed on opposite surfaces of the lower heat exchange sheet 3a, the upper heat exchange sheet 3b may have no embosses if such are not needed.

[0051] In other words, regarding the pattern shape and arrangement of the embosses, a relationship should be maintained in which the same patterns do not overlap in the direction of superposition of the segments. Thus, the patterns may be shifted in phase or varied in direction to avoid a state as shown in Fig. 15.

[0052] Fig. 16 shows gas currents through a location without the embosses 25a and 25b. Fig. 17 shows gas currents through a location with the embosses 25a and 25b. (Though embosses 25b are not shown in Fig. 17, the same currents occur where the embosses 25b are formed.) It will be understood that the latter has an advantage over the former in that turbulence can break boundary layers that lower heat transfer and material transfer performance.

Third Embodiment

[0053] As in the first embodiment and second embodiment, a heat exchange element 5 in the third embodiment is formed by superposing heat exchange segments 1. As in the second embodiment, as shown in Fig. 7, heat exchange sheets 3a and 3b constituting the heat exchange segment 1 have emboss patterns formed thereon.

[0054] The first hollow resin spacers 2a have an r surface-to-surface dimension La equal to that (La) of the second hollow resin spacers 2b. In the third embodiment, the second hollow resin spacers 2b have a flat surface-to-surface dimension Lb 1.2 to 1.3 times as large as that (Lb) of the first hollow resin spacers 2a.

[0055] The second hollow resin spacers 2b may, for example, have a 5.0mm r surface-to-surface dimension La, a 2.0mm flat surface-to-surface dimension Lb, a 0.1mm thickness, and a 171mm total length. The first hollow resin spacers 2a may, for example, have a 5.0mm r surface-to-surface dimension La, a 1.6mm flat surface-to-surface dimension Lb, a 0.1mm thickness, and a 171mm total length.

[0056] As in the first embodiment, the heat exchange segments 1 are secured to one another by using a suitable adhesive or adhesive tape.

[0057] Thus, the heat exchange element 5 of layer structure is obtained easily as seen in Fig. 8 showing a perspective view thereof. A heat exchange sheet 3c not having embosses formed thereon is bonded to the uppermost heat exchange segment 1. This heat exchange element 5 defines gas flow channels 4a having a smaller opening area, and gas flow channels 4b having a larger opening area.

[0058] That is, the gas flow channels 4a and gas flow channels 4b have the same horizontal dimension but, as shown in Fig. 18, the dimension Ga in the direction of height of gas flow channels 4b (Z-direction) is larger than the dimension Gb in the direction of height of gas flow channels 4a (Z-direction). This effects an excellent heat exchange where an inflow resistance of one gas (e.g. gas A) and an outflow resistance of the other gas (e.g. gas B) are in an unbalanced relationship.

[0059] Specifically, Fig. 19 illustrates a heat exchange between gas A (outdoor air) flows in from outside partitioned by an outer wall 11 and gas B (indoor air) discharged outdoors from the room. Air is free under atmospheric pressure with no outdoor obstruction, and only a small resistance is applied to the inflow of outdoor air. On the other hand, a larger resistance is applied to the outflow of indoor air, depending on a room size, a spatial relationship with adjoining rooms, an airtight condition, and opening and closing of doors. Gas B (indoor air) flows through the gas flow channels 4b of heat exchange element 5 having the larger opening area than the gas flow channels 4a through which gas A (outdoor air) flows. Consequently, a heat exchange is performed while maintaining a pressure loss difference ΔP not exceeding 3Pa.

[0060] The illustrated air-conditioning and ventilating fan apparatus has an exhaust fan 15a, a suction fan 15b, a filter 26 and heat exchange element 5 replaceably attached to a support 27 mounted in a casing 13.

[0061] In this case, the dimensions Ga and Gb in the direction of height of gas flow channels 4a and 4b are appropriately adjusted by a compression applied in Z-direction by an appropriate device not shown. Consequently, Ga and Gb become smaller than Lb, but such an adjustment is possible since the first and second hollow resin spacers 2a and 2b are elastic.

[0062] Since the flat surface-to-surface dimension Lb of the first hollow resin spacers 2a is different from the flat surface-to-surface dimension Lb of the second hollow resin spacers 2b, the dimensions Ga and Gb in the direction of height of gas flow channels 4a and 4b do not become equal (Ga=Gb) even when the heat exchange element 5 is compressed in Z-direction. The size difference between the two remains fixed.

[0063] The above construction has the relationship of Ga>Gb. A relation of Ga<Gb may be adopted as necessary, that is the flat surface-to-surface dimension Lb of the first hollow resin spacers 2a may be made larger than the flat surface-to-surface dimension Lb of the second hollow resin spacers 2b. This construction also effects an excellent heat exchange where an inflow resistance of one gas and an outflow resistance of the other gas are in an unbalanced relationship.

[0064] The difference is provided in the flat surface-to-surface dimension Lb, rather than the r surface-to-surface dimension La between the first and second hollow resin spacers 2a and 2b. This is because a difference provided in the r surface-to-surface dimension La would result in different widths of adhesive application for securing the heat exchange sheets 3a and 3b, and hence an imbalance in sheet adhesion to lower heat transfer and moisture penetration capabilities.

[0065] It is preferable to form the embosses 25a and 25b, but these may be omitted where they are unnecessary. The embosses may have any shape in vertical section such as circular or truncated cone shaped, and any shape in plan such as point-shaped, linear, dashed or cross-shaped. Their patterns may be any patterns. The heat exchange sheets 3a, 3b and 3c may have uneven surfaces with a crepe (gathering) in creases.

[0066] The shape of heat exchange segment 1, securing of heat exchange sheets 3a and 3b to the first hollow resin spacers 2a and other aspects are the same as in the first and second embodiments.

INDUSTRIAL UTILITY

[0067] Thus, the gas-to-gas heat exchange element according to this invention is suitable for installation in an air-conditioning and ventilating fan apparatus used in a house, office or the like.

Claims

1. A gas-to-gas heat exchange element comprising a superposition of heat exchange segments each having a plurality of hollow resin spacers secured at predetermined intervals to either surfaces of heat exchange sheets, wherein

said hollow resin spacers have a compressed elliptical shape, and arranged with flat portions thereof contacting said heat exchange sheets.

2. A gas-to-gas heat exchange element as defined in claim 1, wherein said hollow resin spacers include first hollow resin spacers and second hollow resin spacers, a plurality of said first hollow resin spacers being secured at predetermined intervals to the heat exchange sheets to form gas flow channels opening in one direction only longitudinally of said first hollow resin spacers, a plurality of said second hollow resin spacers extending in a direction crossing a longitudinal direction of said first hollow resin spacers and secured at predetermined intervals to the heat exchange sheets.

3. A gas-to-gas heat exchange element as defined in claim 2, wherein said first hollow resin spacers have a dimension between flat surfaces of the compressed elliptical shape different from a dimension between flat surfaces of the compressed elliptical shape of said second hollow resin spacers.

4. A gas-to-gas heat exchange element as defined in claim 1, wherein said hollow resin spacers include first hollow resin spacers and second hollow resin spacers, a plurality of said first hollow resin spacers being secured at predetermined intervals to the heat exchange sheets to form gas flow channels opening in one direction only longitudinally of said first hollow resin spacers, a plurality of said second hollow resin spacers extending in a direction perpendicular to a longitudinal direction of said first hollow resin spacers and secured at predetermined intervals to the heat exchange sheets.

5. A gas-to-gas heat exchange element as defined in claim 4, wherein said first hollow resin spacers have a dimension between flat surfaces of the compressed elliptical shape different from a dimension between flat surfaces of the compressed elliptical shape of said second hollow resin spacers.

6. A gas-to-gas heat exchange element as defined in claim 1, wherein said heat exchange sheets have patterns of embosses formed thereon.

7. A gas-to-gas heat exchange element as defined in claim 6, wherein said embosses have a height H in a range of at least 0.3G to less than 1.0G where G is a spacing between the lower heat exchange sheet and the upper heat exchange sheet.

8. A gas-to-gas heat exchange element as defined in claim 1, wherein one end of each of said heat exchange sheets is secured only to a flat portion of one of said hollow resin spacers.

9. A gas-to-gas heat exchange element as defined in claim 1, wherein one end of each of said heat exchange sheets is secured to a flat portion and a curved portion of one of said hollow resin spacers.

10. A gas-to-gas heat exchange element as defined in claim 1, wherein said heat exchange sheets are formed of a paper material having heat transfer property, moisture permeability and fire resistance.

11. A gas-to-gas heat exchange element as defined in claim 1, wherein said heat exchange sheets are formed of paper impregnated with calcium chloride.

12. A gas-to-gas heat exchange element as defined in claim 1, wherein said gas-to-gas heat exchange element is formed by inserting a superposition of said heat exchange segments between supports including lower pinch lugs and upper pinch lugs.

13. A gas-to-gas heat exchange element as defined in claim 1, wherein said hollow resin spacers are formed with CaO powder or $CaCO_3$ powder mixed therein.

Fig.1

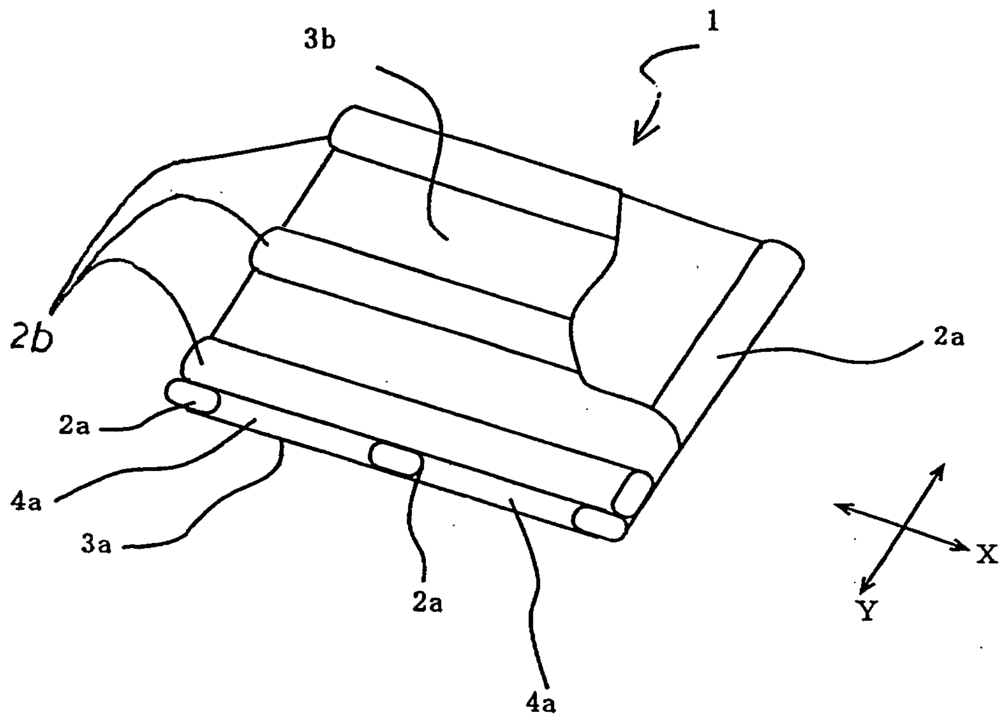


Fig.2

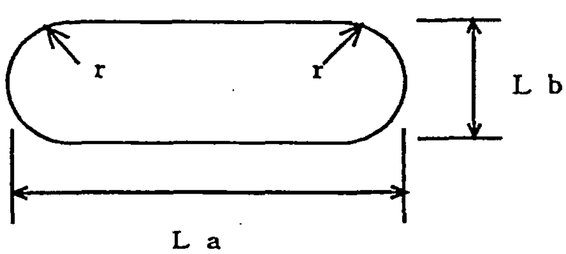


Fig.3

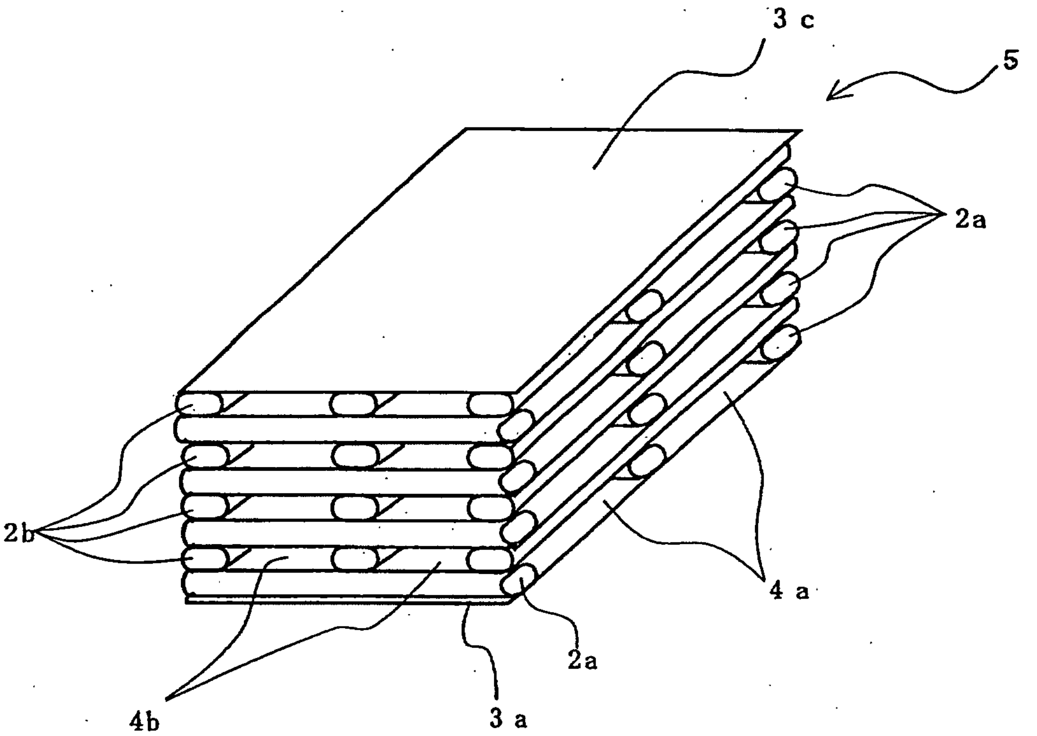


Fig.4

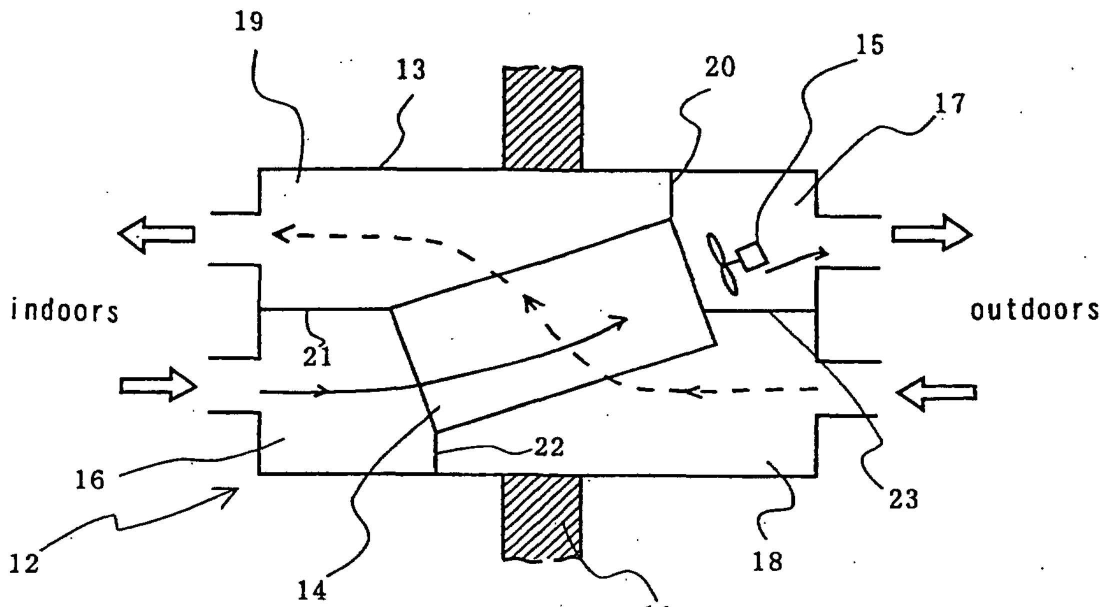


Fig.5

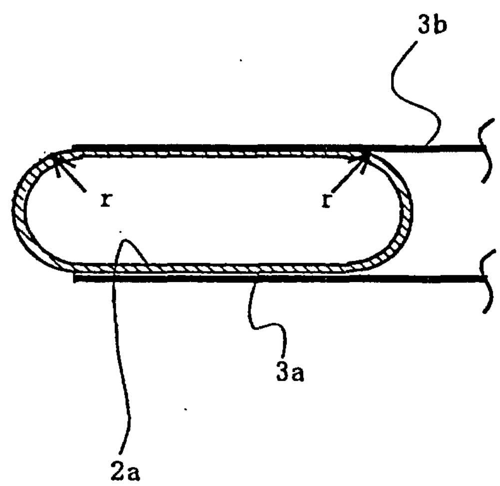


Fig.6

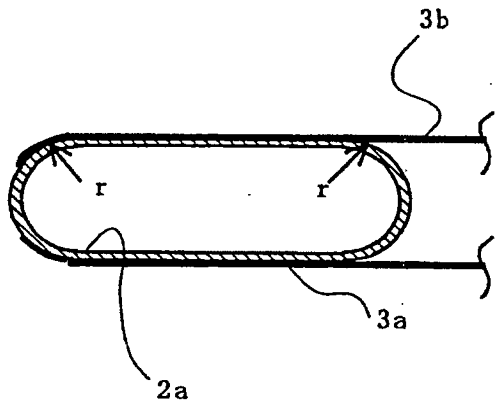


Fig.7

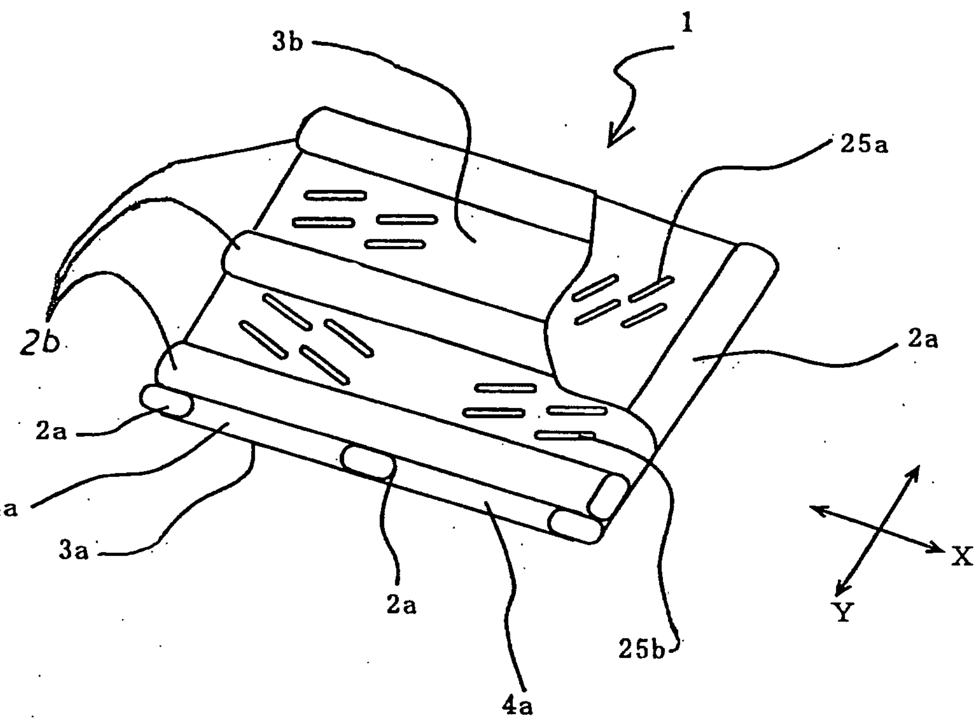


Fig.8

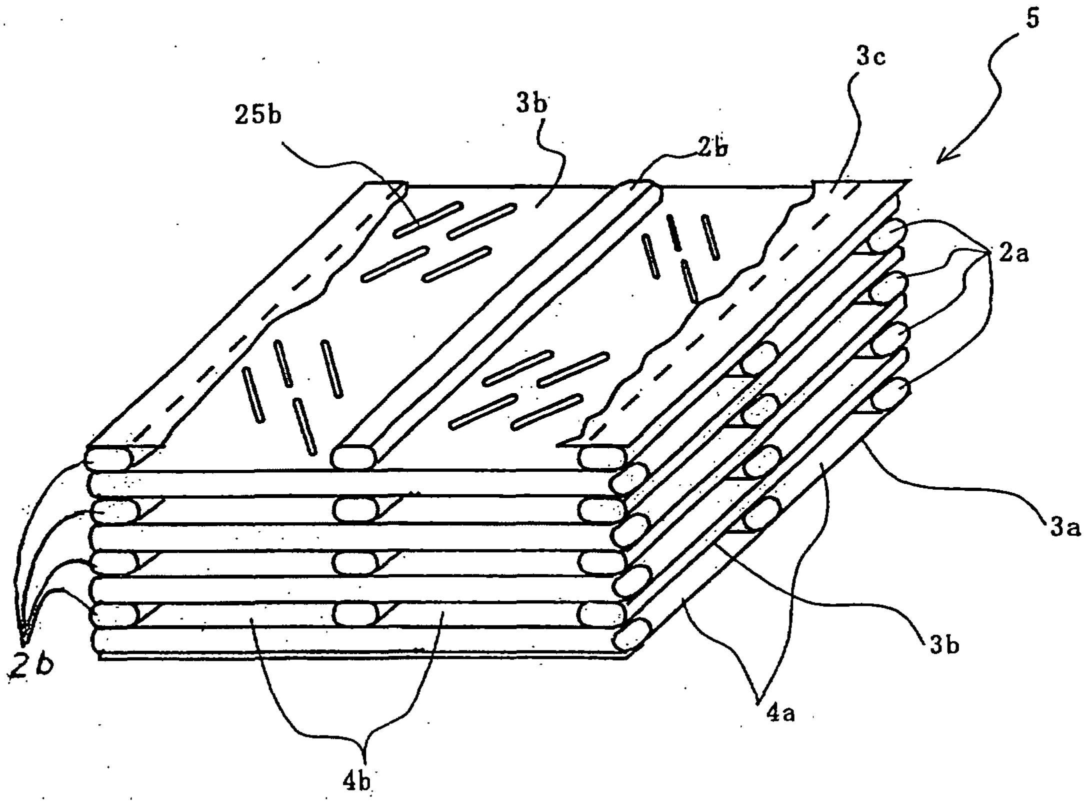


Fig.9

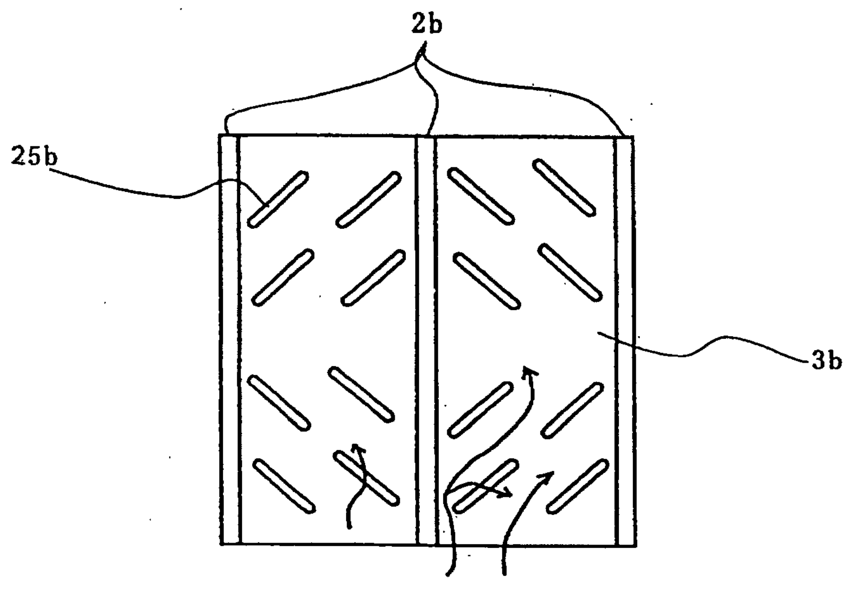


Fig.10

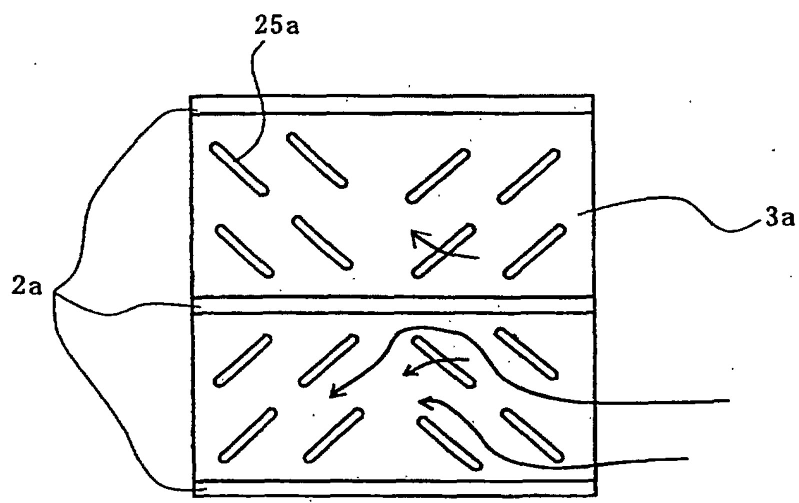


Fig.11

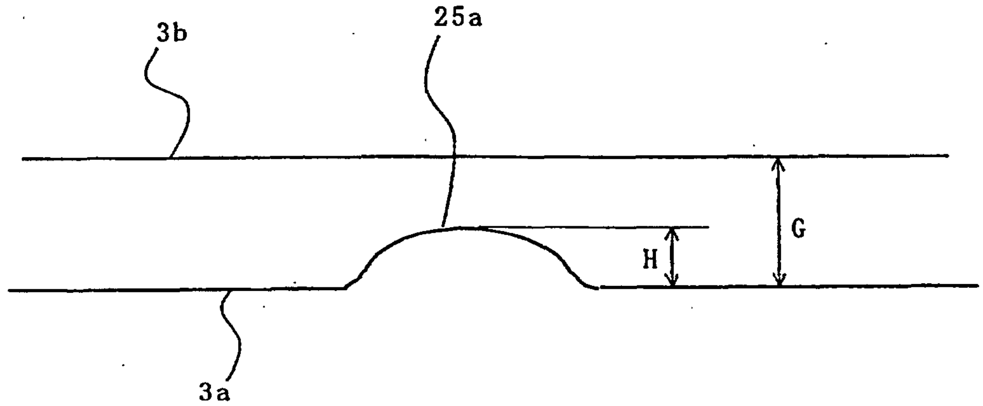


Fig.12

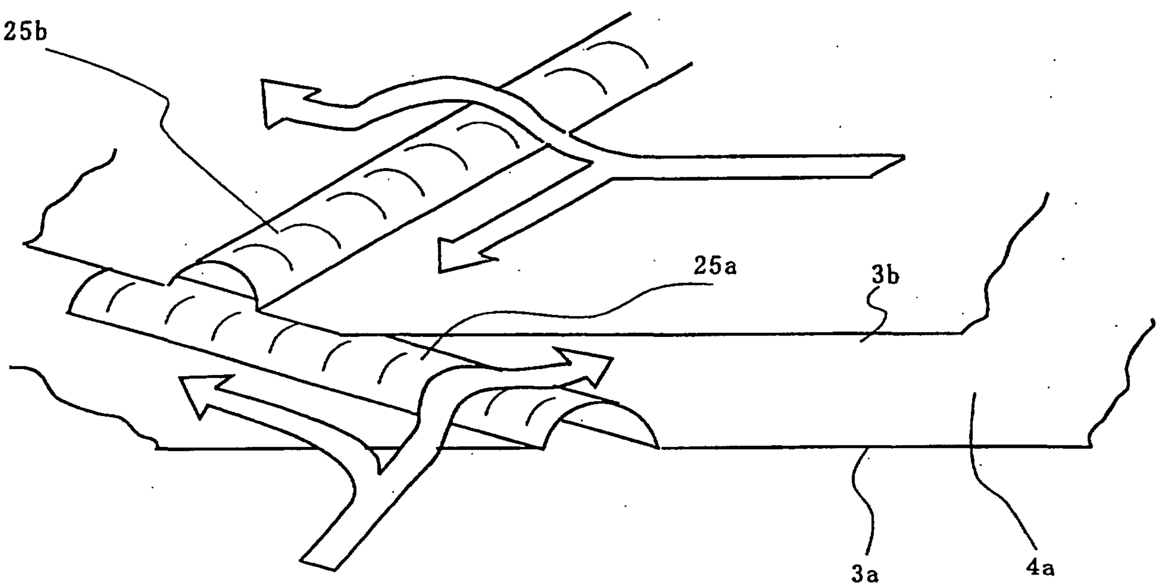


Fig.13

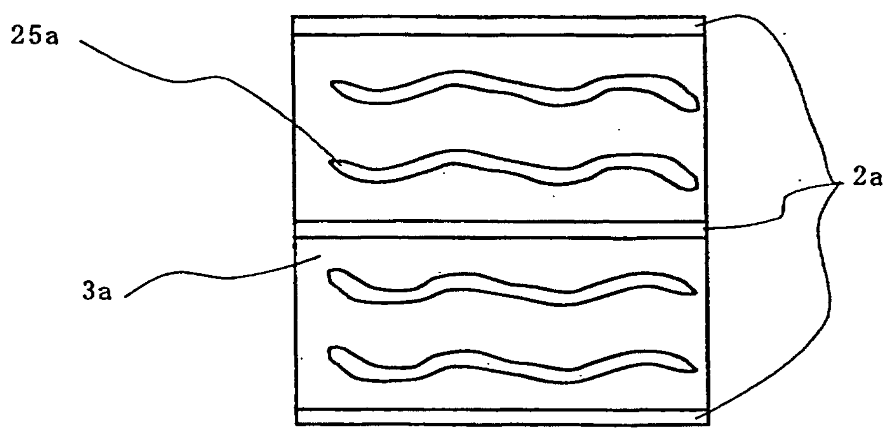


Fig.14

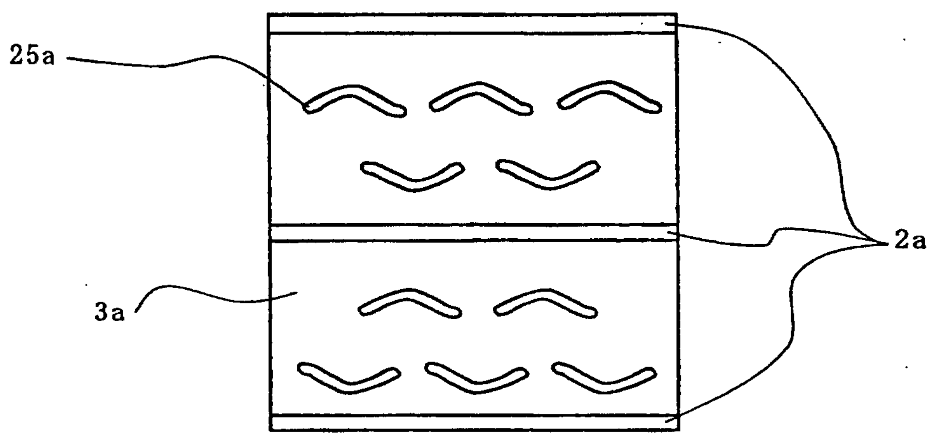


Fig.15

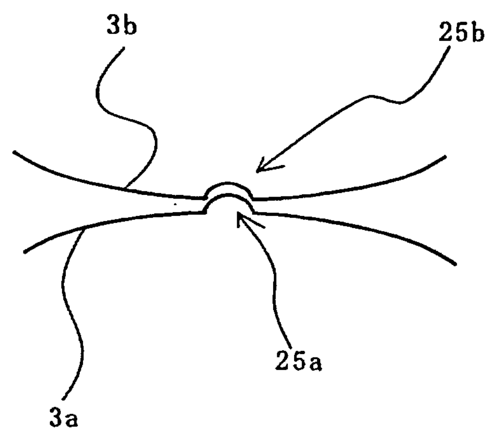


Fig.16

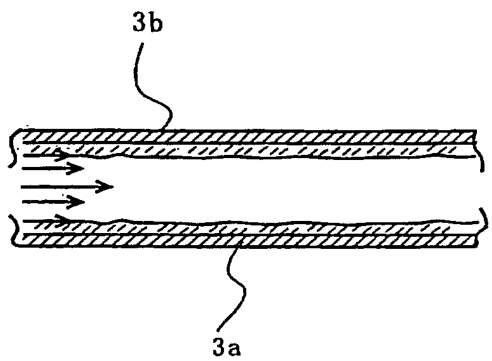


Fig.17

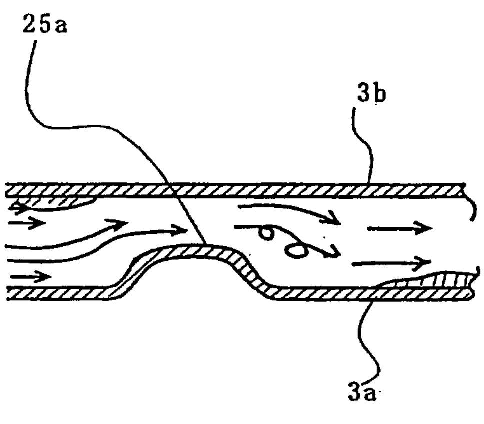


Fig.18

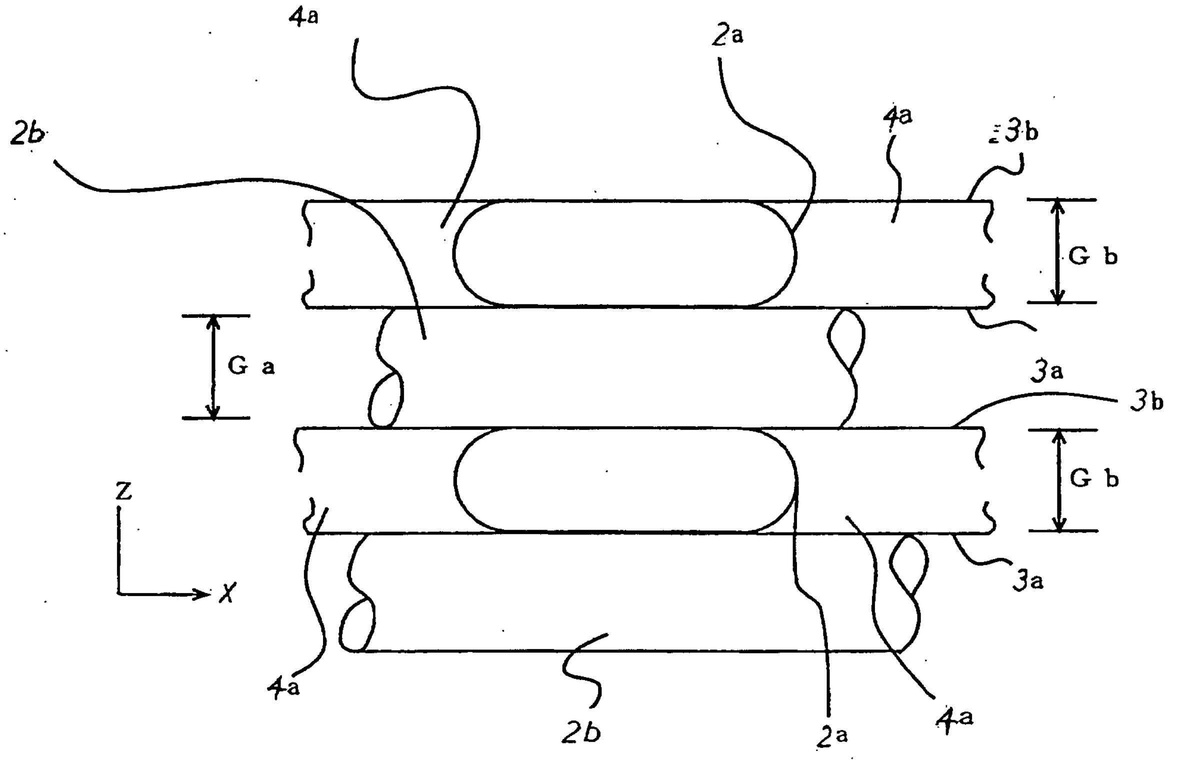
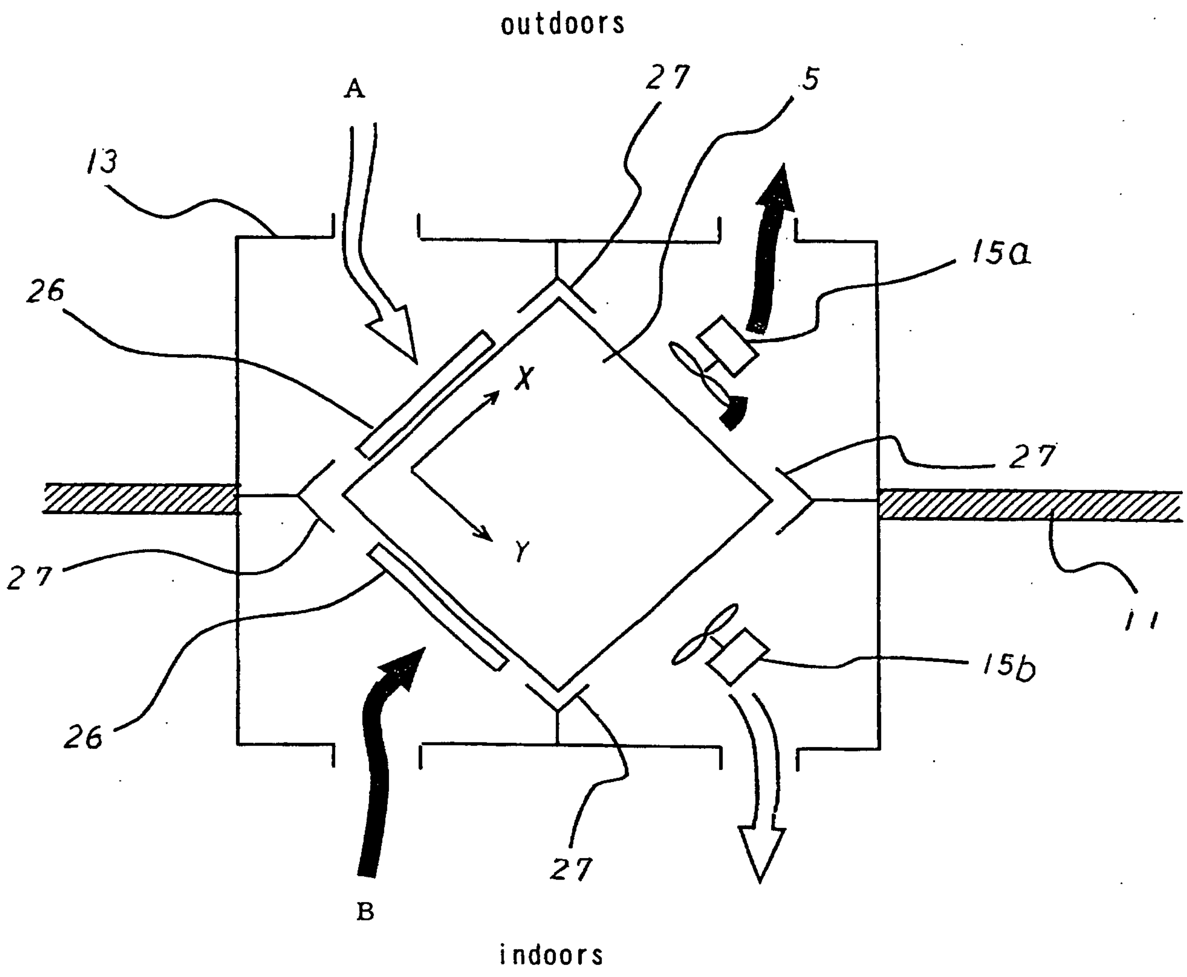


Fig.19



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/06127

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F28F3/08, F28F3/10, F28D9/00

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] F28F3/08, F28F3/10, F28D9/00

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.
Y A	JP, 7-103681, A (Sekisui Plastics Co., Ltd.), 18 April, 1995 (18.04.95) (Family: none)	1-12 13
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No.132465/1978 (Laid-open No.51427/1980) (Kobe Steel, Ltd.), 04 April, 1980 (04.04.80), especially, Fig. 7 (Family: none)	1-12
Y	JP, 5-5597, A (Showa Aluminum Corporation), 14 January, 1993 (14.01.93) (Family: none)	3,5
Y	JP, 2-29430, Y2 (Sumitomo Seimitsu Kogyo K.K.), 07 August, 1990 (07.08.90) (Family: none)	3,5
Y	JP, 7-22618, Y2 (Iwai Kikai Kogyo K.K.), 24 May, 1995 (24.05.95) (Family: none)	3,5
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No.87339/1985 (Laid-open No.204185/1986)	6,7

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

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Date of the actual completion of the international search	Date of mailing of the international search report
04 December, 2000 (04.12.00)	12 December, 2000 (12.12.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/06127

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	JP, 61-29696, A (FANUC LTD), 10 February, 1986 (10.02.86) (Family: none)	6,7
Y A	JP, 2960603, B2 (Toshiba Corporation), 30 July, 1999 (30.07.99) (Family: none)	9 1-8,10-13
Y	JP, 6-109395, A (ABB GADELIUS K.K.), 19 April, 1994 (19.04.94) (Family: none)	10,11
Y A	JP, 11-108409, A (Daikin Industries, Ltd.), 23 April, 1999 (23.04.99) (Family: none)	10 13
Y A	JP, 53-34663, B2 (Mitsubishi Electric Corporation), 21 September, 1978 (21.09.78) (Family: none)	10,11 13
Y A	JP, 6-101988, A (Toshiba Corporation), 12 April, 1994 (12.04.94) (Family: none)	12 1-11,13
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No.52869/1990 (Laid-open No.17279/1992) (Ishikawajima-Harima Heavy Industries Co., Ltd.), 13 February, 1992 (13.02.92) (Family: none)	13
A	JP, 4-81718, B2 (Mitsubishi Electric Corporation), 24 December, 1992 (24.12.92) (Family: none)	1-13

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