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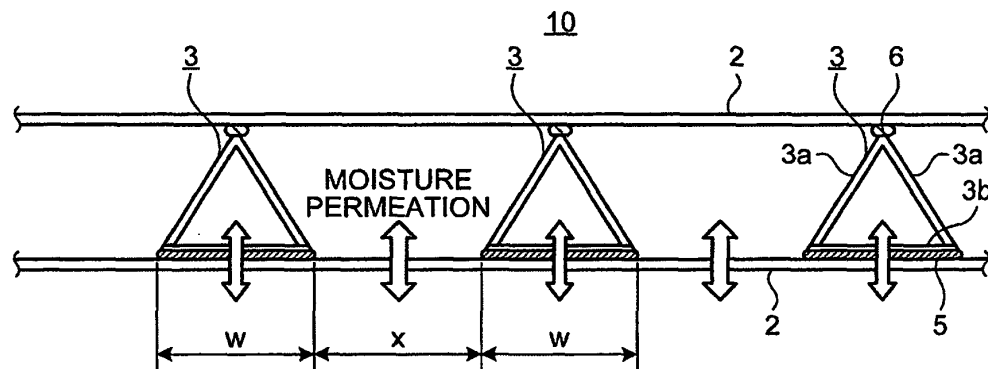
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(54) TOTAL ENTHALPY HEAT EXCHANGE ELEMENT

(57) In a total heat exchange element, unit components (10) each including a partition member (2) and spacers (3) are laminated with directions of the unit components alternately changed, flow passages, spaces among which are retained by the spaces (3), are formed among the partition members (2), two kinds of fluids are caused to pass through the flow passages adjacent to each other, and heat exchange is performed between the two kinds of fluids via the partition members (2). The partition member (2) has a heat transfer property, moisture permeability, and a gas blocking property. The spacer

(3) is formed in a hollow cylindrical shape polygonal in section extending substantially in parallel along the surface of the partition member (2) and includes an overlapping wall (3b) that overlaps the partition member and supporting walls (3a) that rise from side ends of the overlapping wall (3b) and are vertically provided between the partition members (2) respectively being upper and lower parts in a laminating direction to retain a space between the partition members (2). The overlapping wall (3b) has thickness smaller than that of the supporting walls (3a) and stuck to the partition member (2) with an adhesive (5) having moisture permeability.

FIG.2



Description

Field

[0001] The present invention relates to a total heat exchange element of a plate laminated type that performs total heat exchange between two fluids in different states, and, more particularly to a total heat exchange element incorporated in a ventilator or an air conditioner and suitably applied as a total heat exchange element that performs air-to-air total heat exchange.

Background

[0002] A heat exchange element of a plate laminated type is widely used because the heat exchange element has a large heat transfer area per unit volume and can perform highly efficient heat exchange with a relatively small size. In particular, in the field of air conditioning and ventilating apparatuses, a material having not only a heat transfer property but also a gas blocking property and moisture permeability is used for partition members that partition two fluids that should be subjected to heat exchange, whereby the partition members are used as a total heat exchange element. In the past, as the heat exchange element of this type, a heat exchange element of a cross-flow structure to which corrugation machining is applied is well known (see, for example, Patent Literature 1).

[0003] However, in such a cross-flow structure to which the corrugation machining is applied, there is a problem in that corrugated spacers that retain a space between the partition members function as an enlarged heat transfer surface (a fin) and, at the same time, increase the ventilation resistance of the element. As the heat exchange element of this type, there is also a heat exchange element in which an area ratio of a space plate to a heat transfer plate is set small and ventilation resistance is reduced without changing heat exchange efficiency (see, for example, Patent Literature 2).

[0004] However, even in such a case, the spacers reduce an area of a flow of fluid (in the field of air conditioning and ventilating apparatuses, the fluid is mainly the air). Therefore, there is also a heat exchange element in which, as means for further reducing ventilation resistance, the spacers are made hollow to further reduce the ventilation resistance of the element (e.g., Patent Literatures 3 to 6).

[0005] Although such a structure is excellent in a reduction of ventilation resistance, there are many problems in manufacturing and mass production of the heat exchange element. A reason for this is as explained below. First of all, in the case of spacers having a circular hollow section, an equivalent diameter, which is a parameter affecting ventilation resistance, is maximized when the height of one layer is fixed, a contact area with partition members is small, and moisture permeability of the partition members is prevented little. Therefore, a best effect can be expected. However, in press molding described in Patent Literature 4, die cutting cannot be performed. Practically, a member having a circular hollow sectional shape needs to be manufactured one by one, placed on a partition members, and bonded. Therefore, labor and time are required. Further, because the shape is circular, positioning is extremely difficult in the work and machining properties are extremely poor.

[0006] Therefore, although the equivalent diameter is slightly reduced, when easiness of machining is taken into account, spacers having a triangular or rectangular hollow section are excellent because press molding is possible and positioning is easy. However, as a problem of the shapes, a contact area with the partition members is large compared with the circular shape. Therefore, although heat transfer is not hindered, moisture permeation of the partition members is prevented and a moisture permeation area of the partition members is reduced. As a result, compared with other elements having the same number of laminated layers, humidity/total heat exchange efficiency is deteriorated.

Citation List

Patent Literature

[0007]

Patent Literature 1: Japanese Patent Application Laid-open No. H04-24492
 Patent Literature 2: Japanese Patent Application Laid-open No. H03-113292
 Patent Literature 3: Japanese Utility Model No. S62-45583
 Patent Literature 4: Japanese Patent No. 3414012
 Patent Literature 5: Japanese Patent Application Laid-open No. 2005-140362
 Patent Literature 6: Japanese Patent Application Laid-open No. 2001-147092
 Patent Literature 7: Japanese Patent Application Laid-open No. 2007-315649
 Patent Literature 8: International Publication No. 2008/041327

Summary

Technical Problem

5 **[0008]** As solutions to the problem in the use of the manufacturable hollow spacers having the triangular or rectangular section, a method of using an adhesive having moisture permeability was proposed in the past (e.g., Patent Literatures 7 and 8). According to this method, partition members functioning as media for moisture exchange of a total heat exchange element and spacers used for retaining a space between the partition members are bonded with a water solvent adhesive containing a water-soluble moisture absorbent (e.g., vinyl acetate resin emulsion adhesive). Consequently, it is possible to prevent moisture exchange efficiency from being deteriorated. The deterioration is caused in the following manner that the water-soluble moisture absorbent added to the partition members comes into contact with moisture of the water solvent adhesive and dissolves and diffuses, flows out from the partition members to a portion to which moisture of the water solvent adhesive and the spacers penetrate, and an amount of the water-soluble moisture absorbent in the partition members decreases. Furthermore, because a bonded surface also has moisture permeability compared with that before the moisture absorbent addition, a portion that has conventionally been a non-moisture permeation surface can be regarded as a moisture permeation area. As a result, it was found that high performance of an element could be expected because a moisture permeation area of the entire element increased.

10 **[0009]** However, in a manufacturing process for the element, for a reduction in drying unevenness, a reduction in an energy amount in use in a drying process due to improvement of energy efficiency, and the like, if it was attempted to perform dielectric drying often used in drying of a water solvent adhesive, a problem was found in that electrodes caused short-circuit, making drying impossible.

15 **[0010]** Concerning a cause of this trouble in the dielectric drying process, as a result of earnestly performing investigation, it was found that the element itself changed to a conductor because of application of an adhesive containing a large amount of the moisture absorbent to the element and the withstanding voltage of the element fell and caused short-circuit. Therefore, this problem needs to be solved to obtain a total heat exchange element that can obtain low ventilation resistance and high moisture exchange efficiency.

20 **[0011]** The present invention has been devised in view of the above and it is an object of the present invention to provide a total heat exchange element that can show an equivalent effect even if an amount of use of a water-soluble moisture absorbent added to an adhesive or coated on or impregnated in partition members is reduced and therefore can be stably manufactured while preventing, for example, a trouble in a dielectric drying process due to use of a large amount of the adhesive.

Solution to Problem

35 **[0012]** To solve the above problems and achieve an object, there is provided a total heat exchange element according to the present invention in which unit components each including a partition member and spacers are laminated with directions of the unit components alternately changed, flow passages, spaces among which are retained by the spacers, are formed among the partition members, two kinds of fluids are caused to pass through the flow passages adjacent to each other, and heat exchange is performed between the two kinds of fluids via the partition members, wherein the partition member has a heat transfer property, moisture permeability, and a gas blocking property, the spacer is formed in a hollow cylindrical shape polygonal in section extending substantially in parallel along a surface of the partition member, and includes an overlapping wall that overlaps the partition member and supporting walls that rise from side ends of the overlapping wall and are vertically provided between the partition members respectively being upper and lower parts in a laminating direction to retain a space between the partition members, and the overlapping wall has thickness smaller than that of the supporting walls and stuck to the partition member with a first adhesive having moisture permeability.

40 **[0013]** There is also provided a total heat exchange element according to the present invention, wherein the spacer is formed in a hollow space triangular in section formed by a singularity of the overlapping wall and a pair of the supporting walls, and the spacers are arranged at a space with which an equivalent diameter d_{e1} of a cross section of a flow passage in the spacer and an equivalent diameter d_{e2} of a cross section of a flow passage formed by the spacers adjacent to each other and the partition members respectively being upper and lower parts in the laminating direction satisfy a relation $1.6 \leq d_{e2}/d_{e1} < 2$.

Advantageous Effects of Invention

55 **[0014]** In the total heat exchange element according to the present invention, the material thinner than the supporting walls is used for the overlapping wall of the spacer having the hollow shape bonded to the partition member. Therefore, an amount of a moisture absorbent necessary for obtaining the same moisture exchange efficiency decreases. Even if

an amount of use of a water-soluble moisture absorbent added to an adhesive or originally coated on or impregnated in the partition member is reduced, the total heat exchange element can show equivalent effects. Consequently, it is possible to stably manufacture the element while preventing the afore mentioned problems, for example, a trouble in a dielectric drying process due to use of a large amount of the adhesive. Because an amount of use of the adhesive can be reduced, energy necessary for drying of the adhesive decreases. This contributes to energy saving in a manufacturing process and resource saving. Further, there is also an effect that a more inexpensive element can be provided.

[0015] In the total heat exchange element according to the present invention, because the arrangement interval of the spacers on the partition members is secured to the maximum, a bonding area per unit volume of the element decreases. Therefore, an amount of use of a moisture permeable adhesive in use decreases. However, an effect of reduction of ventilation resistance by the hollow spacers decreases and is meaningless if the arrangement interval is secured too large. Therefore, both of a reduction in ventilation resistance and possibility of performing a dielectric drying process are realized only when the spaces are arranged at an optimum interval on the partition members. An input of a hydraulic power apparatus of a machine in which the element is incorporated can be reduced by reducing the ventilation resistance. This contributes to energy saving of the machine. Further, because the dielectric drying process is possible, energy saving of a manufacturing process, resource saving, and manufacturing of an inexpensive element are possible.

Brief Description of Drawings

[0016]

FIG. 1 is a perspective view of a total heat exchange element according to a first embodiment of the present invention.

FIG. 2 is a sectional view showing the configuration of a unit component included in the total heat exchange element.

FIG. 3 is a perspective view of a spacer.

FIG. 4 is a perspective view of an intermediate product formed by coupling spacers and a state of one spacer separated from the intermediate product.

FIG. 5 is a structure schematic diagram of a one-side corrugated board processing machine for manufacturing the intermediate product of the spacers.

FIG. 6 is a perspective view of a roll coater that applies an adhesive to the spacer.

FIG. 7 is a sectional view for explaining a relation between the thickness of a sheet used for the spacers and a flow passage area.

Description of Embodiments

[0017] Embodiments of a total heat exchange element according to the present invention are explained in detail below based on the drawing. The present invention is not limited by the embodiments.

First Embodiment

[0018] FIG. 1 is a perspective view of a total heat exchange element according to a first embodiment of the present invention. A total heat exchange element 50 is configured by laminating a plurality of unit components 10 while changing the direction of each of the unit components 10 by 90 degrees. One unit component 10 includes partition members 2 and hollow cylindrical spacers 3 triangular in section arranged in parallel and fixedly attached to the principal planes of the partition members 2. The spacers 3 retain a space between two partition members 2 adjacent to each other in a laminating direction and form a flow passage between the two partition members 2. A plurality of the flow passages are alternately formed in the laminating direction with the direction of each of the flow passages changed by 90 degrees. As indicated by arrows in FIG. 1, two kinds of fluids (e.g., gas such as the air) are caused to pass through the flow passages from different directions to perform total heat exchange between the two kinds of fluids via the partition members 2.

[0019] FIG. 2 is a sectional view of the configuration of the unit component 10 included in the total heat exchange element 50. FIG. 3 is a perspective view of the spacer 3. The partition members 2 are made of a material having a heat transfer property, moisture permeability, and a gas blocking property. The spacer 3 is formed in a hollow cylindrical shape triangular in section extending substantially in parallel along the surfaces of the partition members 2. Among three wall surfaces forming the hollow cylindrical shape triangular in section of the spacer 3, one wall surface forms an overlapping wall 3b that overlaps and is fixedly attached to the partition member 2. The remaining two wall surfaces form supporting walls 3a that rise from side ends of the overlapping wall 3b to be vertically provided between two partition members 2 respectively being upper and lower parts in the laminating direction and retain a space between the two partition members 2. In this embodiment, the two supporting walls 3a are manufactured by folding a sheet-like material into two. The folded supporting walls 3a and the overlapping wall 3b are fixedly attached with an adhesive (a third

adhesive) 7 applied to side portions thereof and form the cylindrical spacer 3 (FIG. 3). The spacer 3 is fixed by sticking the overlapping wall 3b to the partition member 2 with an adhesive having moisture permeability (a first adhesive) 5. As a characteristic of this embodiment, the thickness of the overlapping wall 3b of the spacer 3 is smaller than the thickness of the supporting walls 3a. Two unit components 10 overlapping in the laminating direction are laminated and bonded by fixedly attaching, with an adhesive (a second adhesive), the top (a bent portion of the supporting walls 3a) of the hollow cylindrical spacer 3 triangular in section and the rear surface of the partition member 2 of another unit component 10 adjacent on the upper side in the laminating direction.

[0020] The spacer 3 according to this embodiment is formed in the hollow cylindrical shape triangular in section formed by the one overlapping wall 3b and the two supporting walls 3a. However, the shape of the spacer 3 is not limited to such a sectional triangular shape. The shape of the spacer 3 only has to be a hollow cylindrical shape polygonal in section including the overlapping wall 3b and the supporting walls 3a. For example, the shape of the spacer 3 can be a hollow cylindrical shape square in section formed by an opposed pair of overlapping walls 3b and an opposed pair of supporting walls 3a.

[0021] There are various methods in manufacturing the hollow spacer 3. An example of the methods is explained below. FIG. 4 is a perspective view of an intermediate product formed by coupling the spacers 3 and a state of one spacer 3 separated from the intermediate product. FIG. 5 is a structure schematic diagram of a one-side corrugated board processing machine for manufacturing the intermediate product of the spacers. An intermediate product of a coupled body shown in FIG. 4 obtained by coupling a large number of the hollow spacers 3 sideways in a lateral direction is manufactured from a sheet-like material to be formed as the supporting walls 3a of the spacers 3 and a sheet-like material to be formed as the overlapping wall 3b (having thickness smaller than that of the sheet-like material to be formed as the supporting walls 3a) using a one-side processing machine shown in FIG. 5 used in general in manufacturing a single-faced corrugated fiberboard for packaging. This intermediate product is separated as appropriate along peaks to obtain the hollow spacers 3. In that case, the shape of the supporting walls 3a is a corrugated shape. However, the spacer 3 is generally manufactured in a hollow shape triangular in section. The corrugated supporting walls 3a are molded by gears h1 and h2, the adhesive 7 is applied to the supporting walls 3a by a roller r1, and the overlapping wall 3b is stuck to the supporting walls 3a by a roller r2. In the triangle of the spacer 3 manufactured using the general machine for manufacturing of corrugated boards in this way, a ratio of the height t to the width w of the bottom side is about 0.3 to 0.5 (FIG. 4). When the spacer 3 is manufactured using the general machine for manufacturing of corrugated boards in this way, it is possible to easily manufacture the spacer 3 in which the thickness of the overlapping wall 3b is smaller than the thickness of the supporting walls 3a, which is the characteristic of this embodiment.

[0022] The adhesive 5 having moisture permeability is applied to the overlapping wall 3b of the hollow spacer 3 manufactured as explained above to bond the spacer 3 to the partition members 2. A brush or the like can be used for the application of the adhesive 5. However, there is concern that, if fluctuation occurs in an adhesive application amount, a drying time is not fixed and manufacturing efficiency is deteriorated. Therefore, it is desirable to manage the application amount and reduce the fluctuation. For that purpose, for example, it is desirable to uniformly apply the adhesive 5 to the overlapping wall 3b of the spacer 3 using a roll coater or the like and place the overlapping wall 3b on the partition member 2 and bond the overlapping wall 3b to the partition member 2. FIG. 6 is a perspective view of the roll coater for applying the adhesive 5 to the spacer 3. A roller R rotates, whereby the adhesive 5 stored in a reservoir is uniformly applied to the rear surface of the overlapping wall 3b of the spacer 3. An example in which the coupled intermediate product is cut and then moisture permeable adhesive 5 is applied is explained above. However, a procedure for first applying the adhesive 5 to the overlapping walls 3b of the coupled spacers 3 and then separating the spacers 3 before bonding the spacers 3 to the partition member 2 can be adopted.

[0023] As the adhesive 5 having moisture permeability used for bonding of the partition members 2 and the spacers 3, for example, an adhesive obtained by mixing any one of water-soluble deliquescent alkali metal salt and deliquescent alkali earth metal salt or a mixture thereof in a water-based solvent resin emulsion adhesive is used. Lithium chloride, calcium chloride, or the like having strong moisture absorption is mainly used in a total heat exchange element for air conditioning. In other adhesives, the effect can be expected as long as the adhesives have moisture permeability. However, in an adhesive containing a water-soluble moisture absorbent, in addition to moisture permeability of the adhesive itself, when the adhesive is applied to the spacer 3, the moisture absorbent quickly penetrates to the spacer 3 itself together with water. Therefore, it is possible to improve moisture permeability of a material itself on the spacer 3 side, and moisture permeability of a bonded portion tends to develop.

[0024] Concerning the partition member 2, there is no limitation on the material and the configuration thereof as long as the heat transfer property, the gas blocking property, and the moisture permeability are concurrently satisfied. In general, for a total heat exchange element, special processed paper imparted with the gas blocking property and the moisture permeability by mixing water-soluble resin or a water-soluble moisture absorbent therein, a material obtained by adding a moisture absorbent to special processed paper substantially not having a hole for air circulation by using well-beaten wood pulp, and a material obtained by sticking porous woven fabric, nonwoven fabric, or the like to a resin thin film in which resin itself has moisture permeability are known. In some case, condensation occurs on the inside of

the element depending on a usage environment condition according to a temperature change during heat exchange. If the condensation drips to the outside, the condensation causes various product failures. Therefore, the material is desirably water absorptive.

[0025] Concerning a material of the supporting walls 3a of the hollow spacer 3 not in contact with the partition members 2, the material plays a role of retaining a space between the partition members 2. Therefore, a material that is deformed as little as possible is desirable. Concerning bending rigidity of a sheet-like material, when the material is considered an elastic member, it is known that, in general, the bending rigidity is proportional to a cube of the thickness in a bending direction. In that regard, a material having large thickness is suitable. However, if the material is too thick, an area of a hollow portion of the spacer 3 decreases (a spacer shown on the right of FIG. 7). This is against a reduction in the ventilation resistance of the element, which is the original purpose of the use of the spacer 3. Therefore, the thickness of the material is suitably about 60 micrometers to 200 micrometers.

[0026] Concerning the overlapping wall 3b of the hollow spacer 3, a material that prevents the heat transfer property and the moisture permeability of the partition members 2 as little as possible is desirable. The gas blocking property for preventing gas transfer between the circulating two fluids is already secured by the partition members 2 and is not necessary for the overlapping wall 3b. Therefore, the material is desirably rather a porous material because circulation of humidity is not prevented. Therefore, in this embodiment, an adhesive having moisture permeability is used to realize, for example, a reduction in moisture permeation resistance between the material and the partition members 2 and, in the case of an adhesive including a water-soluble moisture absorbent, a reduction in the moisture permeation resistance of the material itself due to penetration of the moisture absorbent. Therefore, it is desirable to add a large amount of the water-soluble moisture absorbent or the like. However, if the adhesive is added by a large amount, the insulation resistance of the element itself falls and the element could substantially change to a conductor because of the influence of a large amount of moisture of the adhesive and impurities (if the moisture absorbent is added, the moisture absorbent itself). When the water-soluble adhesive is dried, dielectric drying is mainly used because of high energy efficiency, little unevenness in a large area, and the like. However, when an object to be dried is a conductor, a circuit is short-circuited and the object cannot be dried. Then, other means such as drying by air heating has to be considered. However, such means is undesirable because energy efficiency is low and energy consumption in a manufacturing process is dramatically increased. Therefore, to reduce a necessary amount of the adhesive, it is desirable to use a material as thin as possible in a portion of the hollow spacer 3 in contact with the partition members 2.

[0027] There is no specific limitation on the adhesive 7 (the third adhesive) used in sticking the supporting walls 3a and the overlapping wall 3b together to manufacture the hollow spacer 3. However, when an adhesive containing a water-soluble moisture absorbent is used for bonding of the spacer 3 and the partition member 2 as a moisture permeable adhesive, if an adhesive not allowing moisture to penetrate after drying is used as the adhesive 7 used for sticking the supporting walls 3a and the overlapping wall 3b together to manufacture the spacer 3, it is possible to prevent moisture and the moisture absorbent itself from penetrating to the supporting walls 3a of the spacer 3 not in contact with the partition member 2 when the moisture permeable adhesive is applied. Therefore, it is possible to diffuse the moisture absorbent only to the partition member 2 and the overlapping wall 3b of the spacer 3 in contact with the partition member 2 where the moisture absorbent is actually necessary. This is more desirable because unnecessary addition of the moisture absorbent can be prevented.

[0028] There is no limitation on the adhesive (the second adhesive) 6 used in, after bonding the hollow spacer 3 and the partition member 2, laminating and bonding the spacer 3 and the partition member 2 while rotating the same by 90 degrees. However, by using the adhesive having moisture permeability explained above, there is an effect of improving moisture permeability to be higher than before in a portion to be laminated and bonded. However, if an amount of the moisture absorbent of the entire element is increased too much, dielectric drying cannot be performed. Therefore, it is necessary to reduce to adjust an amount of the moisture absorbent added to other portions (e.g., the partition member 2 and the adhesive having moisture permeability used in bonding the partition member 2 and the spacer 3).

Example 1

[0029] Examples based on the first embodiment are explained below. As the partition member 2, a sheet was used that was obtained by impregnating about 8 g/m² of water-soluble and deliquescent lithium chloride as a moisture absorbent in special processed paper (having basis weight of about 40 g/m² and thickness of about 50 micrometers) devised to secure Gurley ventilation resistance in JIS P8117, which served as a scale of the gas blocking property, equal to or higher than 200 seconds by a method of, for example, sufficiently beating pulp. As a material of the supporting walls (corrugated) 3a of the hollow spacer 3 not in contact with the partition member, general white single-glazed high-quality paper (having basis weight of about 80 g/m² and thickness of 100 micrometers) was used. As a material of the overlapping wall 3b in contact with the partition member 2, porous special processed paper containing wood pulp, hemp pulp, or the like as a main material and having basis weight of about 20 g/m², thickness of about 30 micrometers, and Gurley ventilation resistance equal to or lower than 20 seconds was used. About 15 g/m² of water-based vinyl acetate

resin emulsion (having a solid content ratio of about 15%) was applied to the adhesive 7 and the special processed paper was bonded using the one-side processing machine shown in FIG. 5. The special processed paper was processed into a shape of one spacer 3 having the width w (FIG. 4) of about 4.3 millimeters and the height t (FIG. 4) of about 1.8 millimeters. After obtaining the hollow spacer 3, as the adhesive 5 having moisture permeability, about 25 g/m² of an adhesive having a solid content ratio of about 28% obtained by mixing about 10% of lithium chloride (LiCl) in a vinyl acetate resin emulsion adhesive, which contains water as a main solvent, as a water-soluble moisture absorbent was applied to the portion of the overlapping wall 3b made of the thin material. The overlapping wall 3b was bonded to the partition member 2. When the spacer 3 was bonded to the partition member 2, the spacers 3 were arranged and bonded such that, when a dimension of the spacer 3 in a direction horizontal to the partition member 2 was represented as width w , a space x (FIG. 2) between the spacers 3 adjacent to each other on the partition member 2 was equal to the width w . Water-based vinyl acetate resin emulsion was applied to the tops of the spacers 3 on the unit component 10 formed in this way using a roll coater. A plurality of the unit components 10 were laminated and bonded while rotating each of the unit components 10 by 90 degrees. The entire element was dried by a dielectric drying apparatus and manufactured.

Comparative Example 1

[0030] In a comparative example 1, as materials of the partition member 2 and the spacer 3, materials same as those in the example 1 were used. The spacer 3 was formed in an external shape same as that in the example 1 and solid rather than hollow. That is, from the configuration of the example 1, the spacer 3 was changed to a spacer that had the same external shape and was solid rather than hollow. As all the adhesives, adhesives not having moisture permeability were used.

Comparative Example 2

[0031] In a comparative example 2, from the configuration of the example 1, the arrangement interval of the hollow spacers 3 was changed to 0.5 w .

Comparative Example 3

[0032] In a comparative example 3, from the configuration of the comparative example 2, the spacer 3 was changed to a spacer that had the same external shape and was solid rather than hollow. As all the adhesives, adhesives not having moisture permeability were used.

Example 2

[0033] In an example 2, from the configuration of the example 1, the arrangement interval of the hollow spacers 3 was changed to 2 w .

Comparative Example 4

[0034] In a comparative example 4, from the configuration of the example 2, the spacer 3 was changed to a spacer that had the same external shape and was solid rather than hollow. As all the adhesives, adhesives not having moisture permeability were used.

Example 3

[0035] In an example 3, from the configuration of the example 1, the arrangement interval of the hollow spacers 3 was changed to 3 w .

Comparative Example 5

[0036] In a comparative example 5, from the configuration of the example 3, the spacer 3 was changed to a spacer that had the same external shape and was solid rather than hollow. As all the adhesives, adhesives not having moisture permeability were used.

Comparative Example 6

[0037] In a comparative example 6, from the configuration of the example 3, the arrangement interval of the hollow

spacers 3 was changed to 4w.

Comparative Example 7

[0038] In a comparative example 7, from the configuration of the comparative example 6, the spacer 3 was changed to a spacer that had the same external shape and was solid rather than hollow. As all the adhesives, adhesives not having moisture permeability were used. Comparative Example 8

[0039] In a comparative example 8, a material same as (having the same thickness as) the supporting walls 3a in the portion not in contact with the partition member 2 was used for the overlapping wall 3b of the hollow spacer 3 in contact with the partition member 2. To obtain the equivalent moisture exchange efficiency, an amount of the moisture absorbent added to the adhesive 5 used for bonding of the spacer 3 and the partition member 2 was increased by a weight increase ratio of the paper of the overlapping wall 3b. Otherwise, the configuration in the comparative example 8 was the same as the configuration in the example 1.

Example 4

[0040] In an example 4, the adhesive having moisture permeability was used for the adhesive 6 for lamination and bonding as well. Instead, to set an amount of the moisture absorbent of the entire element same as that in the example 1, an amount of a moisture absorbing material added to the adhesive 5 used for bonding of the spacer 3 and the partition member 2 was reduced. Otherwise, shapes and materials are the same as those in the example 1. Reference Example

[0041] As a reference example, the hollow spacers 3 having an external dimension and formed of a material same as those of the example 1 were arranged without a space. In other words, the arrangement interval of the hollow spacers 3 was set to 0. This means that this configuration has spacers of a general corrugated fin shape in the past.

[0042]

Table 1

	Distance X between spacers	Spacer shape	Dielectric drying possibility	Moisture exchange efficiency	Ventilation resistance	De2/ de1
Example 1	w	Hollow triangle	△	52%	74 Pa	1.6
Comparative Example 1	w	Solid triangle	○	35%	89 Pa	-
Comparative Example 2	0.5w	Hollow triangle	×	Unavailable		
Comparative Example 3	0.5w	Solid triangle	○	30%	108 Pa -	
Example 2 Example 2	2w	Hollow triangle	○	54%	66 Pa	1.8
Comparative Example 4	2w	Solid triangle	◎	38%	73 Pa	-
Example 3	3w	Hollow triangle	○	54%	62 Pa	1.9
Comparative Example 5	3w	Solid triangle	◎	45%	66 Pa	-
Comparative Example 6	4w	Hollow triangle	◎	56%	60 Pa	2.0
Comparative Example 7	4w	Solid triangle	◎	51%	62 Pa	-
Comparative Example 8	w	Hollow triangle	×	Unavailable		
Example 4	w	Hollow	△	53%	74 Pa	1.6

(continued)

	Distance X between spacers	Spacer shape	Dielectric drying possibility	Moisture exchange efficiency	Ventilation resistance	De2/ de1
Reference Example	0	Hollow triangle	-	53%	112 Pa	-

[0043] Dielectric drying possibility during manufacturing of the elements obtained in the examples and the comparative examples and the moisture exchange efficiency and the ventilation resistance of the elements are summarized in Table 1. According to the table, in the examples 1 to 3 in which the adhesive having moisture permeability is used for the hollow spacers 3, compared with the other comparative examples, the dielectric drying is possible if the space is equal to or larger than w. The element has lower ventilation resistance and higher efficiency than those of the element including the solid spacers having the same external shape. Irrespective of whether the spacers 3 are hollow or solid, the ventilation resistance falls as the space between the spacers 3 is increased. However, because a degree of the fall is different, there is little difference in the ventilation resistance between hollow and solid (a difference is smaller than 5%) when the distance between the spacers 3 is increased to 4w. This is because an equivalent diameter de2 of a flow passage formed between the spacers 3 is large with respect to an equivalent diameter de1 of the spacers 3 and, therefore, the air does not substantially flow to the flow passage in the spacers 3. Therefore, the meaning of hollow is lost if the spacers 3 are further separated. It is seen from this that a ratio de2/de1 of de1 and de2 is desirably in a range of a value equal to or larger than 1.6 and smaller than 2.

[0044] As in the comparative example 8, when a thick material was used for the contact surface of the space regaining member 3 with the partition member 2, drying was not able to be performed because an amount of the moisture absorbent increases. However, when the amount of the moisture absorbent was suppressed using a relatively thin material as in the example 1, the dielectric drying property was improved and machining was able to be performed.

[0045] As it is seen when the example 1 and the example 4 are compared, although the amounts of the moisture absorbent are substantially the same, the moisture exchange efficiency of the example 4 is slightly improved. This is because the moisture absorbent was added to the lamination side as well and therefore the moisture absorbent easily penetrated to the lamination side adhesive and the paper in the bonded portion and moisture permeability was improved.

Industrial Applicability

[0046] The present invention can be applied to various forms in the total heat exchange element and effects can be expected. Concerning uses, besides an apparatus used for ventilation of a building, the total heat exchange element is optimum for a heat exchange ventilator that performs, for example, ventilation in a movable body such as an automobile or a train. Besides, the total heat exchange element is suitable for apparatuses in various fields that make use of total heat exchange for simultaneously exchanging latent heat and sensible heat.

Reference Signs List

[0047]

- 2 PARTITION MEMBER
- 3 SPACER
- 3a SUPPORTING WALLS OF THE SPACER
- 3b OVERLAPPING WALL OF THE SPACER
- 5 ADHESIVE (FIRST ADHESIVE)
- 6 ADHESIVE (SECOND ADHESIVE)
- 7 ADHESIVE (THIRD ADHESIVE)
- 10 UNIT COMPONENT
- 50 TOTAL HEAT EXCHANGE ELEMENT

Claims

1. A total heat exchange element in which unit components each including a partition member and spacers are laminated with directions of the unit components alternately changed, flow passages, spaces among which are retained by

the spacers, are formed among the partition members, two kinds of fluids are caused to pass through the flow passages adjacent to each other, and heat exchange is performed between the two kinds of fluids via the partition members, wherein

the partition member has a heat transfer property, moisture permeability, and a gas blocking property,

the spacer is formed in a hollow cylindrical shape polygonal in section extending substantially in parallel along a surface of the partition member, and includes an overlapping wall that overlaps the partition member and supporting walls that rise from side ends of the overlapping wall and are vertically provided between the partition members respectively being upper and lower parts in a laminating direction to retain a space between the partition members, and

the overlapping wall has thickness smaller than that of the supporting walls and stuck to the partition member with a first adhesive having moisture permeability.

2. The total heat exchange element according to claim 1, wherein the spacer is formed in a hollow space triangular in section formed by a singularity of the overlapping wall and a pair of the supporting walls, and the spacers are arranged at a space with which an equivalent diameter d_{e1} of a cross section of a flow passage in the spacer and an equivalent diameter d_{e2} of a cross section of a flow passage formed by the spacers adjacent to each other and the partition members respectively being upper and lower parts in the laminating direction satisfy a relation $1.6 \leq d_{e2}/d_{e1} < 2$.
3. The total heat exchange element according to claim 2, wherein an adhesive having moisture permeability is used as an adhesive for laminating and bonding the unit components, the adhesive being a second adhesive for bonding a top of the hollow cylindrical spacer triangular in section and the partition member of the adjacent unit component in the laminating direction.
4. The total heat exchange element according to claim 3, wherein a material having a liquid absorption property is used as a material of the partition member and the spacer, and an adhesive obtained by mixing a water-soluble moisture absorbent in a resin emulsion adhesive containing water as a main solvent is used as the first adhesive and the second adhesive.
5. The total heat exchange element according to claim 4, wherein any one of deliquescent alkali metal salt and deliquescent alkali earth metal salt or a mixture thereof is used as the water-soluble moisture absorbent.
6. The total heat exchange element according to claim 1, wherein an adhesive that substantially loses moisture permeability after completion of bonding is used as a third adhesive for bonding the supporting walls and the overlapping wall.

FIG.1

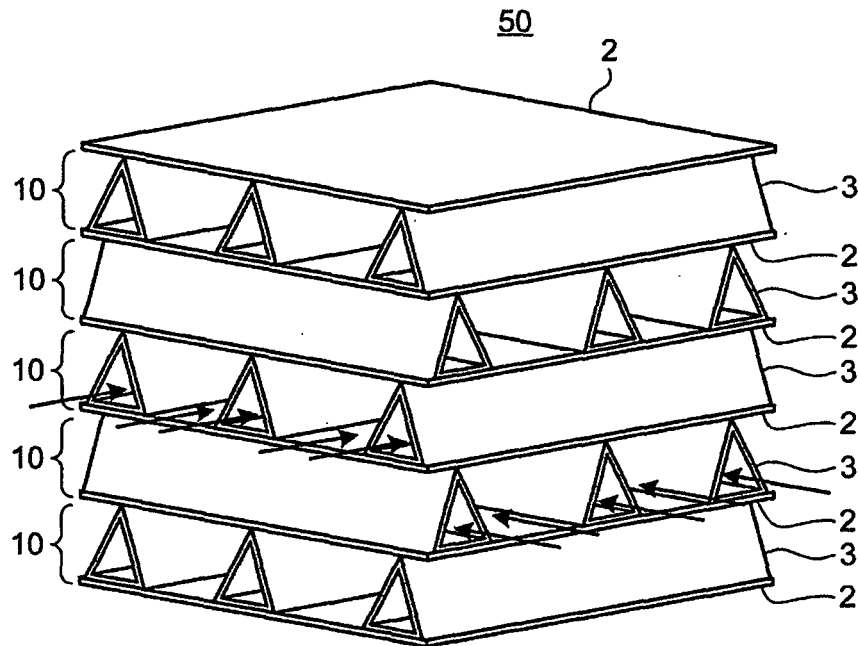


FIG.2

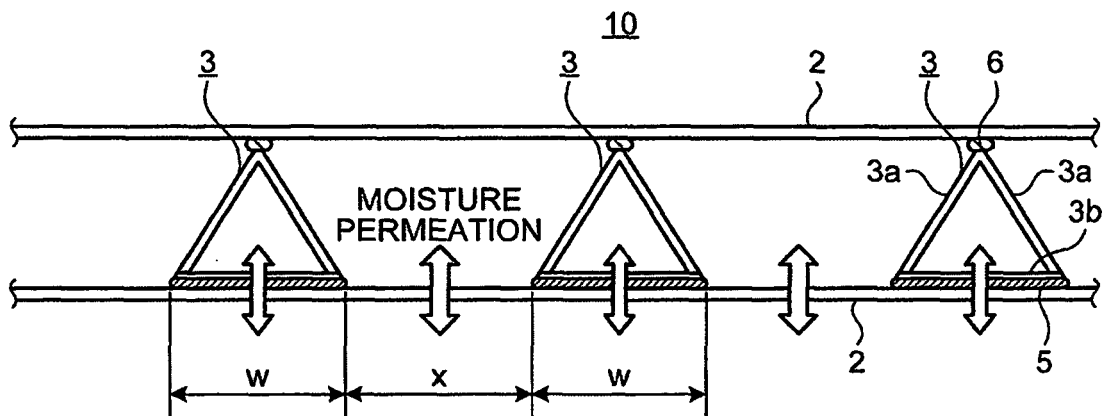


FIG.3

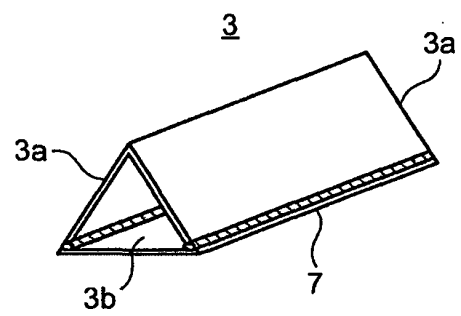


FIG.4

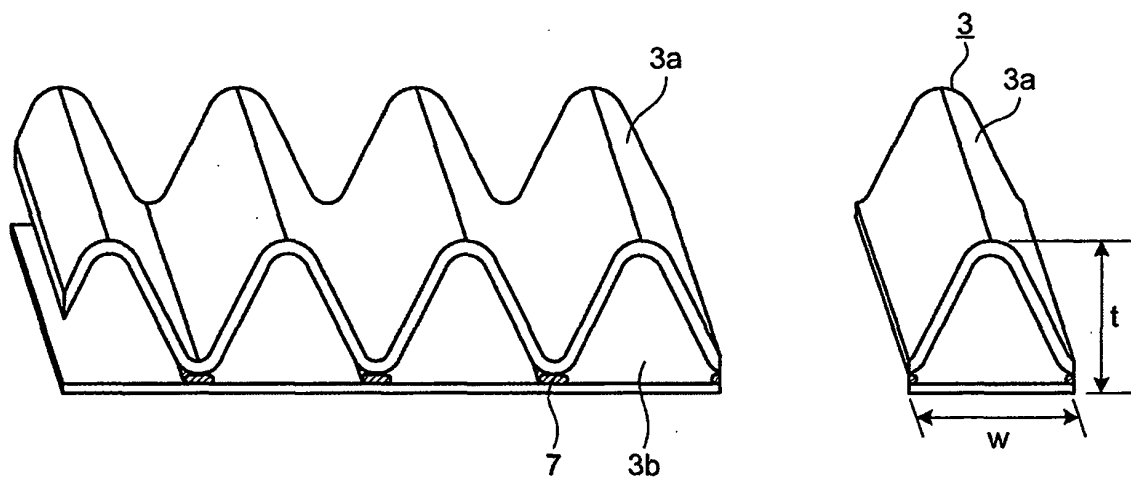


FIG.5

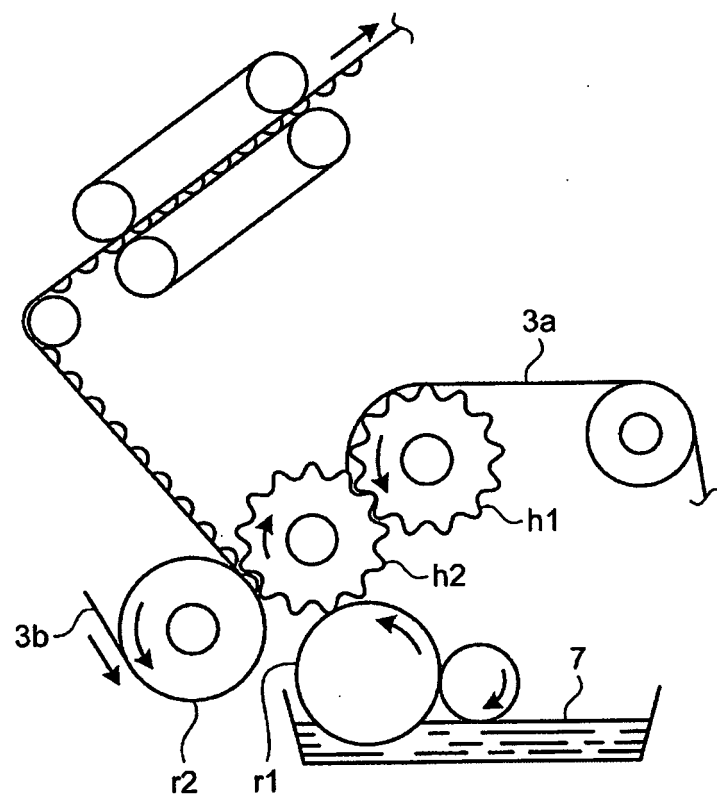


FIG.6

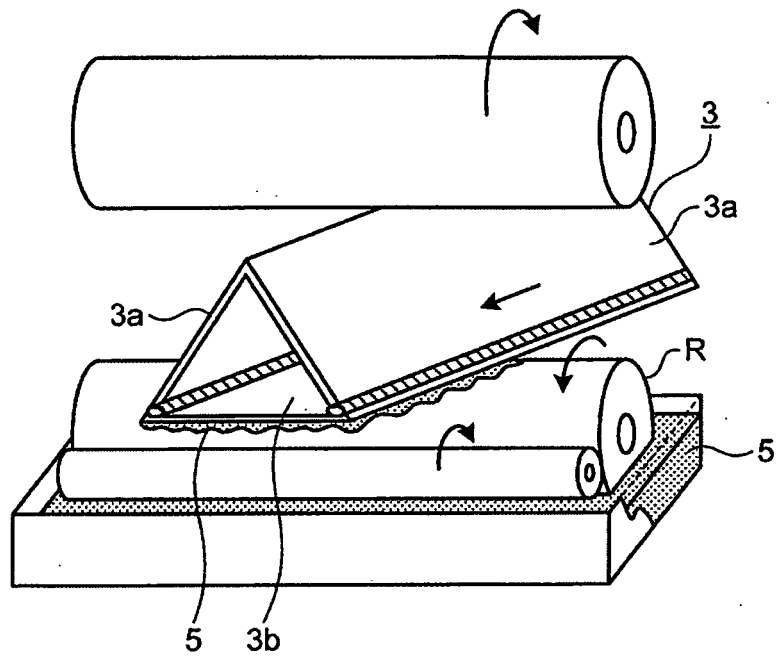
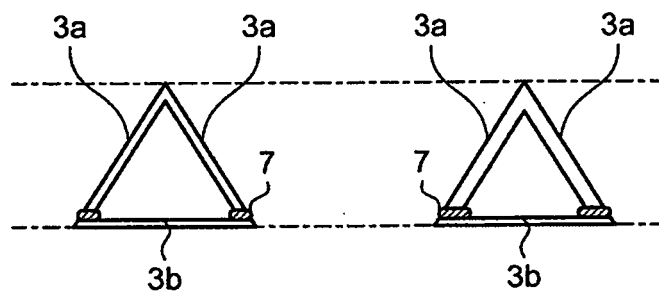


FIG.7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/066163

A. CLASSIFICATION OF SUBJECT MATTER

F28F3/08 (2006.01) i, F28F3/06 (2006.01) i

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)

F28F3/08, F28F3/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009
 Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009

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	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 136165/1985 (Laid-open No. 45583/1987) (Mitsubishi Electric Corp.), 19 March 1987 (19.03.1987), page 5, line 4 to page 7, line 18; fig. 1 to 4 (Family: none)	1-6
Y	WO 2008/041327 A1 (Mitsubishi Electric Corp.), 10 April 2008 (10.04.2008), paragraphs [0021] to [0038]; fig. 1 to 6 & EP 2071267 A & WO 2008/041327 A1	1-6



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
19 October, 2009 (19.10.09)Date of mailing of the international search report
27 October, 2009 (27.10.09)Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/066163

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 158113/1984 (Laid-open No. 74787/1986) (Mitsubishi Electric Corp.), 20 May 1986 (20.05.1986), page 3, line 20 to page 8, line 9; fig. 1 to 3 (Family: none)	1-6

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REFERENCES CITED IN THE DESCRIPTION

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- JP 3414012 B [0007]
- JP 2005140362 A [0007]
- JP 2001147092 A [0007]
- JP 2007315649 A [0007]
- JP 2008041327 A [0007]