



Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number:

0 147 866
A2

(12)

EUROPEAN PATENT APPLICATION

(21) Application number: 84116425.4

(51) Int. Cl.⁴: **F 28 F 3/08**
F 28 D 9/02

(22) Date of filing: 28.12.84

(30) Priority: 29.12.83 SE 8307215
27.09.84 SE 8404845

(43) Date of publication of application:
10.07.85 Bulletin 85/28

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

(71) Applicant: Fläkt Aktiebolag
Sickla Allé 13
S-131 34 Nacka(SE)

(72) Inventor: Holmberg, Poy
Stattutgatan 51
S-552 59 Jönköping(SE)

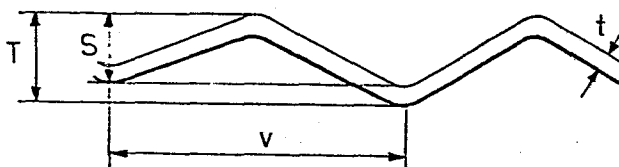
(74) Representative: Eitle, Werner, Dipl.-Ing. et al,
Hoffmann, Eitle & Partner Patentanwälte Arabellastrasse
4
D-8000 München 81(DE)

(54) Plate heat exchanger.

(57) This invention relates to a plate heat exchanger designed for heat exchange between gaseous media, preferably air. The heat exchanger comprises a plurality of thin plates (1a-c) stacked upon each other and provided with distance members (2) lengthwise in the flow direction in the form of pleats. Every second plate is offset 90° in relation to the adjacent plate in order to form throughgoing ducts (3) of largely rectangular cross-sections. In order to reduce the material thickness and to increase the heat transfer capacity and at the same time to maintain the flow resistance at a low level, according to the invention the plates between the lengthwise distance members (2) are furnished with a friction pressure drop forming fine structure (4) in the form of corrugations essentially at right angles to the distance members. Moreover, the invention provides means to obtain an efficient seal between the separate gas flow passages in the heat exchanger. Thus each contact plate at its two end sides terminating along the distance members displays a lengthwise edge zone area, that each contact plate at its two end sides terminating across the distance members displays a lengthwise part within which a folding edge is arranged. The edges are in order to be joined with an adjacent plate folded around the edge zone area of the adjacent plate and thus form a folded edge, which extends over the corresponding edge zone area and encloses it. The folded edge and the enclosing material display a lengthwise pleating which

extends along the whole width of the plate in order to lock the folding edge. Within the pleating fine structure is partly deformed by being pressed against each other and thus forms an effective seal between the plates. The heat exchanger plates are preferably made of aluminium.

Fig. 2b



EP 0 147 866 A2

Plate Heat Exchanger

The present invention relates to a plate heat exchanger designed for heat exchange between gaseous media in accordance with the preamble of Claim I.

5 Plate heat exchangers of this type are used primarily in heat recovery systems in ventilation plants. As a rule, it is the heat from an exhaust air flow to an intake air flow that is transmitted in that the respective flows pass through the heat exchanger in separate flow passages in so-called cross-current.

10 A common design feature of such heat exchangers is cross-laid flat plates provided with distance members, the latter being formed by and comprising a part of the plate and elaborated as round nipples or oblong nipples extending in the flow direction. The distance between these distance members must be selected large in relation to their height to avoid unfavourable generation of turbulence in the heat exchanger. Consequently,
15 ly, the material thickness of the plates, which are often made of aluminium, must be chosen relatively large in order for the plates to be able to withstand the large pressure differential between the plates which is common without their deflection becoming excessive. Since the material cost comprises a significant portion of the cost of a finished heat exchanger the relatively large material thickness thus constitutes a considerable disadvantage for this type of heat exchanger.
20

Another common design of plate heat exchanger for heat recovery features cross-laid flat plates with interlying corrugated/pleated plates which comprise distance members to the flat plates, which latter plates
25 separate the two flows of gas. A common embodiment of the pleated plates gives triangular flow passages and permits the choice of small material thicknesses. One disadvantage, however, is that the triangular shape of the flow passage together with laminar flow necessitates a large heating

area, which results in narrow flow passages to prevent the volume of the heat exchanger from becoming excessively large. The narrow flow passages give, among other things, an undesirably high increase in pressure drop upon condensate precipitation.

5 Furthermore, it is well known through the German 'Offenlegungs-
schrift 26 30 905' that in a heat exchanger made with only cross-laid
plates which are furnished with distance members, these latter are formed
as pleats in the plate extending in the flow direction, whereupon rectan-
gular flow passages are formed so that the gas flows through the heat
10 exchanger. It is known that the rectangular cross-sectional shape is high-
ly advantageous from the viewpoint of flow, but a disadvantage of this
embodiment is also the necessity of a high material thickness as other-
wise the strength will be too low. As an example it may be mentioned that
the material thickness of this type of plates is at least 0.3 mm, and
15 that the distance between distance members/pleats is up to about 100 mm.
A further disadvantage is that the laminar flow formed with flat plates
also in this case leads to narrow flow passages. A seal for this type of
heat exchanger plates is usually achieved by means of some kind of seal
compound between the plates, alternatively by folding one edge of the
20 plate around the edge of the adjacent plate which as a result provides an
acceptable seal with a flat plate of the thickness indicated above.

The object of the present invention is to provide a heat exchanger
which does not display the disadvantages of the prior art heat exchang-
ers, but is made with plates which display essentially thinner material
25 at the same time as the heat transfer capacity is improved. Moreover, the
flow resistance, i.e., the pressure drop through the heat exchanger, must
be retained at an acceptably low level, both when the heat exchanger sur-
faces are dry and when condensate is precipitated. One object is also to
obtain an efficient seal between the separate gas flow passages in the
30 heat exchanger which implies that the adjacent plates are joined together
in a for the manufacture efficient and rational way.

These objects are mainly achieved through an embodiment with the
characteristics according to Claim 1. The invention is based on the
insight that through the fine structure a friction pressure drop is
35 obtained which effectively increases heat transfer without any
appreciable increase in the flow resistance, which is due to the fact
that a favourable generation of turbulence can be maintained in the duct.

At the same time, the fine structure gives a substantial stiffening of the plates which, thanks to the invention, can be made with a material thickness (and thus a total material consumption) which is only between 20-30 per cent of the thickness of conventional plates.

5 The invention is further based on the insight that by means of a lengthwise pleating of the folded connecting edge of the plates, the folded part of the plate is prevented from springing back, i.e., in that locking of the connecting edge is achieved. In addition, the invention is based on the insight that through the fine structure a friction pressure
10 drop is obtained which effectively increases heat transfer without any appreciable increase in the flow resistance. This is due to the fact that a favourable generation of turbulence can be maintained in the flow passages. At the same time, the fine structure gives a substantial stiffening of the plates which, thanks to the invention, can be made with
15 a material thickness (and thus a total material consumption) which is only between 20-30% of the thickness of conventional plates. The folded edges of the plates are also provided with lengthwise pleats. As a result, it has been possible to combine the plates into a heat exchanger package with a great heat transfer capacity, low pressure drop, considerable tightness between the flow passages and stable surfaces on the sides
20 of the package, as well as they withstand great differences in pressure between the flow passages, all this thanks to the combination of a fine structure of the thin plates and the connection of the separate plates designed according to the invention. Practical embodiments of the heat
25 exchanger are evident from the following sub-claims.

The invention will now be described in greater detail and with reference to the accompanying drawings, wherein

30 Fig. 1 shows schematically in perspective three heat exchanger plates stacked upon each other but without demonstrating the means of their connection,

Fig. 2a shows schematically an end view of two heat exchanger plates
35 stacked upon each other,

Fig. 2b shows schematically a cross-section of two heat exchanger plates stacked upon each other,

Fig. 3 shows a heat exchanger body,

Fig. 4 shows schematically in detail how two heat exchanger plates are joined together,

5

Fig. 5a shows schematically a detail of the connection of two plates,

Fig. 5b shows schematically a cross-section of the connection of two plates,

10

Fig. 6 shows schematically a full view of a heat exchanger plate.

Shown in Fig. 1 is the principle of how three heat exchanger plates 1a, 1b and 1c, are stacked upon each other and offset 90° in relation to each other. This figure does not show the means of how the separate plates are connected with each other. Each plate is equipped with lengthwise distance members 2, devised as pleats in the plate. This results in the formation of extended rectangular flow passages designated 3a and 3b for the air which is thus made to pass in cross-current. The air flows are indicated by the arrows A and B, respectively. The width "b" (Fig. 2a) of the flow passages is between 10 to 50 mm, preferably between 20-30 mm, and their height "h" corresponding to the pleat height of the distance members is greater than 1.5 mm, preferably 2-10 mm. It has been found that this form of flow passages is beneficial in view of heat transfer, pressure drop, strength and production technology. Preferably, the plates of the heat exchanger are made of aluminium material.

According to the invention the plates are equipped with a friction pressure drop forming fine structure 4 in the form of corrugations as shown in Fig. 2a and 2b. The corrugations are preferably arranged at right angles to the distance members. Also the distance members can be designed with a fine structure.

The design of the fine structure in greater detail is demonstrated by the schematic Fig. 2b which shows a cross-section of a contact plate. The corrugations of the fine structure display a pleat height S which amounts to between 0.1 and 1 mm. The fine structure of the plate 1b has a wavelength λ of between 1 and 5 mm, preferably 3 mm, and its shape is

triangular as indicated in the figure. The shape may also be sinusoidal or some interlying shape. A fine structural plate has a material thickness (t) of less than 0.1 mm, and the fine structural thickness (T) of the plates, defined as the total thickness of the plate areas with undeformed fine structure (4), i.e., S plus t, amounts to 0.1 and 1 mm, preferably 0.5 mm.

It has been found that by means of the fine structure a favourable generation of turbulence is achieved in the flow passage, which actively increases the heat transfer capacity without the pressure drop losses increasing to an unjustifiably high extent. The invention is thus based partly on the insight that the fine structure, in accordance with the above connection to the shaping of the flow passage, is given a favourable generation of turbulence in the duct and, as opposed to prior art devices, does not give rise to a dissolution flow. Thanks to the stiffening function given by the fine structure the material thickness of the plates can be chosen as small as 0.1 mm or less. This gives a total material consumption of the order of 25 per cent in comparison with the material consumption for a conventional heat exchanger with the corresponding heat transfer capacity and pressure drop.

Shown in detail and schematically in Fig. 2a is an end view of two heat exchanger plates 1a and 1b. Formed between two distance members 2 in the lower plate and the upper plate is the air flow passage 3 which is thus shown in cross-section. The sides 5a and 5b of the distance members 2 are accordint to one embodiment pressed together towards each other to form a small gap 6 at the underside of the plate. One effect of the gap 6 is that it contributes towards some generation of turbulence in the air on the underside of the plate, which is sufficient to increase the heat transfer coefficient, but only contributes to a minor extent towards an increase of the pressure drop in the flow passage.

The fine structure of the plate 1b has a wavelenght λ of between 2-5 mm, preferably 3 mm, and its shape is sinusoidal as shown in the figure. The shape may also be triangular or some interlying shape.

Shown in Fig. 3 is how a plurality of exchanger plates are combined into a heat exchanger package. The heat exchanger package is usually arranged so that the heat exchanger plates are disposed vertically. The heat exchanger body is inclined towards the horizontal plane to facilitate discharge of condensate water precipitated in the flow passage.

Fig. 4, 5a and 5b as well as 6 show in detail how a bottom heat exchanger plate according to the invention is connected at its end edge with a top heat exchanger plate. A necessity for the heat exchanger package to function properly is that the plates are joined effectively, both from a mechanical and a sealing point of view. A leakage between the separated flow passages should be avoided as far as possible and may in some applications prove definitely harmful. Fig. 6 shows how the heat exchanger plate terminating along the distance members at its two end sides 10a, b displays a lengthwise section of end zones 11a, b. Each contact plate also displays at its two end sides 20a, b terminating across the distance members, a lengthwise section 21a, b, in which a folding edge 22a, b is arranged. At its edges the plate displays the notches 26. The edges 22a, b are intended to be joined with an adjacent plate in such a way that they will be folded around the adjacent edge zone area, by which a folded edge 23 is formed. In addition, the folding edge 22a, 22b displays a distance section 25 which by its size corresponds to the distance between the adjacent plates determined by the pleat height, and forms a seal of the side for the corresponding flow passages 3a, 3b at the ends of the plates. The folded edge 23 extends over the corresponding edge zone area and encloses this. The edge 23 and the enclosing material also display a lengthwise pleating 24 which extends along the whole width of the plate and is designed to achieve locking of the edge 23 and, if necessary, thus prevent the folding edge 22a, b from springing back. The fine structure in the pleating of the two plates is partly deformed owing to their being pressed together and forms an effective seal between the plates. In effect, the thickness resulting from the compression is not larger than the plate thickness T defined in figure 2b.

An especially purposeful embodiment according to the invention is the arrangement of downfolding the distance member, as shown in Fig. 5a, and then covering from the underlying plate it by the edge 23. As a result, the fine structure of the plates stacked upon each other (including the folding edge 22a, b and the edge 23) has been deformed so that the common thickness, on the whole, still is enclosed in the plate thickness T, as defined in the figure 2b. This condition can be accomplished also when both sides 5a, 5b of the distance members 2 are provided with a fine structure.

The pleating 24 displays according the invention a wavelength Y and

0147866

a waveheight y which are dimensioned so that they give rise to a stretching of the material that at least corresponds to the surface expansion ensuing from the deformation of the fine structure in the pleating. The wavelength Y of the pleating amounts to about 10 mm and its waveheight y to about 2 mm. The surface expansion of the fine structure amounts to between 1% and 10%, preferably 3%.

A very effective seal between the separate flow passages is achieved by this method. The stretching of the folded edge 23 brought about (effected) by the lengthwise pleating 24 smoothes out the fine structure of the edge 23 and renders a pleated, smooth and tight joint. Moreover, whenever applicable, the downfolded distance members 2 can be enclosed in thickness T of the plates thanks to the fine structure. By compressing the folded edge 23 together the function of the resultant fine structure may be ranked in the same category as the function of a packing.

The shown embodiment of the plate heat exchanger is intended in the first instance for application in comfort ventilation plants, but obviously the invention is not limited to this embodiment.

CLAIMS

1. A plate heat exchanger designed for heat exchange between gaseous media which preferably consist of air and are kept separated from each other in the heat exchanger, the said heat exchanger consisting of a number of plates (1a-c) stacked upon each other and provided with distance members (2) lengthwise in the flow direction in the form of pleats, the latter being formed by and comprising a part of the plates, where every second plate is offset 90^0 in relation to the adjacent plate in order to form throughgoing flow passages (3a, b) of largely rectangular cross-section, characterized in that the plates (1a-c) between the lengthwise distance members (2) are provided with a friction pressure drop forming (4) fine structure in the form of corrugations.
2. A plate heat exchanger as claimed in Claim 1, characterized in that the fine structure (4) is essentially arranged at right angles to the distance members.
3. A plate heat exchanger as claimed in Claim 1-2, characterized in that each contact plate at its two end sides (10a, b) terminating along the distance members displays a lengthwise edge zone area (11a, b), that each contact plate at its two end sides (20a, b) terminating across the distance members displays a lengthwise part (21a, b) within which a folding edge (22a, b) is arranged, that said edges (22a, b) in order to be joined with an adjacent plate are folded around the edge zone area of the adjacent plate and thus form a folded edge (23), which extends over the corresponding edge zone area and encloses it, and that the folded edge (23) and the enclosing material display a lengthwise pleating (24) which extends along the whole width of the plate in order to lock the folding edge (22a, b).
4. A plate heat exchanger as claimed in Claim 3, characterized in that and that the fine structure of the two plates within the lengthwise pleating (24) is partly deformed by being pressed against each other and thus forms an effective seal between the plates.

5. A plate heat exchanger as claimed in Claims 1-4, characterized in that the distance members (2), including their sides (5a, b) display a fine structure (4).

5 6. A plate heat exchanger as claimed in Claims 1-5, characterized in that the sides (5a,b) of the distance members (2) are being pressed against each other.

10 7. A plate heat exchanger as claimed in Claim 3-6, characterized in that the distance members (2) within the edge zone areas (11a, b) display a folded part enclosed by the folded edge (23).

15 8. A plate heat exchanger as claimed in Claims 3-7, characterized in that the pleating (24) displays a wavelength (Y) and a waveheight (y) which are so dimensioned that they render a stretching of the material that at least corresponds to the surface expansion effected by the deformation of the fine structure within the pleating.

20

9. A plate heat exchanger as claimed in Claim 8, characterized in that the wavelength (Y) amounts to about 10 mm and the waveheight (y) to about 2 mm.

25 10. A plate heat exchanger as claimed in Claims 2-9, characterized in that the surface expansion of the fine structure amounts to between 1% and 10%, preferably 3%.

30 11. A plate heat exchanger as claimed in Claims 1-10, characterized in that the fine structure (4) displays a pleat height (S) that amounts to between 0.1 to 1 mm.

12. A plate heat exchanger as claimed in Claims 1-11, characterized in that the flow passages (3a, 3b) formed have a
35 width of between 10 and 50 mm, preferably 20 - 30 mm.

13. A plate heat exchanger as claimed in Claims 1-12, characterized in that the material thickness of the plates (1a-c) is less than 0.1 mm.

5 14. A plate heat exchanger as claimed in Claims 2-13, characterized in that the material thickness (t) of the plates (1a-c) is less than 0.1 mm and that the fine structure thickness (T) of the plates, defined as the total thickness of the parts of the plates with undeformed fine structure (4), i.e., S plus t, amounts to between
10 0.1 and 1 mm, preferably 0.5 mm.

15 15. A plate heat exchanger as claimed in Claims 1-14, characterized in that the total thickness of the compressed plates at the pleating (24) essentially does not exceed the fine structure thickness (7).

16. A plate heat exchanger as claimed in Claims 1-15, characterized in that the plates (1a-c) are made of aluminium.

Fig. 1

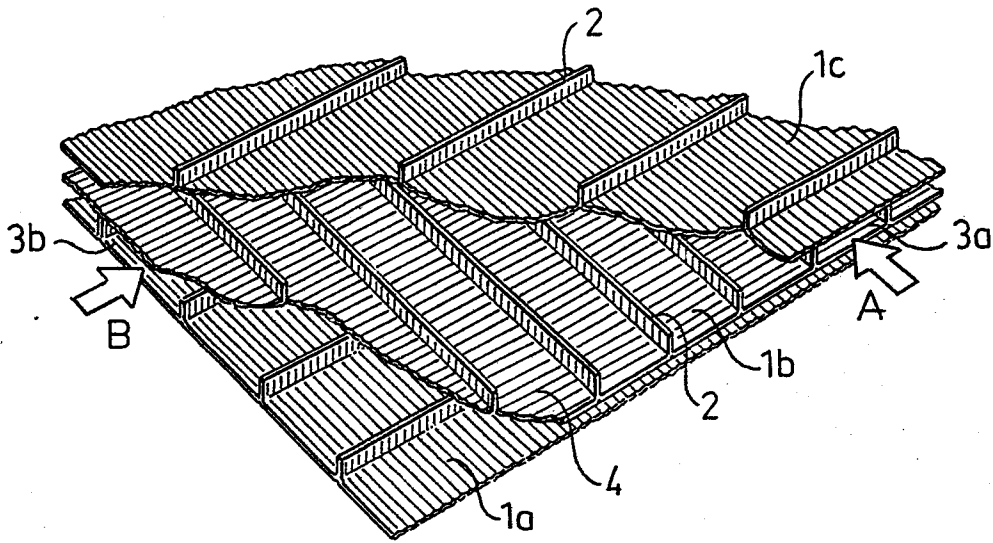


Fig. 2a

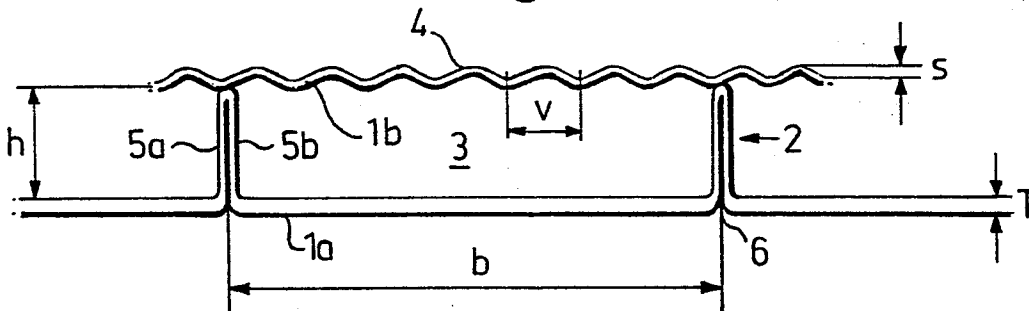


Fig. 2b

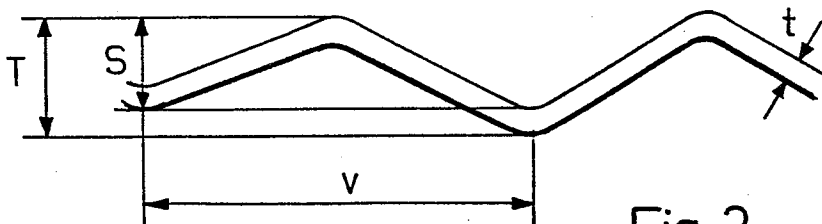


Fig. 3

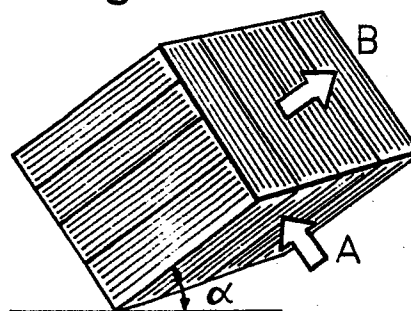


Fig. 4

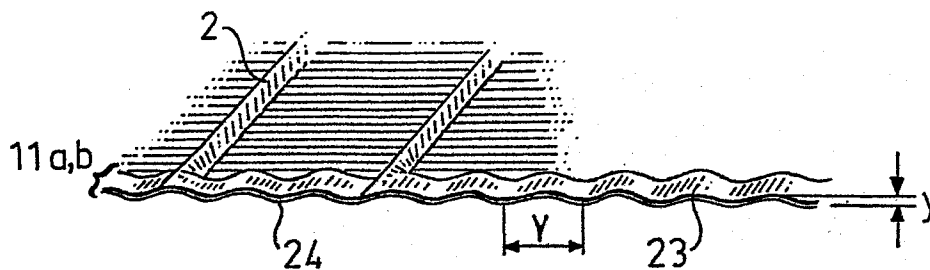


Fig. 5a

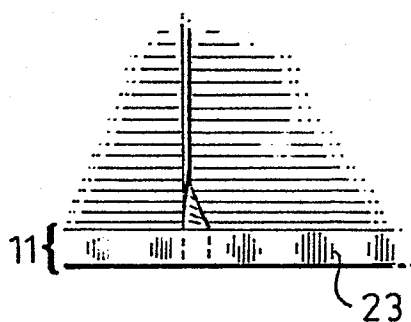


Fig. 5b

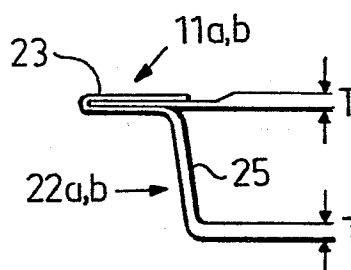


Fig. 6

