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(54) Mixture delivery device

(57) The invention relates to a heat transfer plate (1) for a plate heat exchanger, wherein said heat transfer plate has an essentially circular shape and is equipped with grooves (2) separated by parallel running ridges (3), said grooves (as well as the ridges) being aligned essentially parallel with each other in a direction exhibiting the main direction of the plate bending stiffness. According to the invention, said heat transfer plate (1) is provided with an elastic element (4) offering elasticity essentially in the main direction of the plate bending stiffness).

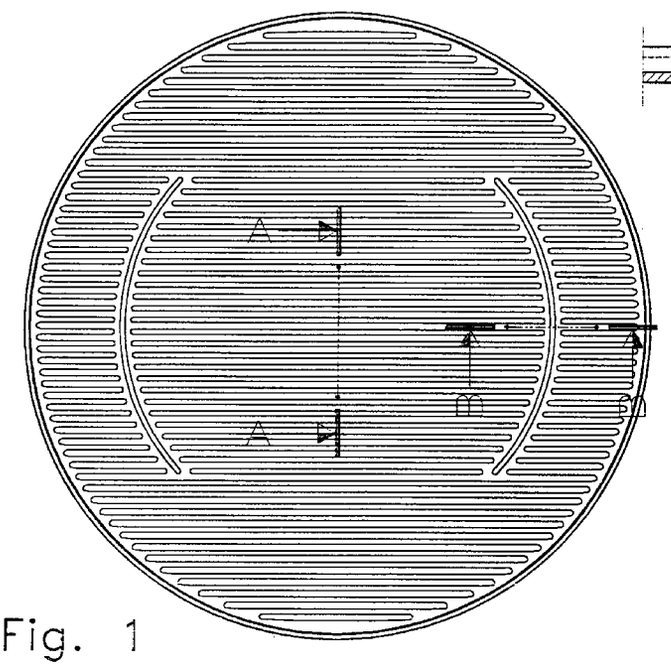

Fig. 1

Fig. B–B

Fig. A–A

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Description

[0001] The present invention relates to a heat transfer plate for a plate heat exchanger, wherein the heat transfer plate has an essentially circular shape and is equipped with grooves separated by ridges, said grooves (as well as the ridges) being aligned essentially parallel with each other in a direction exhibiting the main bending stiffness of the plate.

[0002] Heat exchangers are frequently used under demanding operating conditions, which term concerns, e.g., a high temperature in the primary and secondary circuits or a situation in which the primary and secondary circuits are operated at widely differing temperatures. Moreover, such demanding conditions often involve a high pressure level and pressure variations in these circuits plus repeated shutdown and startup cycles that further increase the varying stress imposed on the heat exchanger. For these conditions, heat exchangers of straight-tube and especially the U-bend tube type have generally been used. As a technical improvement of these heat exchanger types toward improved expansion margin, corrugation of the heat-exchanger tubes has been proposed. However, the straight-tube and U-bend tube type heat exchangers are hampered by their very large size, whereby needs for smaller footprint and cost savings stimulate a search toward smaller-size alternatives of competitive design.

[0003] In EP Pat. No. 0 375 691 is disclosed a plate heat exchanger, whose one practicable embodiment has the outer edges of the heat-exchange plates joined to each other by welding, whereby also the outer casing of the heat exchanger is formed all the same. A particular benefit of this construction is its small size. Moreover, the heat exchanger of this type is elastic permitting expansion within a given range. Such elasticity permits internal movements of the plates within the heat exchanger to some degree due to temperature and pressure differentials between the primary and secondary circuits. This elastic margin is made possible by not having the heat-transfer plates joined to each other by brazing, for instance, but by having the plates only supported to each other. To extend the useability of the plate heat exchanger disclosed in EP Pat. No. 0 375 691 to a greater number of applications in replacing the above-mentioned bulky and expensive tube heat exchangers under demanding conditions, the strength of the plate heat exchanger that is based on the elasticity of its construction needs further improvement particularly with regard to the stresses caused by varying and frequently repeating temperature variations. By the same token, the improved design should not make the heat exchanger dimensions larger or increase its production costs essentially.

[0004] Hence, it is an object of the present invention to bring about an improvement to the design of the plate heat exchanger described in EP Pat. No. 0 375 691. Inherently, the grooves of the antecedent design has provided sufficient elasticity in a direction perpendicular to the grooves. However, more elasticity is required in the direction of the grooves (that is, main direction of bending stiffness) to render the heat exchanger a longer life also under stressing conditions.

[0005] The goal of the invention is achieved by providing the heat transfer plate with an elastic element offering elasticity essentially in the main direction of the plate bending stiffness. According to a preferred embodiment, the elastic element is formed by at least one additional groove (or ridge) having at least a portion of its length aligned at least essentially perpendicular or almost perpendicular to the main direction of the plate bending stiffness. Alternatively, such an elastic element may also be formed by an essentially laterally undulated shape of the grooves/ridges which run over the main direction of the plate bending stiffness. By virtue of the invention, the elasticity of heat transfer plates can be improved significantly, particularly in the main direction of the plate bending stiffness.

[0006] In the following the invention will be examined in greater detail with reference to the appended drawings, in which

Figure 1 is a top view of a heat transfer plate having elastic elements formed thereto according to a preferred embodiment of the invention;

Figure 2 is an enlarged sectional view of the plate along the line A-A of Fig. 1;

Figure 3 is an enlarged sectional view of the plate along the line B-B of Fig. 1;

Figure 4 is a top view of a heat transfer plate having an elastic elements formed thereto according to a second preferred embodiment of the invention; and

Figure 5 is an enlarged sectional view of the plate along the line C-C of Fig. 4.

[0007] Referring to Fig. 1, therein is shown a heat transfer plate 1 of a plate heat exchanger, said plate being provided with a number of parallel grooves 2 with ridges 3 running parallel with the grooves. The grooves 2 are advantageously made by deep-drawing. The grooves 2 are made mutually parallel with their direction forming the main direction of the plate bending stiffness. Conventionally, plate heat exchangers are assembled by stacking heat transfer plates so that the grooves of the adjacently stacked plates are aligned at a given angle as described in EP Pat. No. 0 375 691. Also other assembly details of the heat exchanger according to the invention will be evident from EP Pat. No. 0 375 691.

[0008] As mentioned above, conventional heat transfer plates offer a very limited elasticity in the main direction of the plate bending stiffness. To overcome this drawback, the heat transfer plate according to the inven-

tion is provided with an elastic element formed in the embodiment illustrated in Fig. 1 by two additional grooves 4 (or ridges, respectively) having at least a portion of their length aligned at least essentially perpendicular or almost perpendicular to the main direction of the plate bending stiffness. A particular embodiment shown in Fig. 1 has the additional grooves 4 (or ridges, respectively) made with a curved shape of a radius of curvature aligned essentially concentric with the center of heat transfer plate. The arc length of each additional groove 4 is about 90° as illustrated in Fig. 1. However, the number, location, length or shape of the additional grooves 4 is not limited by those shown in the preferred embodiment. As the particular duty of the additional grooves is to prevent stresses tending to disrupt the structure of the heat exchanger from being transmitted to the plate perimeter (to the plate edges in the main direction of the plate bending stiffness) and the outer casing of the heat exchanger along the basic grooves, the desired properties of the additional grooves can be implemented in a manner best suited for the desired application.

[0009] Essentially, the embodiment shown in Figs. 4 and 5 offers the same function as the embodiment illustrated in Figs. 1-3. Herein, the elastic element is formed by the essentially laterally undulated wavy shape of the grooves/ridges which run over the main direction of the heat transfer plate bending stiffness. The crests 5 (and thereby also the valleys 6) of the adjacent grooves 2 are aligned essentially adjacently coincident with each other, whereby the plate will be provided with lateral wave crest rows (and wave valley rows, respectively) extending from one side of the plate to the opposite side thereof, said rows being aligned essentially perpendicular to the main direction of the plate bending stiffness. The grooves 2 (and also the ridges 3, respectively) may be formed with an S-shape on the plate surface, whereby their depth/height with respect to the plate remains constant. While such a nonlinear groove shape, e.g., the above-described S-shape, will plausibly offer a further improvement of the heat transfer coefficient, the corroboration of this assumption needs further tests.

[0010] To those versed in the art it is obvious that the invention is not limited by the exemplifying embodiments described above, but rather, may be varied within the scope and spirit of the appended claims.

Claims

1. A heat transfer plate (1) for a plate heat exchanger, wherein said heat transfer plate has an essentially circular shape and is equipped with grooves (2) separated by ridges (3), said grooves (as well as the ridges) being aligned essentially parallel with each other in a direction exhibiting the main direction of the plate bending stiffness, **characterized** in that said heat transfer plate (1) is provided with an elastic element (4; 5, 6) offering elasticity essentially in the main direction of the plate bending stiffness).

2. A heat transfer plate as defined in claim 1, **characterized** in that said elastic element is formed by at least one additional groove (4) (or ridge) having at least a portion of its length aligned at least essentially perpendicular or almost perpendicular to the main direction of the plate bending stiffness.

3. A heat transfer plate as defined in claim 2, **characterized** in that said additional groove (4) (or ridge, respectively) is provided with a curved shape aligned essentially concentrically with the center of the heat transfer plate (1).

4. A heat transfer plate as defined in claim 1, **characterized** in that said elastic element is formed by an essentially laterally undulated shape of the grooves (2) (and of the ridges (3), respectively) which run over the main direction of the heat transfer plate bending stiffness.

5. A heat transfer plate as defined in claim 4, **characterized** in that the crests (5) (and thereby also the valleys (6)) of the adjacent grooves are aligned essentially adjacent, whereby the plate will be provided with wave crest rows (and wave valley rows, respectively) extending from one side of the plate to the opposite side thereof, said rows being aligned essentially perpendicular to the main direction of the plate bending stiffness.

6. A heat transfer plate as defined in claim 1, **characterized** in that said grooves (2) running in the main direction of the bending stiffness of the heat transfer plate (1) are made with an essentially S-shaped form on the plate surface, whereby their depth/height with respect to the plate remains constant.

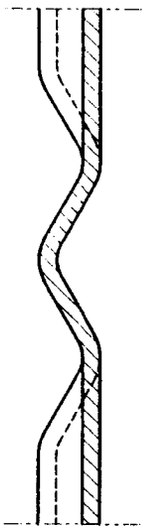

Fig. B–B

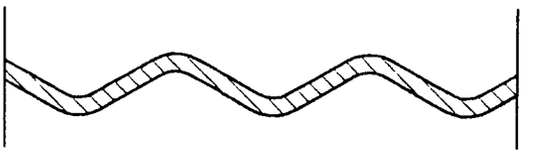

Fig. A–A

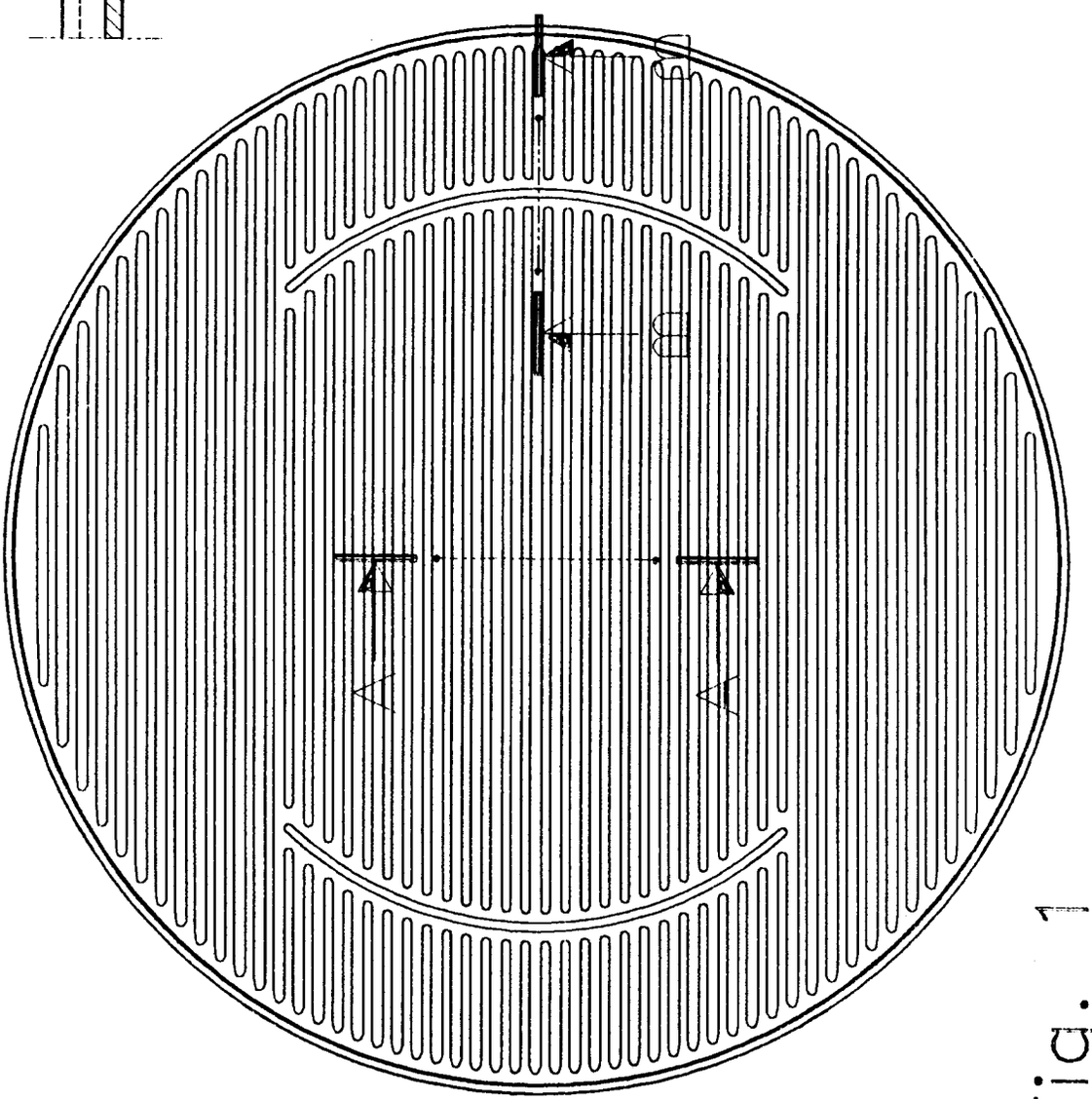

Fig. 1

Fig. C—C

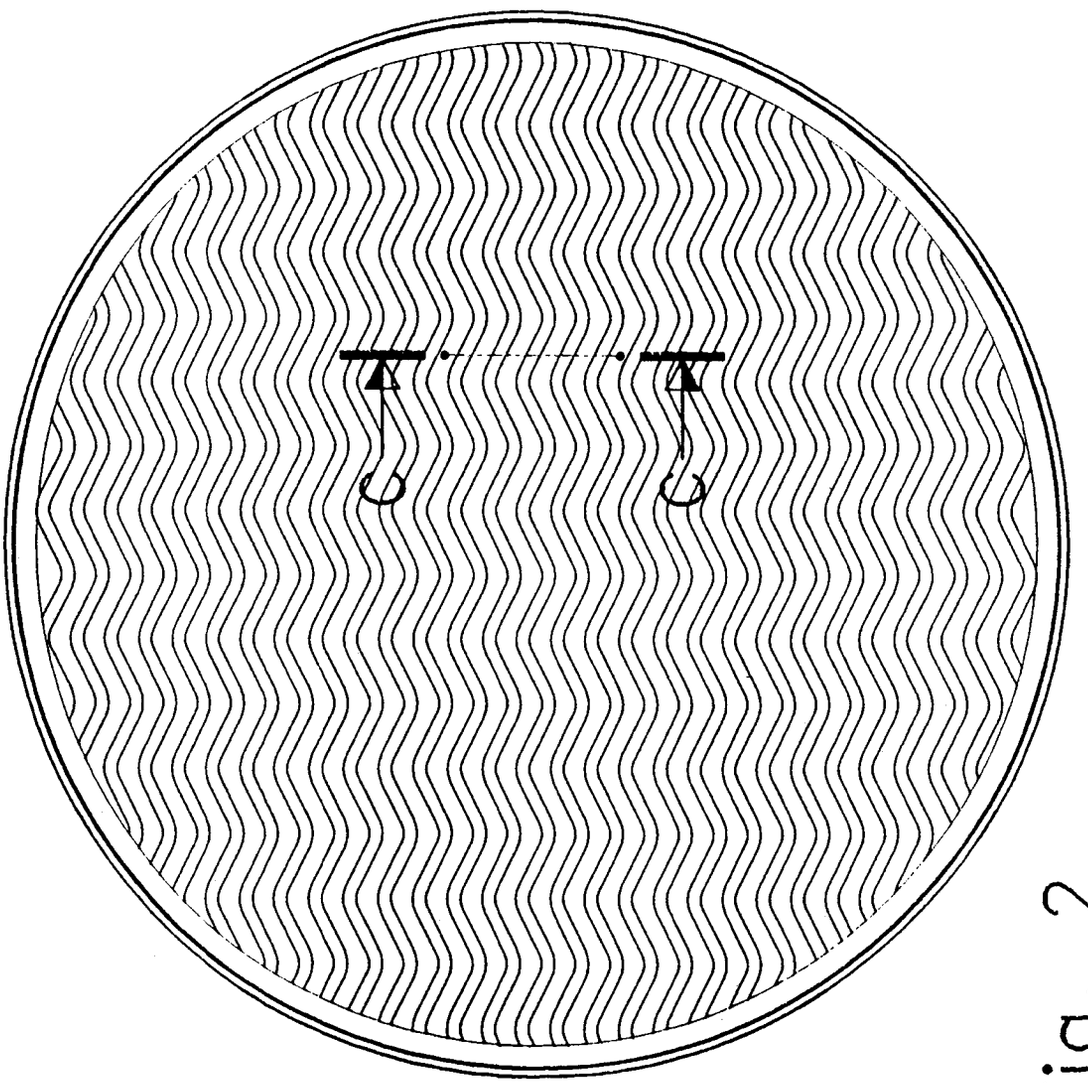

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 97 20 2894

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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A	BERGER, C.M. ET AL.: "Crossflow Heat Exchanger" IBM TECHNICAL DISCLOSURE BULLETIN, vol. 13, no. 10, March 1971, page 3011 XP002055774 * the whole document *	4-6	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F28D F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 February 1998	Mootz, F

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 97 20 2894

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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