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Hecht et al.(10) **Pub. No.: US 2010/0181053 A1**(43) **Pub. Date: Jul. 22, 2010**(54) **PLATE HEAT EXCHANGER**(30) **Foreign Application Priority Data**(75) Inventors: **Thomas Hecht**, Gauting (DE);
Reinhold Hoelzl, Geretsried (DE);
Bernd Jungfer, Muenchen (DE);
Thomas Bretschneider, Neuried
(DE); **Ekatarina Ananieva**,
Muenchen (DE); **Joerg Conradt**,
Muenchen (DE); **Guenther Koenig**,
Chieming (DE)

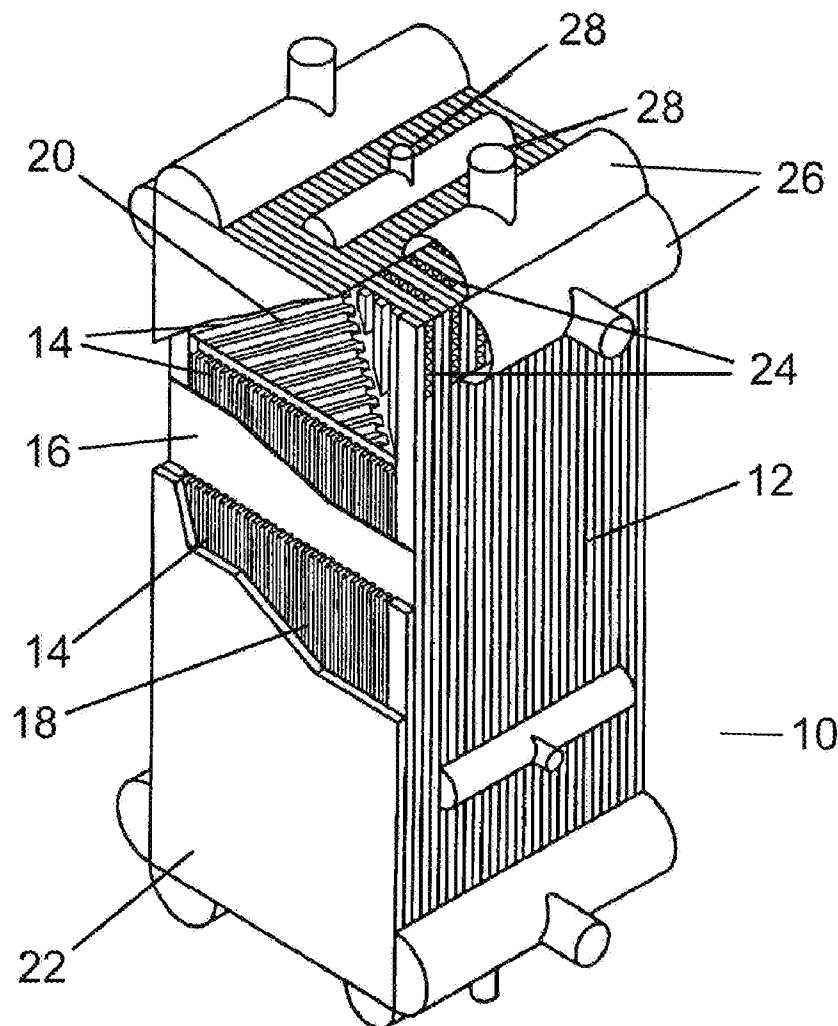
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F28D 7/00 (2006.01)(52) **U.S. Cl.** 165/164(57) **ABSTRACT**

Correspondence Address:

MILLEN, WHITE, ZELANO & BRANIGAN, P.C.
2200 CLARENDON BLVD., SUITE 1400
ARLINGTON, VA 22201 (US)(73) Assignee: **Linde Aktiengesellschaft**,
Muenchen (DE)(21) Appl. No.: **12/582,247**(22) Filed: **Oct. 20, 2009**

A plate heat exchanger (10), in particular a brazed aluminium plate heat exchanger, has a heat exchange portion (12), which comprises two or more first passages (14a), through which a first fluid may flow, and two or more second passages (14b), through which a second fluid may flow, in such a way that heat exchange takes place between the first fluid and the second fluid. To reduce thermal stress inside the heat exchange portion (12), the heat exchange portion (12) comprises at least one layer (30) through which no fluid flows, which is arranged between two passages (14a, 14b) through which fluid may flow.



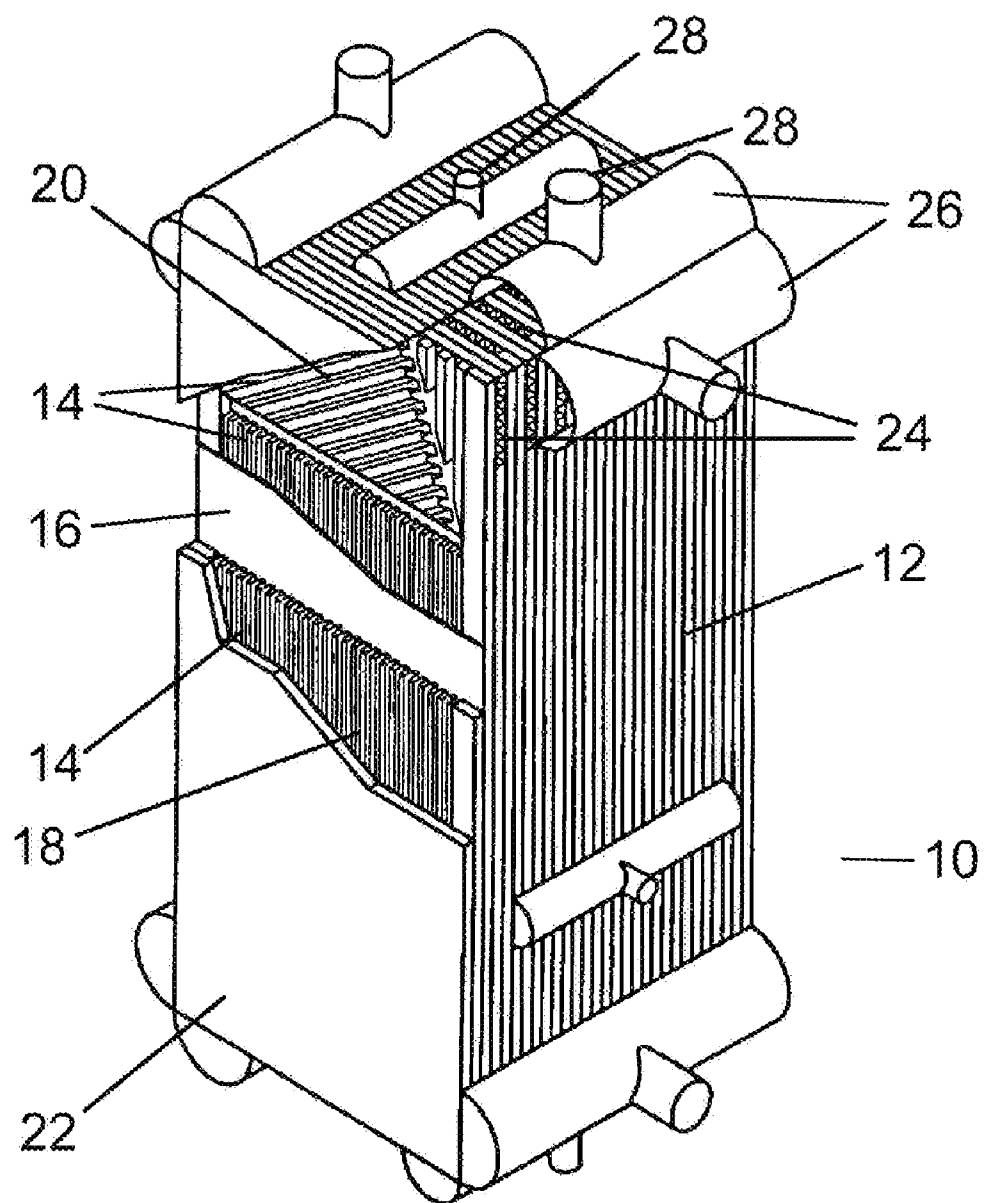


Fig. 1

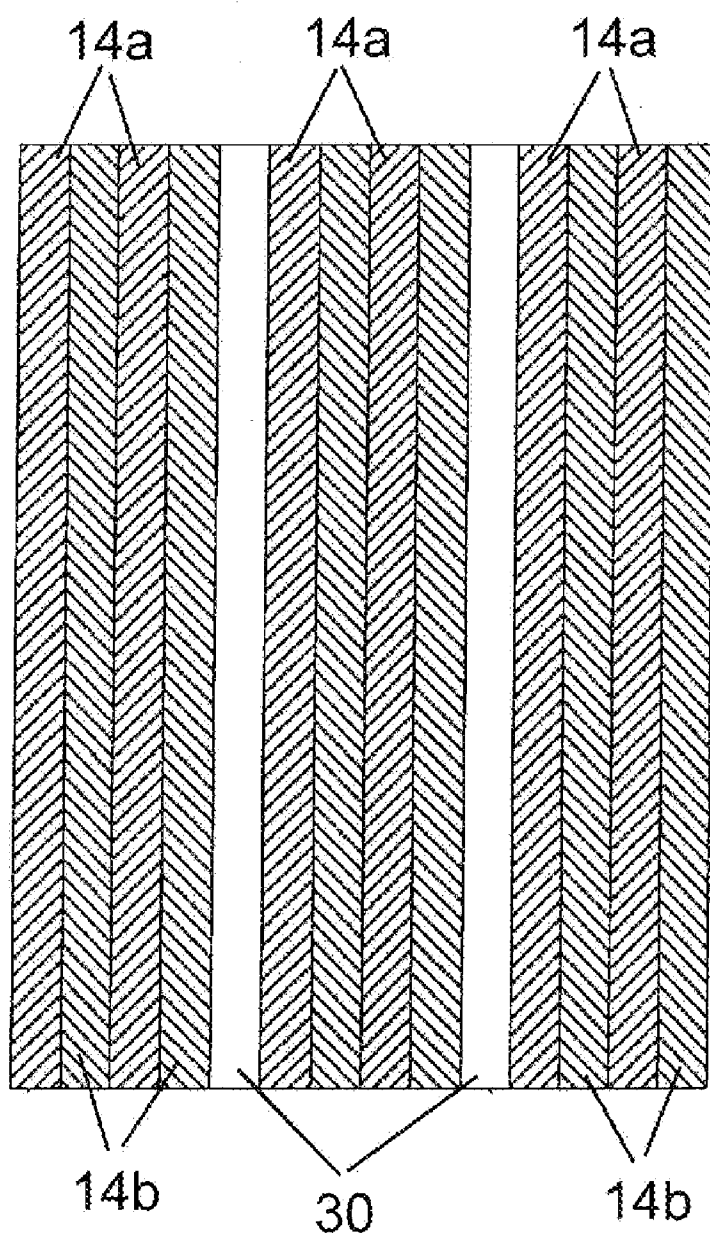
**Fig. 2**

PLATE HEAT EXCHANGER

[0001] The invention relates to a plate heat exchanger, in particular a brazed aluminium plate heat exchanger.

[0002] The heat exchange portion of a plate heat exchanger consists in general of two or more layers of heat exchange passages, which are each delimited relative to one another by partition plates. Closing strips and cover plates form the outer frame of the heat exchange portion, which is often also known as a heat exchanger block. Further separating strips may be provided within a layer, which separate from one another the heat exchange passages for different fluid streams.

[0003] The heat exchanger block initially consisting of loose components is brazed in a brazing furnace, such that all the components are joined together in a sealed manner. Then, headers are welded on over the inlet and outlet openings of the heat exchange passages, these headers each being provided with a fluid connection. Semi-cylindrical shells are conventionally used as the headers; the fluid connections are formed by connecting pieces, which are arranged in the semi-cylinder material of the headers. The pipes for incoming and outgoing fluid streams are connected to these tubular connecting pieces.

[0004] By suitable arrangement of the separating strips, plate heat exchangers may be designed for simultaneous heat exchange of a plurality of fluid streams. Corresponding headers are then mounted for each of the fluid streams over the respective inlet and outlet openings of the heat exchange passages and provided with pipes.

[0005] The basic structure of such plate heat exchangers is described in detail for example in the ALPEMA (Brazed Aluminium Plate-Fin Heat Exchanger Manufacturer's Association) standard.

[0006] Since fluids flow through the plate heat exchanger at different temperatures and also the fluids flowing through the heat exchange passages themselves have temperature distributions variable over space and time, different parts or portions of the heat exchanger block have different temperatures. These different temperatures in turn bring about thermal stresses in the heat exchanger block. The greater the temperature gradients within the heat exchange portion, the greater too are the thermal stresses caused, which increases the risk of leaks. As a rule, non-uniformities within the heat exchange portion increase these thermal stresses still further.

[0007] The applicant has therefore already proposed methods of producing a plate heat exchanger in documents EP 1 798 508 A1 and EP 1 830 149 A1, in which a three-dimensional digital simulation is performed in order to calculate the thermal stresses inside the heat exchanger block during operation thereof.

[0008] In many processes, such as for example LNG processes such as natural gas liquefaction or evaporation, complying with the recommended limit values for thermal stressing of heat exchangers has hitherto only been possible by using highly complex apparatus.

[0009] It is an object of the present invention to provide an improved plate heat exchanger, in which the thermal stresses are reduced within its heat exchange portion.

[0010] This object is achieved by a plate heat exchanger having the features of Claim 1. Advantageous embodiments and further developments of the invention constitute the subject matter of the subclaims.

[0011] The plate heat exchanger of the invention has a heat exchange portion, which comprises two or more first passages, through which a first fluid may flow, and two or more second passages, through which a second fluid may flow, in such a way that heat exchange takes place between the first fluid and the second fluid. In addition, the heat exchange portion comprises at least one layer through which no fluid flows, which is arranged between two passages through which fluid may flow.

[0012] In the heat exchange portion of the plate heat exchanger according to the invention, at least one layer is arranged through which no fluid flows or can flow, i.e. which is inactive. The arrangement of such inactive layers at suitable points between passages through which fluid may flow reduces the temperature gradient within the heat exchange portion and consequently also the thermal stresses therein. As a result, large temperature differences may be allowed between the fluid streams, without increasing the risk of leaks.

[0013] Improvement of the plate heat exchanger in relation to the thermal stresses arising in its heat exchange portion are achieved according to the invention by a very simple structural measure. The arrangement of layers through which no fluid flows between heat exchanger passages does not change the basic structure of the plate heat exchanger and accordingly does not require any further adaptation of the other components.

[0014] The "plate heat exchanger" is in particular a brazed aluminium plate heat exchanger for indirect heat exchange between at least two fluid streams.

[0015] The terms "heat exchange portion" or "heat exchanger block" are understood to mean that part of a plate heat exchanger which may be prefabricated to the extent of already comprising warming and cooling passages. The terms "warming passages" and "cooling passages" relate to the ordinary operation for which the respective heat exchanger is designed. In ordinary operation a first fluid, which flows through the warming passages, absorbs heat and a second fluid, which flows through the cooling passages, dissipates heat. The present invention naturally also comprises condensers and evaporators. In the case of an evaporator, the "warming passages" take the form of evaporation passages, while in the case of a condenser the "cooling passages" take the form of liquefaction passages.

[0016] In one embodiment of the invention, at least one layer through which no fluid flows is arranged between two groups of two or more passages through which fluid may flow. These groups of two or more passages through which fluid may flow each contain at least one first passage and at least one second passage. In addition, the groups of two or more passages through which fluid may flow are formed for example by individual packages of passages within a heat exchange portion or by individual heat exchange portions, which are joined together in the form of modules, for example.

[0017] The layers through which no fluid flows may take the form, for example, of closed cavities. Alternatively, the layers through which no fluid flows may also take the form wholly or in part of solid layers. In the case of the former variant in particular, reinforcing elements are provided in the layers through which no fluid flows, for which, in a preferred embodiment, the heat exchange profiles may be used which are also arranged in the layers through which fluid flows.

[0018] In a further development of the invention, a height dimension (dimension across the direction of flow) of the at least one layer through which fluid does not flow corresponds to at most one height dimension of the passages through which fluid may flow. In an alternative embodiment, a height dimension of the at least one layer through which fluid does not flow corresponds to at least one height dimension of the passages through which fluid may flow. The size ratios and numerical ratios between the passages through which fluid may flow and the passages through which fluid does not flow are suitably selected by a person skilled in the art in accordance with the temperatures of the fluid streams when the plate heat exchanger is in ordinary operation and the strength of the heat exchange portion.

[0019] The height dimension of the passages through which fluid may flow is defined for example as the height dimension of the first passages, the height dimension of the second passages, the average height dimension of the two passages, the larger height dimension of the two passages or the smaller height dimension of the two passages.

[0020] In a preferred embodiment of the invention, the heat exchange portion comprises a plurality of groups with two or more passages through which fluid may flow, between which there is in each case arranged at least one layer through which fluid does not flow.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The above and further features and advantages of the invention are revealed by the following description of a preferred exemplary embodiment made with reference to the appended drawings, in which:

[0022] FIG. 1 is a schematic perspective view, with partially omitted cover plates and attachments, of a plate heat exchanger according to the present invention; and

[0023] FIG. 2 is a schematic sectional representation of the arrangement of the passages in the heat exchange portion of the plate heat exchanger of FIG. 1.

[0024] FIG. 1 is a perspective view of a plate heat exchanger 10, in particular a brazed aluminium plate heat exchanger, according to the present invention. The plate heat exchanger 10 has a central heat exchange portion (also known as a heat exchanger block) 12, which has for example the following dimensions: a length (extent in the top-to-bottom direction in FIG. 1) of approx. 6 m and a width and a height of in each case approx. 1.2 m.

[0025] Inside this heat exchange portion 12 there are provided a plurality of heat exchange passages (warming passages, cooling passages) 14. These heat exchange passages 14 are formed by alternating layers of partition plates 16 and heat exchange profiles (for example ribbed or corrugated plates, fins) 18 or distributor profiles 20. The plate heat exchanger 10 of the exemplary embodiment takes the form of a two-stream heat exchanger, i.e. it contains alternately, parallel to the direction of flow of the fluids, first passages 14a, through which a first fluid may flow, and second passages 14b, through which a second fluid may flow.

[0026] However, the present invention is not restricted solely to two-stream heat exchangers. Very generally, the plate heat exchanger of the invention contains n different passages ($n \geq 2$), through which n fluid streams may be conveyed, in order to exchange heat between the n fluid streams.

[0027] Both the partition plates 16 and the profiles 18, 20 are made from aluminium. The external passages 14 of the

heat exchange portion 12 are covered by a cover 22 of aluminium lying parallel to the passages 14 and the partition plates 16.

[0028] On the sides of the heat exchange portion 12, the distributor profiles 20 comprise distributor profile access points 24, through which the respective fluids may be introduced into the associated passages 14 and removed once again therefrom. The distributor profiles 20 are covered by headers (also known as distributors/collectors) 26, which are each semi-cylindrical in shape in the exemplary embodiment and comprise a connecting piece 28. The connecting pieces 28 are joined to corresponding pipes (not shown), in order to convey the fluid streams via the headers 26 into the passages 14 or out of the passages 14.

[0029] The heat exchange portion 12 is conventionally produced by applying a brazing metal to the surfaces of the partition plates 16 and then alternately stacking the partition plates 16 and the profile plates 18, 20. The covers 22 cover this stack. Then this stack is brazed by heating in an appropriate brazing furnace. Finally, the headers 26 are brazed or welded onto this stack at the appropriate points.

[0030] As is shown by way of example in FIG. 2, the heat exchange portion 12 of the plate heat exchanger 10 comprises first passages 14a, through which a first fluid may flow, and second passages 14b, through which a second fluid may flow. These first and second passages 14a, 14b are for example arranged in packages of in each case two or more first and second passages 14 (two first passages 14a and two second passages 14b in the exemplary embodiment of FIG. 2). Between these packages of first and second passages 14a, 14b there is in each case arranged a layer 30 through which no fluid flows, i.e. which is inactive.

[0031] These layers 30 through which no fluid flows take the form for example of a cavity or wholly or in part of solid layers. To increase stability it may additionally be advantageous for the layers 30 through which no fluid flows to be provided with a reinforcing element or profile. These reinforcing elements may advantageously comprise the heat exchange profiles needed in any event for the plate heat exchanger, which are inserted in the layers 14 through which fluid may flow.

[0032] The insertion of such inactive layers between the passages 14a, 14b through which fluid may flow reduces the temperature gradient within the heat exchange portion 12 when the plate heat exchanger 10 is in ordinary operation and thereby reduces thermal stresses. Consequently, greater temperature differences may be allowed between the fluid streams through the heat exchange portion 12, without the risk of leakage as the consequence of thermal stresses.

[0033] In FIG. 2, packages are in each case put together from two first passages 14a and two second passages 14b. The invention is, of course, not restricted to this embodiment. Any desired numbers of passages 14 through which fluid may flow may in principle be put together, between which an inactive layer 30 is then arranged. Moreover, a package of passages 14 may also comprise different numbers of first and second passages 14a, 14b.

[0034] In FIG. 2, in each case precisely one layer 30 through which fluid does not flow is arranged between the passage packages. The present invention is, of course, not restricted to this embodiment. Two or more inactive layers 30 may optionally also be used between the packages of passages 14 through which fluid may flow.

[0035] In FIG. 2, the layers 30 through which no fluid flows are inserted between packages of first and second passages 14a, 14b through which fluid may flow. The invention is, however, not restricted to this embodiment. The inactive layers 30 may for example also be arranged between the passages 14 through which fluid may flow of two heat exchange portions 12, which are joined together in modular manner.

[0036] In FIG. 2, the first passages 14a and the second passages 14b have substantially the same cross-sectional areas and shapes. The present invention is, of course, not restricted solely to this embodiment. In principle, differently dimensioned and/or shaped passages 14 may also be used.

[0037] In FIG. 2, the layers 30 through which no fluid flows have substantially the same cross-sectional shapes and height dimensions (dimensions across the direction of flow) as the first and second passages 14 through which fluid may flow. The invention is, however, not restricted solely to this embodiment. The inactive layers 30 may alternatively also have a different cross-sectional shape from the passages 14 through which fluid may flow. In addition, the inactive layers 30 may optionally also have a height dimension which is greater or less than the height dimension of the passages 14 through which fluid may flow. Selection of the cross-sectional shapes, height dimensions and numbers of inactive layers 30, in particular the ratios thereof to the corresponding sizes of the passages 14 through which fluid may flow, depends on the temperature differences between the fluid streams through the first and second passages 14a, 14b when the plate heat exchanger is in ordinary operation and the strength of the heat exchange portion 12.

[0038] The height dimension of the passages 14 through which fluid may flow may be defined for example as the height dimension of the first passages 14a, the height dimension of the second passages 14b, the average height dimension of the two passages 14a and 14b, the larger height dimension of the two passages 14a, 14b or the smaller height dimension of the two passages 14a, 14b. If, for example, the first passages 14a also have different height dimensions amongst themselves, the height dimension is determined as the average value thereof. Similar considerations also apply of course if the plate heat exchanger comprises more than two passages 14 through which fluid may flow.

[0039] Typical values for the height dimensions both of the passages 14 through which fluid may flow and of the layers 30 through which no fluid flows are for example in the range from approx. 2 to 15 mm, more preferably from approx. 3 to 10 mm.

[0040] By way of precaution, it should be noted that a distinction must be made between the layers 30 through which no fluid flows of the plate heat exchanger 10 of the invention and such inactive layers in conventional plate heat exchangers, which arise at the edge areas thereof during the brazing process during manufacture of the plate heat exchanger or are required as a weld backing for the headers to be attached.

[0041] Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. The preceding preferred specific embodiments are, therefore, to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way whatsoever.

[0042] In the foregoing and in the examples, all temperatures are set forth uncorrected in degrees Celsius and, all parts and percentages are by weight, unless otherwise indicated.

[0043] The entire disclosures of all applications, patents and publications, cited herein and of corresponding DE application No. 102008052875.7, filed Oct. 23, 2008, are incorporated by reference herein.

[0044] The preceding examples can be repeated with similar success by substituting the generically or specifically described reactants and/or operating conditions of this invention for those used in the preceding examples.

[0045] From the foregoing description, one skilled in the art can easily ascertain the essential characteristics of this invention and, without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.

1. Plate heat exchanger (10), having a heat exchange portion (12), which comprises two or more first passages (14a), through which a first fluid may flow, and two or more second passages (14b), through which a second fluid may flow, in such a way that heat exchange takes place between the first fluid and the second fluid,

characterized in that

the heat exchange portion (12) comprises at least one layer (30) through which no fluid flows, which is arranged between two passages (14a, 14b) through which fluid may flow.

2. Plate heat exchanger according to claim 1,

characterized in that

the at least one layer (30) through which no fluid flows is arranged between two groups of two or more passages (14a, 14b) through which fluid may flow.

3. Plate heat exchanger according to claim 1,

characterized in that

the at least one layer (30) through which no fluid flows takes the form of a closed cavity.

4. Plate heat exchanger according to claim 1,

characterized in that

the at least one layer (30) through which no fluid flows takes the form at least in part of a solid layer.

5. Plate heat exchanger according to claim 3,

characterized in that

at least one reinforcing element is provided in the at least one layer (30) through which no fluid flows.

6. Plate heat exchanger according to claim 1, characterized in that

a height dimension of the at least one layer (30) through which fluid does not flow corresponds at most to one height dimension of the passages (14a, 14b) through which fluid may flow.

7. Plate heat exchanger according to one of claim 1, characterized in that

a height dimension of the at least one layer (30) through which fluid does not flow corresponds to at least one height dimension of the passages (14a, 14b) through which fluid may flow.

8. Plate heat exchanger according to claim 1,

characterized in that

the heat exchange portion (12) comprises a plurality of groups with two or more passages (14a, 14b) through which fluid may flow, between which there is in each case arranged at least one layer (30) through which fluid does not flow.

9. Plate heat exchanger according to claim 2, characterized in that the at least one layer (30) through which no fluid flows takes the form of a closed cavity.

10. Plate heat exchanger according to claim 2, characterized in that the at least one layer (30) through which no fluid flows takes the form at least in part of a solid layer.

11. Plate heat exchanger according to claim 4, characterized in that at least one reinforcing element is provided in the at least one layer (30) through which no fluid flows.

12. Plate heat exchanger according to claim 2, characterized in that

a height dimension of the at least one layer (30) through which fluid does not flow corresponds at most to one height dimension of the passages (14a, 14b) through which fluid may flow.

13. Plate heat exchanger according to claim 3, characterized in that

a height dimension of the at least one layer (30) through which fluid does not flow corresponds at most to one height dimension of the passages (14a, 14b) through which fluid may flow.

14. Plate heat exchanger according to claim 4, characterized in that

a height dimension of the at least one layer (30) through which fluid does not flow corresponds at most to one height dimension of the passages (14a, 14b) through which fluid may flow.

15. Plate heat exchanger according to claim 5, characterized in that

a height dimension of the at least one layer (30) through which fluid does not flow corresponds at most to one height dimension of the passages (14a, 14b) through which fluid may flow.

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