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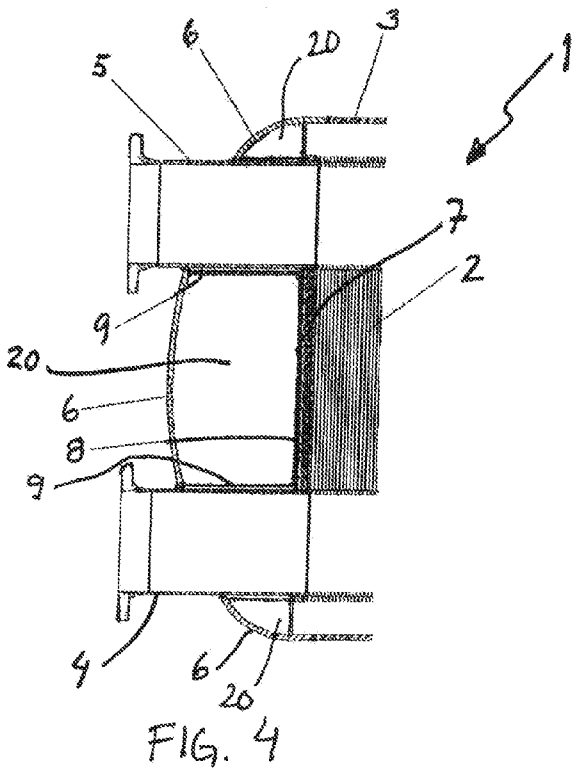

FIG. 4

(57) Abstract: The invention relates to a plate heat exchanger (1) and a method for supporting a plate pack (2) of a plate heat exchanger. In a typical plate heat exchanger according to the invention the end of the plate heat exchanger comprises a convex end (6), which forms a space (20) separate from the shell. In a typical method according to the invention for supporting a plate pack of a plate heat exchanger, the plate pack is supported with a space (20) formed by a convex end of the plate heat exchanger, which space is separate from the shell. The separate space (20) can be filled with a suitable filler, such as concrete or liquid heat exchange medium used in the plate heat exchanger.

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PLATE HEAT EXCHANGER AND METHOD FOR SUPPORTING A PLATE PACK OF A PLATE HEAT EXCHANGER

TECHNICAL FIELD OF THE INVENTION

The invention relates to a plate heat exchanger and a method for supporting a plate pack of a plate heat exchanger according to the preambles of the independent claims presented below.

PRIOR ART

Heat exchangers are traditionally divided into plate structure and tube structure heat exchangers. Tube heat exchangers consist of a shell and a bundle of tubes placed inside the shell. A first heat exchange medium is arranged to flow inside the tubes in the bundle of tubes. A second heat exchange medium is arranged to flow inside the shell, along the outer surfaces of the bundle of tubes. Tube heat exchangers are to their shape such that they are suited for use in high pressures. A plate heat exchanger, on the other hand, usually consists of several thin plates pressed against each other. Plate heat exchangers are usually more effective and thus take up less space than tube heat exchangers. On the other hand, plate heat exchangers are not traditionally suited for use in high pressures.

A plate heat exchanger of the plate and shell type consists of a plate pack formed by heat exchange plates and a shell surrounding it. The core of the heat exchanger is made up of a plate pack, which consists of plates and plate pairs welded to each other. A primary circuit of the heat exchanger is formed between the openings in the plates and a secondary circuit between the connections of the shell surrounding the plate pack, so that a primary side flow medium flows in every other plate space and a secondary side flow medium in every other plate space.

The straight heat exchange plates of the plate heat exchanger need to be supported with end plates, which receive the pressure of the plate pack. Especially when the diameter of the shell of the heat exchanger is large, the end plates must be dimensioned to be thick, whereby the weight of the heat exchanger increases. When using expensive materials for the end plates, the price of the

heat exchanger may become high. The availability of the materials can also become a problem, especially when using thick end plates and materials such as AISI 904 L, SMO 254 and Hastelloy C22.

Due to the abovementioned problems, so-called convex ends are generally used in containers and tube heat exchangers. The wall strength of the convex end is typically the same magnitude as that of the wall of the circular shell. Thus cost savings can be achieved with the use of convex ends. The cost savings can be significant especially when the diameter of the shell is large and/or when using expensive materials, such as for example acid-proof steel and the above-mentioned more precious metals.

OBJECT AND BRIEF DESCRIPTION OF THE INVENTION

It is an object of the present invention to reduce or even to eliminate above-mentioned problems appearing in the prior art.

It is especially an object of the present invention to provide a plate heat exchanger, the manufacturing of which is inexpensive and easy.

It is an object of the present invention to make possible the use of a space separate from the shell, which space supports the plate pack, in plate heat exchangers.

It is still another object of the present invention to make possible the use of thinner end plates for supporting the plate pack of a plate heat exchanger.

In order to realize the above-mentioned objects, among other things, the present invention is characterized by what is presented in the characterizing parts of the enclosed independent claims.

The embodiments and advantages mentioned in this text are in suitable parts applicable to both a plate heat exchanger and a method for supporting a plate

pack of a plate heat exchanger according to the invention, even if this is not always specifically mentioned.

A typical plate heat exchanger according to the invention comprises a plate pack formed by heat exchange plates and a shell surrounding the plate pack, wherein

- inlet and outlet connections for a first and a second heat exchange medium have been arranged through the shell,
- the inlet and outlet connection of the first heat exchange medium has been arranged in connection with inner parts of the plate pack, whereby a primary circuit of the plate heat exchanger is formed between the inlet and outlet connection of the first heat exchange medium,
- the inlet and outlet connection of the second heat exchange medium has been arranged in connection with the inside of the shell, i.e. the outside of the plate pack, whereby a secondary circuit of the plate heat exchanger is formed between the inlet and outlet connection of the second heat exchange medium,

and a convex end of the plate heat exchanger forms a space separate from the shell. In other words a space is arranged inside a convex end of the heat exchanger, which space is at least essentially separate from the space formed by the shell surrounding the plate pack.

A typical method according to the invention for supporting a plate pack of a plate heat exchanger comprises at least the following steps of

- arranging a shell around the plate pack and inlet and outlet connections through it for a first and a second heat exchange medium,
- arranging the inlet and outlet connection of the first heat exchange medium in connection with inner parts of the plate pack, whereby a primary circuit of the plate heat exchanger is formed between the inlet and outlet connection of the first heat exchange medium,
- arranging the inlet and outlet connection of the second heat exchange medium in connection with the inside of the shell, i.e. the outside of the plate pack, whereby a secondary circuit of the plate heat exchanger is

formed between the inlet and outlet connection of the second heat exchange medium

and supporting the plate pack with a space separate from the shell, which space is formed by the convex end of the plate heat exchanger. In other words a space is arranged inside a convex end of the heat exchanger, which space is at least essentially separate from the space formed by the shell surrounding the plate pack.

The separate space formed by the convex end can for example be filled with a suitable solid filler, such as concrete. The filler can for example be liquid. The filler can for example be the liquid heat exchange medium used in the heat exchanger. The separate space in the end can be arranged in liquid contact with the inner parts of the shell or the plate pack, whereby the first or second heat exchange medium can flow inside the convex end. When supporting a plate pack with the aid of a filled space separate from the shell, the end plate supporting the plate pack can for example be arranged to be thinner or the end plate can be manufactured from a material, the breaking strength or yield strength of which is weaker. Thus cost savings can be achieved.

A typical plate heat exchanger according to the invention can for example comprise 1 or 2 spaces formed by a convex end, which spaces are separate from the shell. The convex ends can be arranged for example in connection with the end plates of the plate pack of the plate heat exchanger. A typical convex end according to the invention can be shaped for example as a so-called fully convex outwards convex space or alternatively plate-like, whereby a part of the end of the space separate from the shell is straight. The part of the convex end, which is towards the plate pack of the plate heat exchanger, is advantageously a straight plate. The straight plate of the convex end can for example be attached to the walls of the shell and/or it can for example be attached to be floating against a straight end plate of the plate pack of the plate heat exchanger. The convex end can also be attached to a flange, which flange is in turn welded to the shell. The convex end can be attached to the shell with a flange connection. The size and thickness of the convex end are determined based on the support need and

pressure differences of the plate pack. The wall strength of the convex end can for example be the same magnitude as the wall of the shell.

The heat exchange plates according to the invention can for example be shaped approximately as circles, the diameter of which is for example 0.2–1.5 meters. The heat exchange plates according to the invention can be grooved or corrugated. The heat exchange performance of a heat exchanger can be adjusted by grooving and corrugation. The plate heat exchanger according to the invention can for example be shaped as a substantial circlular cylinder, the length of which can for example be 0.5–3 meters and the diameter 0.2–1.6 meters.

According to an embodiment of the invention an end plate has been arranged between the convex end and the plate pack. The plate pack can be supported with the aid of the end plate arranged in connection with the plate pack of the plate heat exchanger. An end plate can be arranged in both ends of the plate pack. The end plate can be for example of steel.

According to an embodiment of the invention the plate pack has a straight end plate attached thereto and the bottom of the space separate from the shell, which space is formed by the convex end, is a straight plate, against which the straight end plate of the plate pack is supported. There are advantageously straight end plates in both ends of the heat exchange plate pack and there are convex ends in both ends of the plate pack, forming spaces separate from the shell, the bottoms of the spaces being straight plates, against which the straight end plates of the plate pack are supported.

According to an embodiment of the invention the inlet and outlet connection of the primary circuit is arranged through the space formed by the convex end, which space is separate from the shell. If the plate heat exchanger has several inlet and outlet connections of the primary circuit, they can be arranged for example through the separate space formed by the convex end arranged in connection with one end of the plate heat exchanger.

According to an embodiment of the invention the primary circuit of the plate heat exchanger is arranged in liquid contact with the space formed by the convex end, which space is separate from the shell. The primary circuit of the plate heat exchanger can be arranged in liquid contact with the space separate from the shell, for example by cutting the inlet connection or outlet connection of the primary circuit inside the space separate from the shell, so that the first heat exchange medium flows into the space formed by the convex end, which space is separate from the shell. A pressure which is at least approximately as high as the one in the inner parts of the plate pack then prevails in the space separate from the shell. Such an arrangement is especially advantageous when the pressure of the primary circuit prevailing in the inner parts of the plate pack is high in relation to the pressure of the secondary circuit. If there is a space separate from the shell in connection with both ends of the plate pack, the inlet connections or outlet connections of the primary circuit can be cut inside the space separate from the shell in both ends of the plate pack.

According to an embodiment of the invention the secondary circuit of the plate heat exchanger is arranged in liquid contact with the space formed by the convex end, which space is separate from the shell. The secondary circuit can be arranged in liquid contact with the space separate from the shell, for example by arranging an opening in the straight end plate which separates the separate space and the shell part from each other, so that the heat exchange medium of the secondary circuit flows from the shell into the separate space. A liquid contact is advantageously arranged between the secondary circuit and the space separate from the shell, so that heat exchange medium cannot flow from the inlet connection of the shell to the outlet connection without the heat exchange medium flowing first between the heat exchange plates. Such an arrangement is especially advantageous when the pressure of the secondary circuit is high in relation to the pressure of the primary circuit.

According to an embodiment of the invention the space formed by the convex end, which space is separate from the shell, is filled with a filler. The filler can be solid, for example concrete. The filler is advantageously almost incompressible. If

the plate heat exchanger has an end plate, the thermal expansion coefficient of the filler is advantageously approximately as large as that of the end plate. A space formed by the convex end, which space is separate from the shell and filled with a filler, can be considered to be a rigid entity, and a great amount of strength is thus not required from the straight plate of the space separate from the shell of the plate heat exchanger. In this case the end plate supporting the plate pack can for example be attached to be floating against the straight bottom plate of the space separate from the shell, against which bottom plate it is freely supported.

According to an embodiment of the invention a protection plate has been arranged between the plate pack and the filler of the space formed by the convex end, which space is separate from the shell.

According to an embodiment of the invention protecting pipes have been arranged between the inlet connection of the first heat exchange medium and the filler of the space formed by the convex end, which space is separate from the shell, and between the outlet connection of the first heat exchange medium and the filler of the space separate from the shell.

According to an embodiment of the invention the thickness of the end plate of the plate pack, which supports the plate pack, is dimensioned with the aid of the push force of the plate pack and the pressure prevailing in the space formed by the convex end, which space is separate from the shell. Because the pressure in the space separate from the shell is usually higher than the pressure outside the plate heat exchanger, thinner end plates of the plate pack can be used in the plate heat exchanger.

According to an embodiment of the invention the space formed by the convex end, which space is separate from the shell, is attached to the shell so that the space separate from the shell can easily be detached. A flange can for example be welded to the shell, to which flange a flange of the separate space is in turn attached for example with bolts.

According to an embodiment of the invention the plate heat exchanger is a plate heat exchanger according to the so-called Plate & Shell ™ technology developed by the applicant, which consists of a plate pack formed by heat exchange plates and of a shell surrounding it. The plate pack is made up of several plate pairs. Each plate pair is formed of two heat exchange plates, which are welded together at least at their outer periphery. Each heat exchange plate has at least two first openings for the flow of the first heat exchange medium. Adjacent plate pairs are attached together by welding or by otherwise combining the first openings of two adjacent plate pairs to each other. Thus the first heat exchange medium can flow from a plate pair to another via the first openings. The second heat exchange medium is arranged to flow inside the shell in the spaces between the plate pairs. Inlet and outlet connections for the first as well as for the second heat exchange medium have been arranged through the shell of the Plate & Shell ™ plate heat exchanger. The inlet and outlet connection of the first heat exchange medium has been arranged in connection with the inner parts of the plate pack. The primary circuit of the plate heat exchanger is thus formed between the inlet and outlet connection of the first heat exchange medium. The inlet and outlet connection of the second heat exchange medium has been arranged in connection with the inside of the shell, i.e. the outside of the plate pack. In other words, the secondary circuit of the plate heat exchanger is formed between the inlet and outlet connection of the second heat exchange medium, inside the shell, in the spaces between the plate pairs. Typically, the primary and secondary circuits are separate from each other, i.e. the first heat exchange medium flowing in the inner part of the plate pack cannot get mixed with the second heat exchange medium flowing in the shell, i.e. outside the plate pack. Thus, the first primary side heat exchange medium flows in every other plate space and the second secondary side heat exchange medium flows in every other plate space of an advantageous plate heat exchanger according to the invention.

BRIEF DESCRIPTION OF THE FIGURES

The invention is described in more detail below with reference to the enclosed schematic drawing, in which

Figure 1 shows a cross-section from the side of a plate heat exchanger according to an embodiment of the invention,

Figure 2 shows a cross section of the plate heat exchanger of Figure 1 seen from the end,

Figure 3 shows a heat exchange plate according to an embodiment of the invention,

Figure 4 shows an arrangement according to an embodiment of the invention,

Figure 5 shows an arrangement according to an embodiment of the invention,

Figure 6 shows an arrangement according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE EXAMPLES OF THE FIGURES

Figure 1 shows a plate heat exchanger 1, inside the shell 3 of which a plate pack 2 has been arranged. The flows of the heat exchange mediums are shown with arrows. The convex end 6 according to the invention is in Figure 1 shown with dotted lines only in one end of the heat exchanger 1.

The plate pack 2 is attached between the end plates 7a, 7b. The plate pack 2 consists of plate pairs, each of which is formed by welding two heat exchange plates 10 shown in Figure 3 together at their outer periphery 10a. For the sake of clarity of the figures, the plate pairs are not shown in greater detail. Each heat exchange plate has two openings 11a and 11b for the flow of the first heat exchange medium, i.e. for the primary circuit. The heat exchange plates are grooved 10b so that a flow channel remains inside the plate pair from opening 11a to opening 11b. The plate pairs are welded together at the edges of the adjacent openings 11a and 11b. The openings form flow channels 12a and 12b penetrating the entire plate pack. Inlet connections 13a and 13b of the first heat exchange medium and outlet connections 14a and 14b of the first heat exchange medium have been arranged at the flow channels 12a and 12b through the end plates 7a and 7b at the ends of the plate pack. The primary circuit of the plate heat exchanger 1 thus passes via inlet connections 13a and 13b to the inner flow channel 12a of the plate pack, from there further inside the plate pairs from opening 11a to opening 11b and to the inner flow channel 12b of the plate pack and along it out of the outlet connection 14a and 14b.

An inlet connection 15a of the second heat exchange medium has been arranged through the upper part 3a of the shell. An outlet connection 15b of the second heat exchange medium has been arranged through the lower part 3b of the shell. Flow guides 16a and 16b have been arranged between the plate pack 2 and the shell 3, which flow guides force the second flow medium into the spaces between the plate pairs of the plate pack in the upper part 17a of the plate heat exchanger in the instant vicinity of the inlet connection 15a. On the other hand, the flow guides 16a and 16b allow the second flow medium to exit from the spaces between the plate pairs only in the lower part 17b of the plate heat exchanger, near the outlet connection 15b. The secondary circuit of the plate heat exchanger 1 thus passes from the inlet connection 15a to the upper part 17a of the plate heat exchanger, from there via the spaces between the plate pairs of the plate pack to the lower part 17b of the plate heat exchanger and to the outlet connection 15b.

The thickness of the heat exchange plate 10 seen in Figure 3 in a perpendicular direction to the view of the figure is for example 0.7–1.2 mm.

Figure 4 shows an arrangement according to an embodiment of the invention, where the space 20 formed by the convex end 6, which space is separate from the shell, is filled with a filler. The space 20 separate from the shell is filled with a cast concrete and closed with a thin protecting plate 8. The connection holes are closed with a thin protecting tube 9. The end plate 7, which supports the plate pack, is attached to float against the straight bottom plate of the space 20 separate from the shell, on which bottom plate it is freely supported.

Figure 5 shows an arrangement according to an embodiment of the invention, where the space 20 formed by the convex end 6, which space is separate from the shell 3, is arranged in liquid contact with the primary circuit of the plate heat exchanger 1. The space 20 separate from the shell is connected to the shell 3, which is closed with the straight end 7. The inlet connection 4 of the primary circuit is cut inside the space 20 separate from the shell. The outlet connection 5 of the primary circuit is continuous. The arrangement leads to the pressure being at least

almost as high in the space 20 separate from the shell as in the inner parts of the plate pack 2. The end plate 7 of the plate heat exchanger can thus be dimensioned to be thinner, if the pressure of the secondary circuit is low in relation to that of the primary circuit.

Figure 6 shows an arrangement according to an embodiment of the invention, where the space 20 formed by the convex end 6, which space is separate from the shell, is arranged in liquid contact with the secondary circuit of the plate heat exchanger 1. The space 20 separate from the shell is connected with the straight end to the shell 3 of the plate heat exchanger. A piece has been cut out of the upper part of the end plate 7 of the plate heat exchanger, whereby the second heat exchange medium can flow into the space 20 separate from the shell, and whereby the pressure in the space separate from the shell is at least almost as high as in the secondary circuit of the plate heat exchanger. If the pressure of the primary circuit is low in relation to that of the secondary circuit, the end plate 7 of the plate heat exchanger can be dimensioned to be thin.

The figures show only some preferred embodiment examples according to the invention. The figures do not specifically show matters that are of secondary importance in view of the main idea of the invention, known as such or obvious as such for someone skilled in the art. It is apparent to someone skilled in the art that the invention is not limited exclusively to the examples presented above, but that the invention may vary within the scope of the claims presented below. The dependent claims present some possible embodiments of the invention, and they are not to be considered to restrict the scope of protection of the invention as such.

CLAIMS

1. A plate heat exchanger (1), which comprises a plate pack (2) formed by heat exchange plates and a shell (3) surrounding the plate pack, wherein

- inlet and outlet connections for a first and a second heat exchange medium have been arranged through the shell,
- the inlet and outlet connection (4, 5) of the first heat exchange medium has been arranged in connection with the inner parts of the plate pack, whereby a primary circuit of the plate heat exchanger is formed between the inlet and outlet connection of the first heat exchange medium,
- the inlet and outlet connection (15a, 15b) of the second heat exchange medium has been arranged in connection with the inside of the shell, i.e. the outside of the plate pack, whereby a secondary circuit of the plate heat exchanger is formed between the inlet and outlet connection of the second heat exchange medium,

characterized in that the end of the plate heat exchanger comprises a convex end (6), which forms a space (20) separate from the shell.

2. The plate heat exchanger according to claim 1, **characterized** in that a straight end plate (7) has been arranged between the convex end and the plate pack.

3. The plate heat exchanger according to claim 1 or 2, **characterized** in that the inlet and outlet connection of the primary circuit is arranged through the space (20) formed by the convex end (6), which space is separate from the shell.

4. The plate heat exchanger according to any of the preceding claims, **characterized** in that the space (20) formed by the convex end, which space is separate from the shell, is filled with a filler.

5. The plate heat exchanger according to claim 4, **characterized** in that the filler is the first or the second heat exchange medium.

6. The plate heat exchanger according to any of the preceding claims, **characterized** in that the primary circuit of the plate heat exchanger is arranged in liquid contact with the space (20) formed by the convex end, which space is separate from the shell.

7. The plate heat exchanger according to any of the preceding claims 1–5, **characterized** in that the secondary circuit of the plate heat exchanger is arranged in liquid contact with the space (20) formed by the convex end, which space is separate from the shell.

8. The plate heat exchanger according to claim 4, **characterized** in that the filler is solid.

9. The plate heat exchanger according to claim 8, **characterized** in that the filler is concrete.

10. The plate heat exchanger according to any of the preceding claims 4–9, **characterized** in that a protecting plate (8) has been arranged between the plate pack and the filler of the space formed by the convex end, which space is separate from the shell.

11. The plate heat exchanger according to any of the preceding claims 4–10, **characterized** in that protecting pipes (9) have been arranged between the inlet connection of the first heat exchange medium and the filler of the space formed by the convex end, which space is separate from the shell, and between the outlet connection of the first heat exchange medium and the filler of the space separate from the shell.

12. A method for supporting a plate pack (2) of a plate heat exchanger (1), which method has at least the steps of

- arranging a shell (3) around the plate pack and inlet and outlet connections through it for a first and second heat exchange medium,

- arranging the inlet and outlet connection (4, 5) of a first heat exchange medium in connection with inner parts of the plate pack, whereby a primary circuit of the plate heat exchanger is formed between the inlet and outlet connection of the first heat exchange medium,
- arranging the inlet and outlet connection (15a, 15b) of the second heat exchange medium in connection with the inside of the shell, i.e. the outside of the plate pack, whereby a secondary circuit of the plate heat exchanger is formed between the inlet and outlet connection of the second heat exchange medium,

characterized in supporting the plate pack with a space (20) formed by a convex end (6) of the plate heat exchanger, which space is separate from the shell.

13. The method according to claim 12, **characterized** in supporting the plate pack with an end plate (7) arranged between the convex end and the plate pack.

14. The method according to claim 12 or 13, **characterized** in arranging the space (20) separate from the shell in liquid contact with the primary circuit of the plate heat exchanger.

15. The method according to claim 12 or 13, **characterized** in arranging the space (20) separate from the shell in liquid contact with the secondary circuit of the plate heat exchanger.

16. The method according to any of the preceding claims 12–15, **characterized** in filling the space (20) separate from the shell with a filler.

17. The plate heat exchanger according to claim 16, **characterized** in that the filler is the first or the second heat exchange medium.

18. The plate heat exchanger according to claim 16, **characterized** in that the filler is a solid filler.

19. The plate heat exchanger according to claim 18, **characterized** in that the filler is concrete.

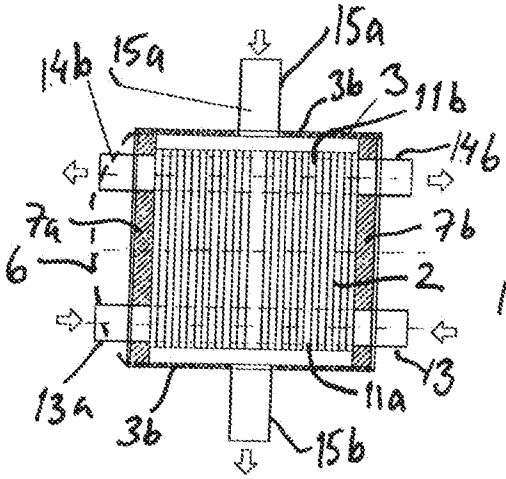

FIG. 1

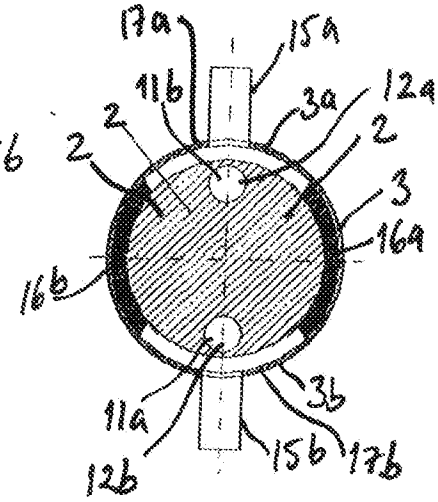

FIG. 2

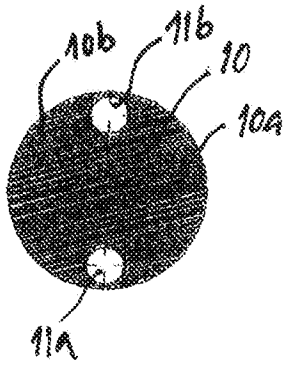

FIG. 3

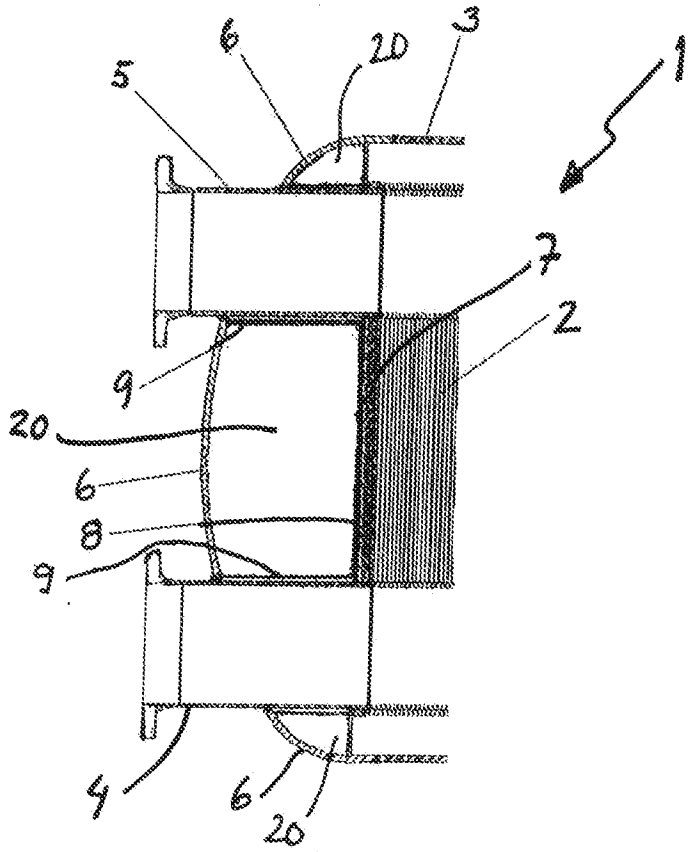

FIG. 4

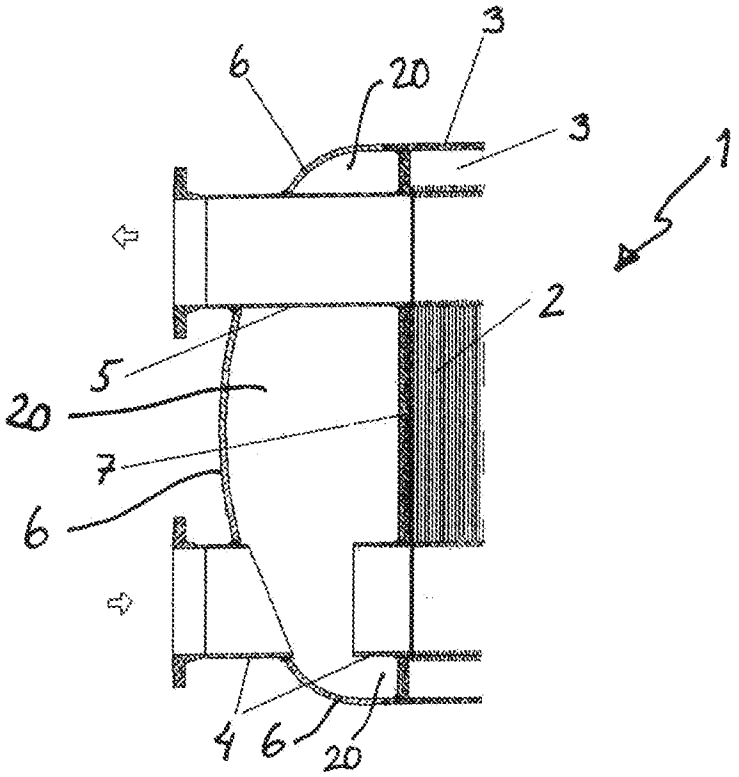

FIG. 5

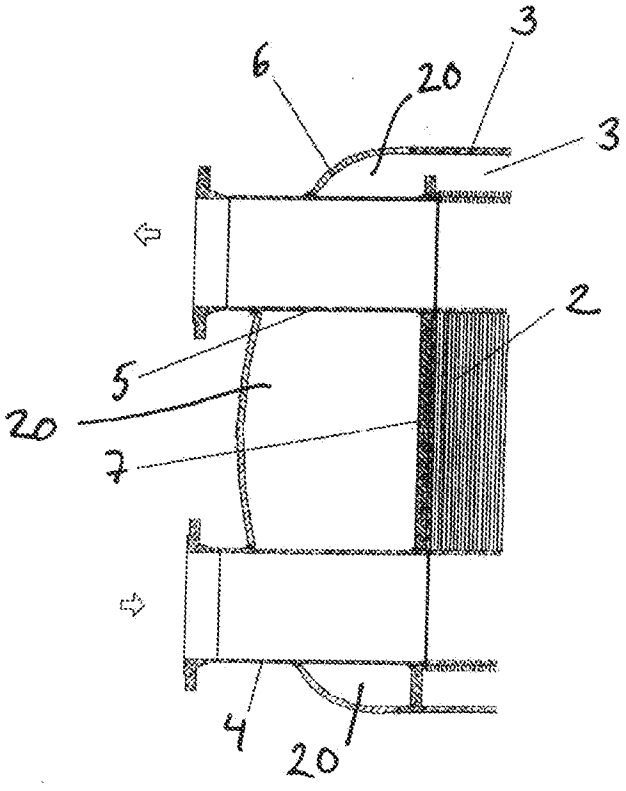

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2010/050541

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: F28F, F28D

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

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 3568765 A (KONRAD OTTO) 09 March 1971 (09.03.1971) column 2, lines 12-38	1, 2, 4-8, 10, 12-18 3, 11
X Y	WO 9712189 A1 (TETRA LAVAL HOLDINGS & FINANCE et al.) 03 April 1997 (03.04.1997) see page 9, line 29 - page 10, line 16, page 12, lines 4-11, figures 7-8	1, 2, 4, 5, 8-10, 12-19 3, 11
Y	GB 2132330 A (APV CO LTD) 04 July 1984 (04.07.1984) page 1, lines 93-127, page 2, lines 8-51, figure 1	3, 11

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

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Date of the actual completion of the international search	Date of mailing of the international search report
13 September 2010 (13.09.2010)	11 October 2010 (11.10.2010)

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Information on patent family members

International application No.
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INTERNATIONAL SEARCH REPORT

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CLASSIFICATION OF SUBJECT MATTER

Int.Cl.
F28F 3/08 (2006.01)
F28D 9/00 (2006.01)