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(54) Benævnelse: **Dividing plate between Heat plates**

(56) Fremdragne publikationer:
WO 2015/121536 A1
US 2008/0110603 A1
US 3228464 A
US 4044825 A
US 3759322 A

(57) Sammendrag:
The invention relates to a heat exchanger (1) comprising a top plate (2) and a bottom plate (3) as well as a plurality of structured plates (4, 5) arranged between the top plate (2) and the bottom plate (3), wherein adjacent structured plates (4, 5) cooperate to form primary fluid channels (10) and secondary fluid channels (11) between neighboring structured plates (4, 5). Task of the invention is to provide a heat exchanger (1) that may be produced with a wider range of parameters without increasing the costs of manufacture. According to the invention this task is solved in that the heat exchanger (1) comprises at least two stacks of structured plates (14, 15). The structured plates (4, 5) in at least one of the stacks of structured plates (14, 15) form different primary fluid channels (10) and secondary fluid channels (11) than the fluid channels (10) and secondary fluid channels (11) in at least one other stack of structured plates (14, 15).

Fortsættes ...

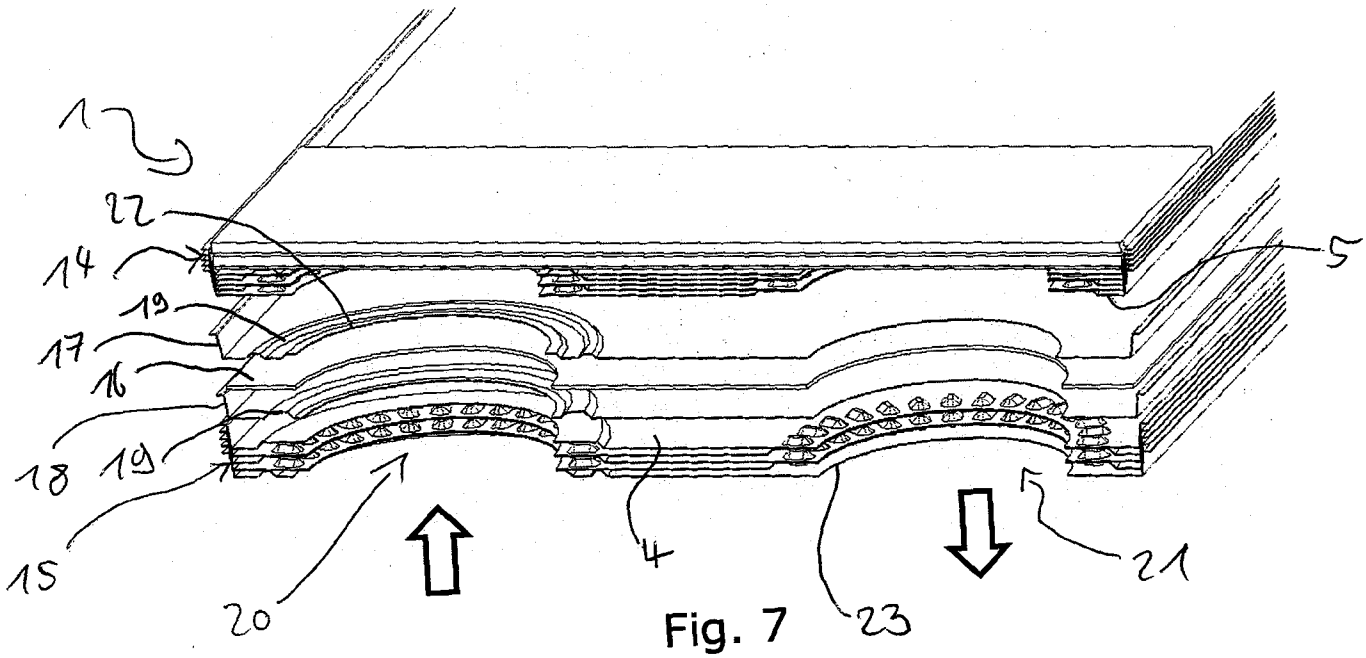

Fig. 7

Heat Exchanger

The invention relates to a heat exchanger comprising a top plate and a bottom plate as well as a plurality of structured plates arranged between the top plate and the bottom plate, wherein adjacent structured plates cooperate to form primary fluid channels and secondary fluid channels between neighboring structured plates.

In a plate heat exchanger heat is usually transferred between a first fluid flowing through primary heat channels and a second fluid flowing through secondary fluid channels. The structured plates are stacked on top of each other and fixed between the top and bottom plates by e.g. bolts. Usually each structured plate cooperates to form primary fluid channels on one of its sides and secondary fluid channels on the opposite side of the structured plate.

Plate heat exchangers of the above kind are produced with a plurality of different structured plates and corresponding primary and secondary fluid channels. The type and number of structured plates that is used for the heat exchanger and the resulting shape of the fluid channels then defines the characteristics of the heat exchanger like the heat transfer efficiency, flow speed, pressure drop etc.

In the publication WO2015121536 a heat exchanger is disclosed comprising a stack of heat transfer plates. There is also provided a plate type countercurrent heat exchanger comprising a stack of heat transfer plates forming a primary flow channels for a first flow of heat exchange gas and a secondary flow channels for a second flow of heat exchange gas.

However, only a limited number of standard types of structured plates are mass produced and can be used to assemble heat exchangers costs efficiently. If a heat exchanger is however desired with specifications that cannot be achieved using one of the types of mass produced standard structured plates, then this will require to use a non-standard design of

structured plates resulting in an increased cost and production time for the heat exchanger.

Task of the invention is therefore to provide a heat exchanger that can be produced with a wide range of specifications without increasing the costs or production time.

According to the present invention the above task is solved in that the heat exchanger comprises at least two stacks of structured plates, wherein the structured plates in at least one of the stacks of structured plates form different primary fluid channels and secondary fluid channels than the primary fluid channels and the secondary fluid channels in at least one other stack of structured plates.

This solution allows to produce heat exchangers with a wider range of specifications by using stacks of different types of structured plates in the same heat exchanger. The individual structured plates can however still be chosen from standard, mass produced types and consequently the production costs and time is not significantly increased compared to a standard heat exchanger.

The types of structured plates that are used may be chosen such that a cooperation of the adjacent structured plates where different stacks meet is possible or by separating adjacent stacks.

In an embodiment between each pair of adjacent stacks of structured plates a structureless separator plate is arranged. The structureless separator plate may still comprise openings to allow the inlet and outlet flows for the primary and secondary fluid to flow towards or away from the primary and secondary fluid channels. Using a structureless separator plate allows to use different kinds of structured plates that would otherwise not be able to be stacked

directly on top of each other. The latter may otherwise result in the failure of the heat exchanger by deformation during assembly or operation.

In an embodiment at least one transition plate is arranged on each side of the structureless separator plate. The transition plates may serve to keep the primary fluid channels and the secondary fluid channels separated despite the presence of the structureless separator plate. The transition plates may to this end comprise inlet and outlet structures to allow to direct the flow from the primary and secondary inlet as well as from the primary and secondary outlet from and to the correct fluid channels.

In an embodiment one of the transition plates is arranged fitting closely to the adjacent structureless plate for the majority of the area of the structureless plate. The majority of the area of the structureless plate may here mean the area of the structureless plate excluding the area surrounding one of the inlets and one of the outlets such that the first fluid and the second fluid may still be kept separate.

In an embodiment one of the transition plates is arranged fitting closely to an adjacent structured plate of one of the adjacent stacks of structured plates for the majority of the area of the adjacent structured plate. As in the previous embodiment this solution allows to keep the primary fluid and the secondary fluid separate in the region adjacent to the separator plate.

In an embodiment each structured plate comprises at least one primary inlet to and at least one primary outlet from adjacent primary fluid channels, and wherein each structured plate comprises at least one secondary inlet to and at least one secondary outlet from adjacent secondary fluid channels. The same may be true for each structureless separator plate as well as each transition plate. However, the structured plates may comprise inlet and outlet structures that are absent in the structureless separator plates.

In an embodiment adjacent to at least one primary inlet and/or at least one primary outlet and/or at least one secondary inlet and/or at least one secondary outlet a fluid separator structure is arranged in at least one of the structured plates. The fluid separation structure may serve to separate the fluid flowing into the primary fluid channel or secondary fluid channel such that the fluid is distributed more effectively over the whole plane of the structured plate.

In an embodiment at least one fluid separation structure is formed by cooperating ridges of two adjacent structured plates. This embodiment furthermore stabilizes the heat exchanger.

In an embodiment the structured plates in at least one of the stacks of structured plates form alternating hills and valleys to improve the heat transfer between the fluids and said structured plates. Depending on the number of stacks of structured plates used more than one of the stacks of structured plates may comprise structured plates with such alternating hills and valleys. Moreover, the heat exchanger may comprise for example two or more stacks of structured plates with alternating hills and valleys wherein the design of the hill and valley structure of the individual stacks is different.

In an embodiment the structured plates in at least one of the stacks of structured plates form wedge-like structures to improve the heat transfer between the fluids and said structured plates. Again depending on the number of stacks of structured plates several of the stacks may comprise structured plates with wedge-like structures and/or the wedge-like structures of different stacks may differ in design.

Embodiments of the invention will now be described with reference to the figures, wherein:

Fig. 1 shows an external view of a heat exchanger according to the invention,

Fig. 2 shows a simplified top view of a structured plate according to the invention,

Fig. 3 shows a simplified side view of several structured plates arranged on top of each other,

Fig. 4 shows an isometric view of a structured plate according to the invention,

Fig. 5a+b show cooperating adjacent structured plates according to the invention,

Fig. 6 shows an embodiment of a heat exchanger in a partial exploded view,

Fig. 7 shows the same embodiment as Fig. 6 in a cut view through an inlet and an outlet,

Fig. 8 shows a detailed view of an inlet or an outlet with cooperating structured plates in the embodiment according to Fig. 6 and 7,

Fig. 9 shows a cut side view of adjacent stacks of structured plates and a separator plate,

Fig. 10 shows a detailed view of the embodiment according to Fig. 6 to 9 of an outlet of a heat exchanger according to the invention.

Fig. 1 shows a simplified depiction of a heat exchanger 1 according to the invention. The heat exchanger 1 comprises a top plate 2 as well as a bottom plate 3. Between the top plate 2 and the bottom plate 3 a plurality of structured plates 4, 5 are arranged.

Fig. 2 shows a simplified top view of a structured plate 4, 5. The structured plate comprises a primary inlet 6 as well as primary outlet 7. A primary fluid entering through the primary inlet 6 flows over the top side of the structured plate 4, 5 towards the primary outlet 7. Similarly, the structured plate 4, 5 comprises a secondary inlet 8 as well as a secondary outlet 9. A secondary fluid flowing along the bottom side of the structured plate 4, 5 enters through the secondary inlet 8 and flows towards the secondary outlet 9. Heat can then be transferred from the primary fluid to the secondary fluid through the structured plate 4, 5. The respective inlets and outlets may alternatively be arranged diagonally from each other across the structured plate 4, 5.

Along the top side of the structured plate 4, 5 primary fluid channels 10 are thus formed to guide the primary fluid from the primary inlet 6 to the primary outlet 7. Similarly, secondary fluid channels 11 are formed on the bottom side of the structured plate 4, 5 to guide the secondary fluid from the secondary inlet 8 to the secondary outlet 9. The primary fluid channels 10 and the secondary fluid channels 11 may be formed by microstructures such as a pattern of alternating hills 12 and valleys 13 as shown in Fig. 2. Alternatively, the structured plates 4, 5 can also comprise different structures, for example, wedge-like structures.

Fig. 3 shows a side view of four structured plates 4, 5 arranged on top of each other. The topmost structured plate 4, 5 cooperates at its valleys 13 with hills 12 of the structured plate arranged directly below. Thereby, primary fluid channels 10 as well as secondary fluid channels 11 are formed.

Fig. 4 shows an isometric view of a structured plate comprising hills 12 and valleys 13 as in Fig. 2 and 3.

Fig. 5a shows a detail of a structured plate 4 cooperating with an adjacent structured plate 5. A valley 13 of the structured plate 4 cooperates with a hill 12 of the structured plate 5. In this example, the structured plates 4, 5 comprise the same microstructure of hills 12 and valleys 13. The contact surface of the hills 12 has the same extent as the contact surface of the valleys 13 thereby allowing a good stability of the cooperating adjacent structured plates 4, 5.

Fig. 5b shows a slightly different situation in which the microstructure of the structured plates 4, 5 is different. Here, the extent of the contact surface of the valleys 13 of the structure plate 4 is smaller than the contact surface of the hills 12 of the structured plate 5. In principle, it is possible that structured plates 4, 5 with different microstructures can cooperate to form primary fluid channels and secondary fluid channels as long as the structured plates can be stacked in such a way that the cooperating structured plates are sufficiently stable. In the example according to Fig. 5b the distance between neighboring hills and valleys would need to be the same for both structured plates 4, 5 to allow them to cooperate to form primary fluid channels and secondary fluid channels despite the difference in shape of the hills 12 and valleys 13.

Fig. 6 shows a further embodiment of a heat exchanger according to the invention. The heat exchanger 1 comprises two stacks of structured plates 14, 15. Between the stacks of structured plates 14, 15 a structureless separator plate 16 is arranged. The structureless separator plate 16 allows to combine a broad range of different structured plates 4, 5 in the same heat exchanger 1. In particular, the microstructures of the structured plates 4, 5 arranged in the stack of structured plates 14 may be different to the

microstructures of the structured plates 4, 5 arranged in the stack of structured plates 15. The structureless separator plate 16, however, comprises openings to allow the primary and secondary fluid to flow through the structureless separator plate 16 form one stack of structure plates 14, 15 to the next stack of structure plates 14, 15.

Fig. 7 shows an exploded cut view of an embodiment of a heat exchanger 1 according to the invention. In this case, the heat exchanger 1 again comprises two stacks of structured plates 14, 15. The heat exchanger 1 may however comprise a larger number of stacks of structured plates 14, 15. Between the stack of structured plates 14 and the adjacent stack of structured plates 15 a structureless separator plate 16 is arranged. On each side of the structureless separator plate 16 one transition plate 17, 18 is arranged. One of the transition plates 17 is arranged fitting closely to the adjacent structureless plate 16 for the majority of the area of the structureless plate 16. On the other hand, the transition plate 18 is arranged fitting closely to an adjacent structured plate 4 for the majority of the area of the adjacent structured plate 4. Thereby, the transition plates 17, 18 ensure that the primary fluid and the secondary fluid can be kept separate despite the use of the structureless separator plate 16 to separate the stacks of structured plates 14, 15. The transition plates 17, 18 may be structureless apart from inlet structures 19 and/or outlet structures formed to block the entry of a primary or a secondary fluid. In Fig. 7 two arrows show the fluid flow direction through an inlet manifold 20 and an outlet manifold 21. The inlet manifold 20 is formed by a plurality of subsequent inlets 22 in adjacent structured plates 4, 5. Similarly, the outlet manifold 21 is formed by a plurality of outlets 23 arranged in adjacent structured plates 4, 5. The inlet manifold 20 as well as the outlet manifold 21 may furthermore be formed by inlets 22 and outlets 23 formed in the structureless separator plate 16 and/or in the separator plates 18, 19.

Fig. 8 shows a further detail of a heat exchanger 1 according to Fig. 6 and 7. Fig. 8 shows a detail of the inlet manifold 20 as shown in Fig. 7. Furthermore, Fig. 8 shows detailed top views of the transition plates 17, 18 as well as the inlet structures 19 arranged in the transition plates 17, 18. The transition plates 17, 18 comprise similar outlet structures that may, for example, be arranged on the diagonally opposite side of the transition plates 17, 18. Furthermore, Fig. 8 shows a detailed top view of the structure of an inlet 22 of the structured plates 4, 5. The inlet 22 here comprises a fluid separation structure 24. The fluid separation structure 24 comprises cooperating ridges 25. The fluid separation structure 24 serves to separate the fluid flow coming out of the outlet 22 into the corresponding primary fluid channel or secondary fluid channel. The use of such a fluid separation structure 24 improves the heat transfer efficiency of the heat exchanger 1. Irrespective of the structures of the structured plates 4, 5, each of the structured plates 4, 5 may comprise the same fluid separation structure 24 but different primary and secondary fluid channels for each stack structured plates 14, 15.

Fig. 9 shows a cut side view of the cooperation of the structureless separator plate 16 with the adjacent transition plates 17, 18. In particular, Fig. 9 shows how the inlet structure 19 fits to the structureless separator plate 16. Moreover, between the transition plate 18 and the structureless separator plate 16 a primary fluid channel 10 or a secondary fluid channel 11 may be arranged. The transition plate 18 may to this end comprise microstructures (hills and valleys and/or wedge-like structures) to improve the heat transfer but these are omitted for simplicity.

Fig. 10 shows a detailed view of an outlet manifold 21 as shown in Fig. 7. Moreover, Fig. 10 shows a detailed isometric view of a fluid separation structure 24. Adjacent structured plates 4 may here cooperate by comprising matching ridges 25 to both form the fluid separation structure 24 as well as

block the entry of e.g. the secondary fluid flowing into a primary fluid channel 10.

Patentkrav

1. Varmeveksler (1), der omfatter en topplade (2) og en bundplade (3) samt et antal strukturplader (4, 5), der er anbragt mellem toppladen (2) og bundpladen (3), hvor tilstødende strukturplader (4, 5) samvirker til dannelse af primære fluidkanaler (10) og sekundære fluidkanaler (11) mellem nabostrukturplader (4, 5), hvor varmeveksleren (1) omfatter mindst to stakke af strukturplader (14, 15), hvor strukturpladerne (4, 5) i mindst én af stakkene af strukturplader (14, 15) danner primære fluidkanaler (10) og sekundære fluidkanaler (11), der er forskellige fra de primære fluidkanaler (10) og sekundære fluidkanaler (11) i mindst én anden stak af strukturplader (14, 15), der er kendetegnet ved, at der mellem hvert par af tilstødende stakke af strukturplader (14, 15) er anbragt en strukturløs skilleplade (16).

2. Varmeveksler (1) ifølge krav 1, der er kendetegnet ved, at der er anbragt mindst én overgangsplade (17, 18) på hver side af den strukturløse skilleplade (16).

3. Varmeveksler (1) ifølge krav 2, der er kendetegnet ved, at én af overgangspladerne (17, 18) er anbragt, så den passer nøje til den tilstødende strukturløse plade (16) for størstedelen af arealet af den strukturløse plade (16).

4. Varmeveksler (1) ifølge krav 2 eller 3, der er kendetegnet ved, at én af overgangspladerne (17, 18) er anbragt, så den passer nøje til den tilstødende strukturplade (4, 5) i én af de tilstødende stakke af strukturplader (14, 15) for størstedelen af arealet af den tilstødende strukturplade (4, 5).

5. Varmeveksler (1) ifølge et hvilket som helst af kravene 1 til 4, der er kendetegnet ved, at hver strukturplade (4, 5) omfatter mindst ét primært indløb (6) til og mindst ét primært udløb (7) fra tilstødende

primære fluidkanaler (10), og hvor hver strukturplade (4, 5) omfatter mindst ét sekundært indløb til og mindst ét sekundært udløb fra tilstødende sekundære fluidkanaler (11).

6. Varmeveksler (1) ifølge krav 5, der er kendetegnet ved, at mindst ét primært indløb (6) og/eller mindst ét primært udløb (7) og/eller mindst ét sekundært indløb og/eller mindst ét sekundært udløb af en fluidskillestruktur (24) er anbragt i mindst én af strukturpladerne (4, 5).

7. Varmeveksler (1) ifølge et hvilket som helst af kravene 1 til 6, der er kendetegnet ved, at mindst én fluidskillestruktur (24) er dannet ved hjælp af samvirkende kamme (25) på to tilstødende strukturplader (4, 5).

8. Varmeveksler (1) ifølge et hvilket som helst af kravene 1 til 7, der er kendetegnet ved, at strukturpladerne (4, 5) i mindst én af stakkene af strukturplader (14, 15) danner skiftevis bakker (12) og dale (13) til forbedring af varmeoverførslen mellem fluiderne og strukturpladerne (4, 5).

9. Varmeveksler (1) ifølge et hvilket som helst af kravene 1 til 8, der er kendetegnet ved, at strukturpladerne (4, 5) i mindst én af stakkene af strukturplader (14, 15) danner kilelignende strukturer til forbedring af varmeoverførslen mellem fluiderne og strukturpladerne (4, 5).

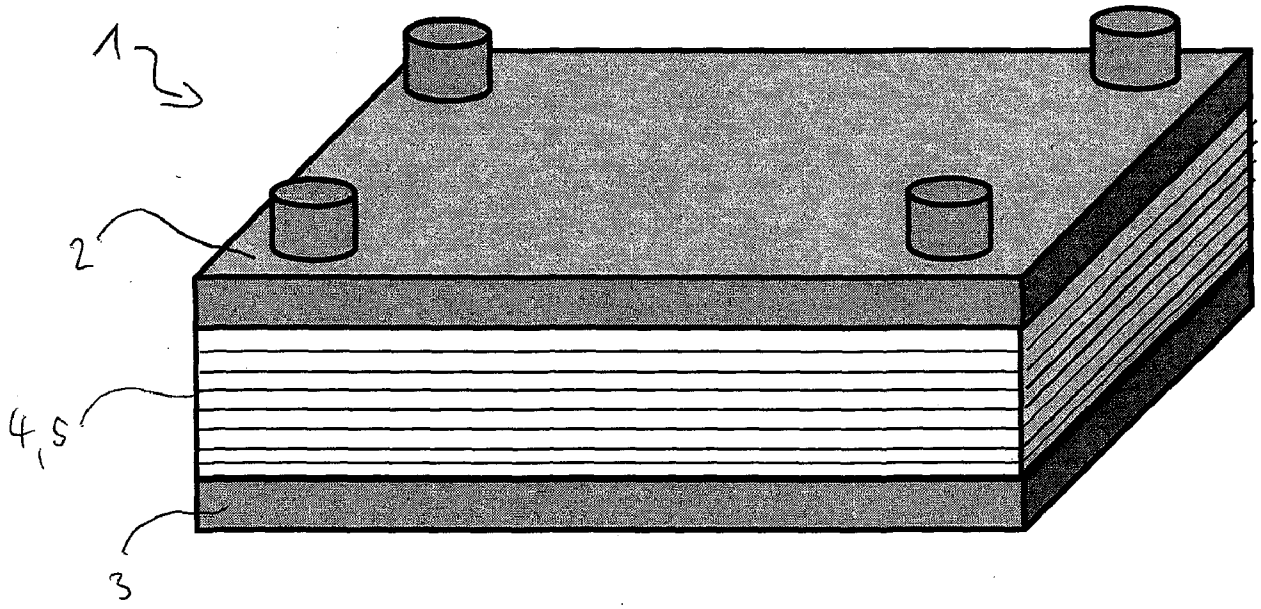

Fig. 1

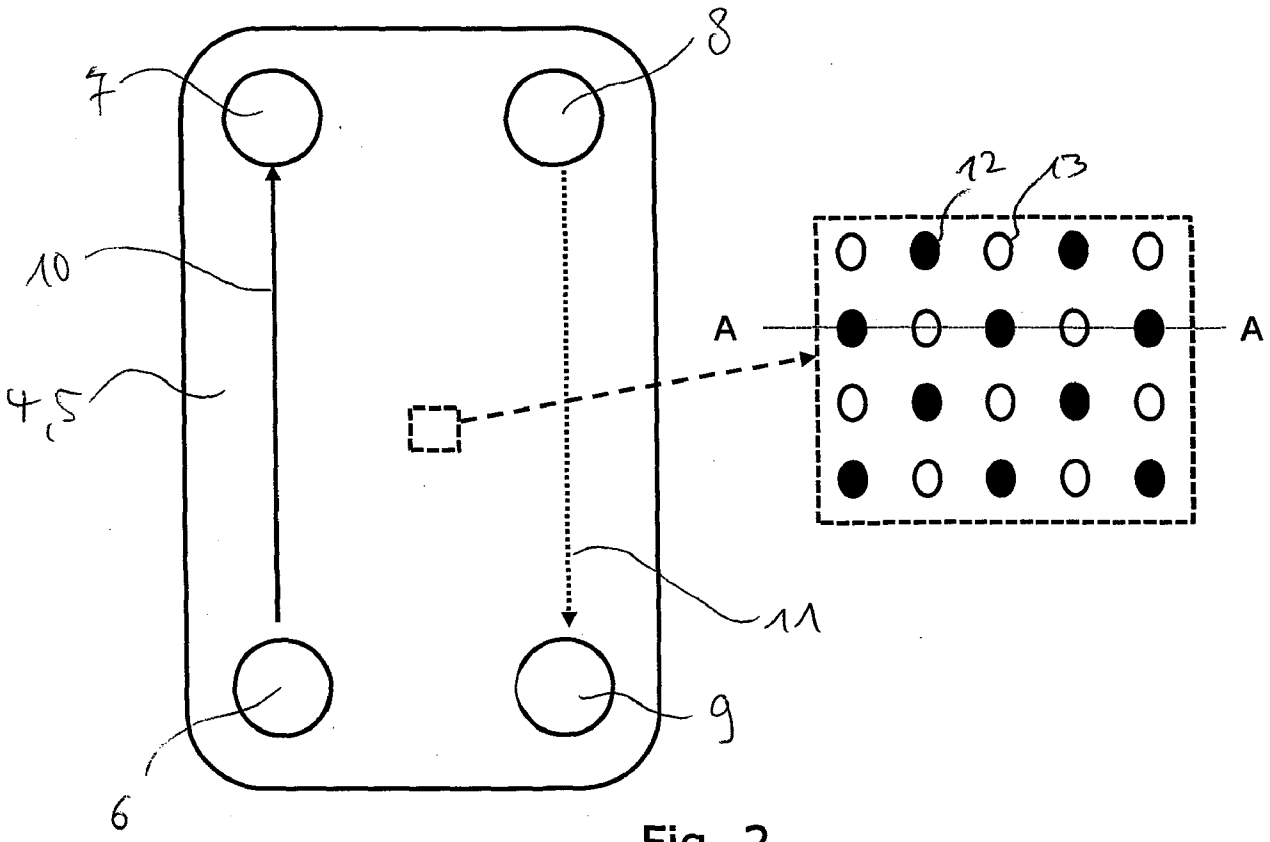

Fig. 2

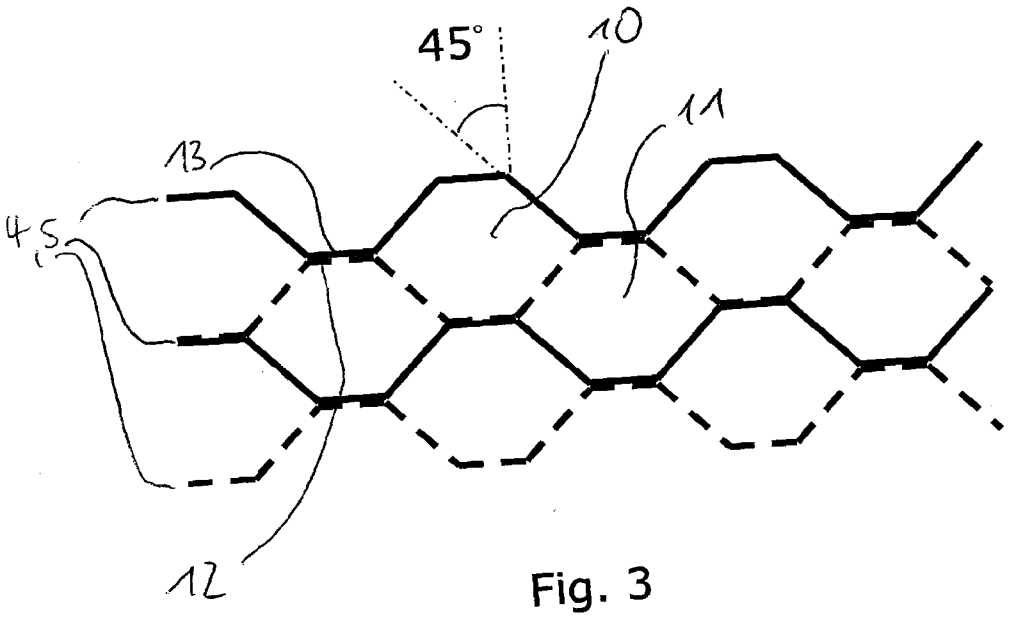

Fig. 3

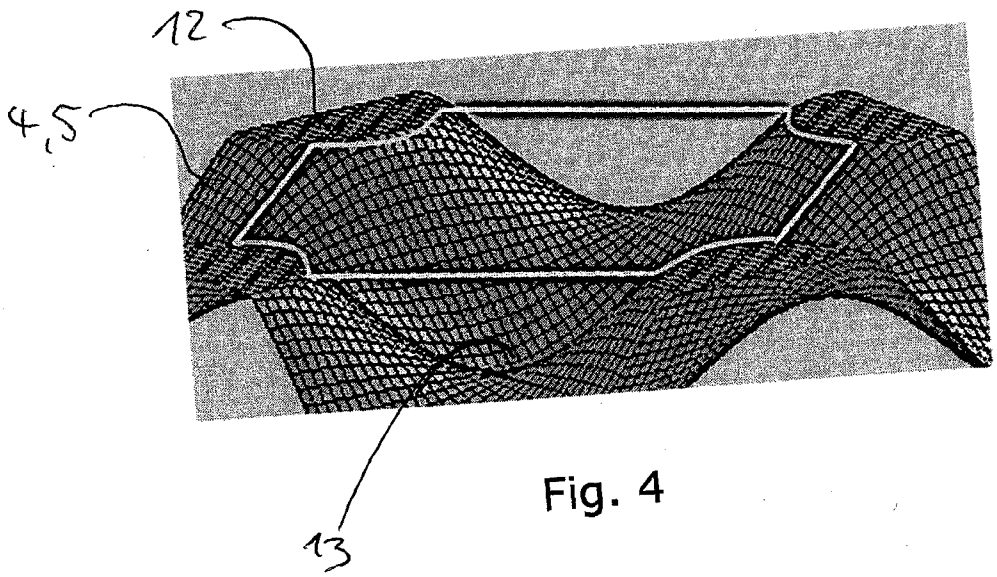

Fig. 4

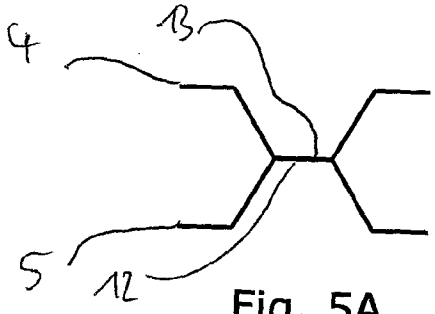

Fig. 5A

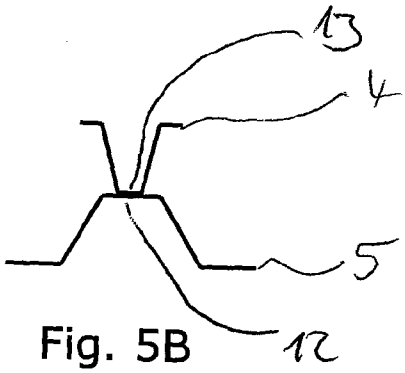

Fig. 5B

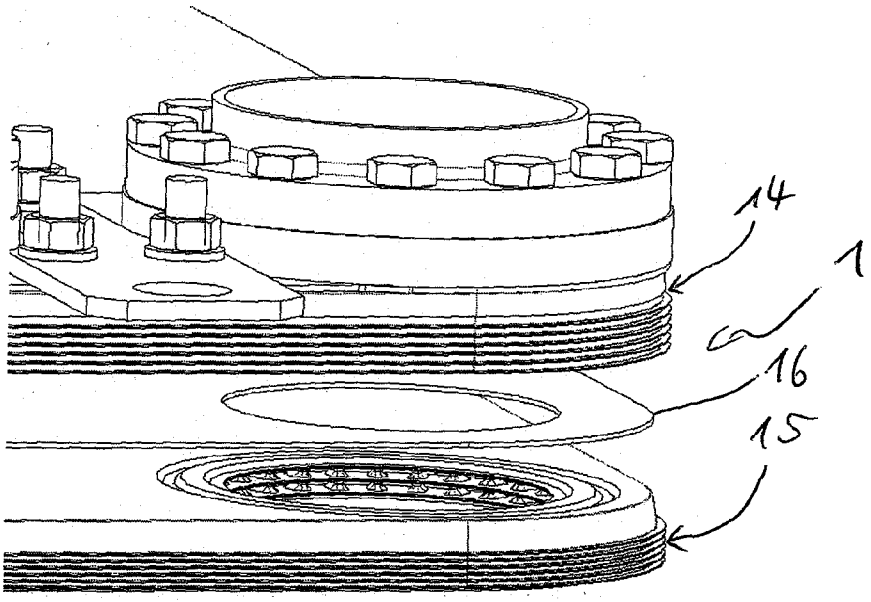

Fig. 6

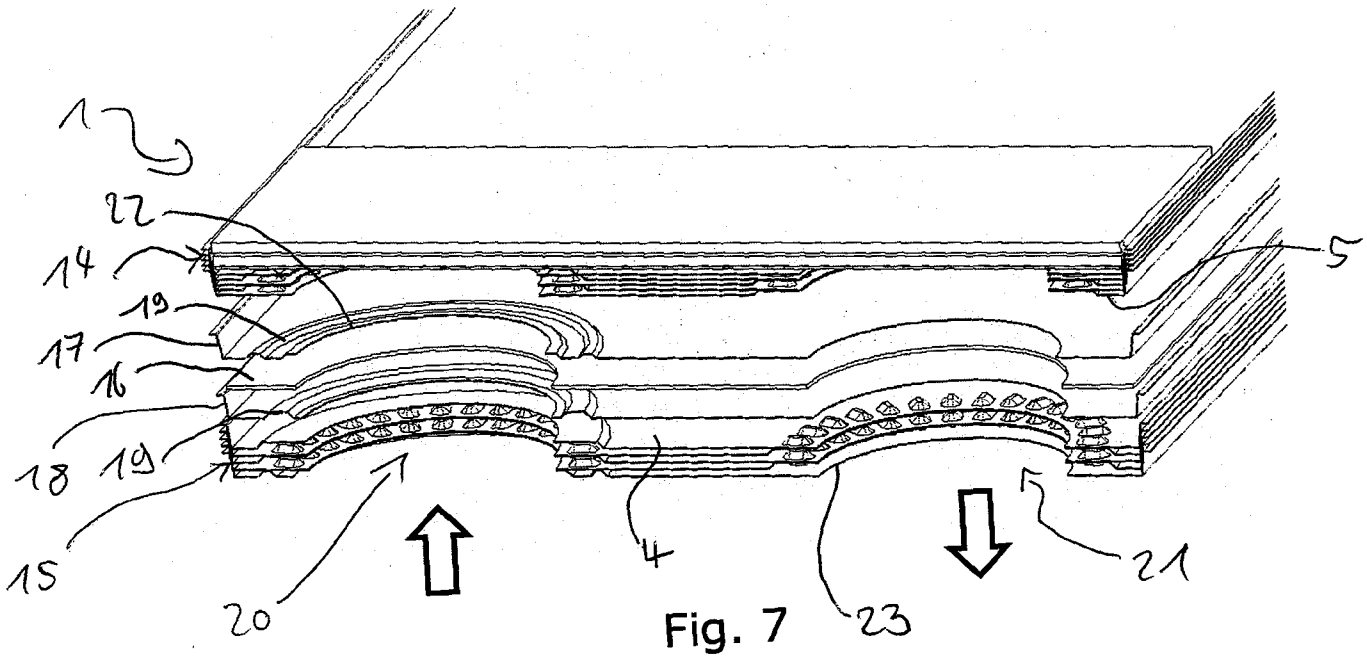

Fig. 7

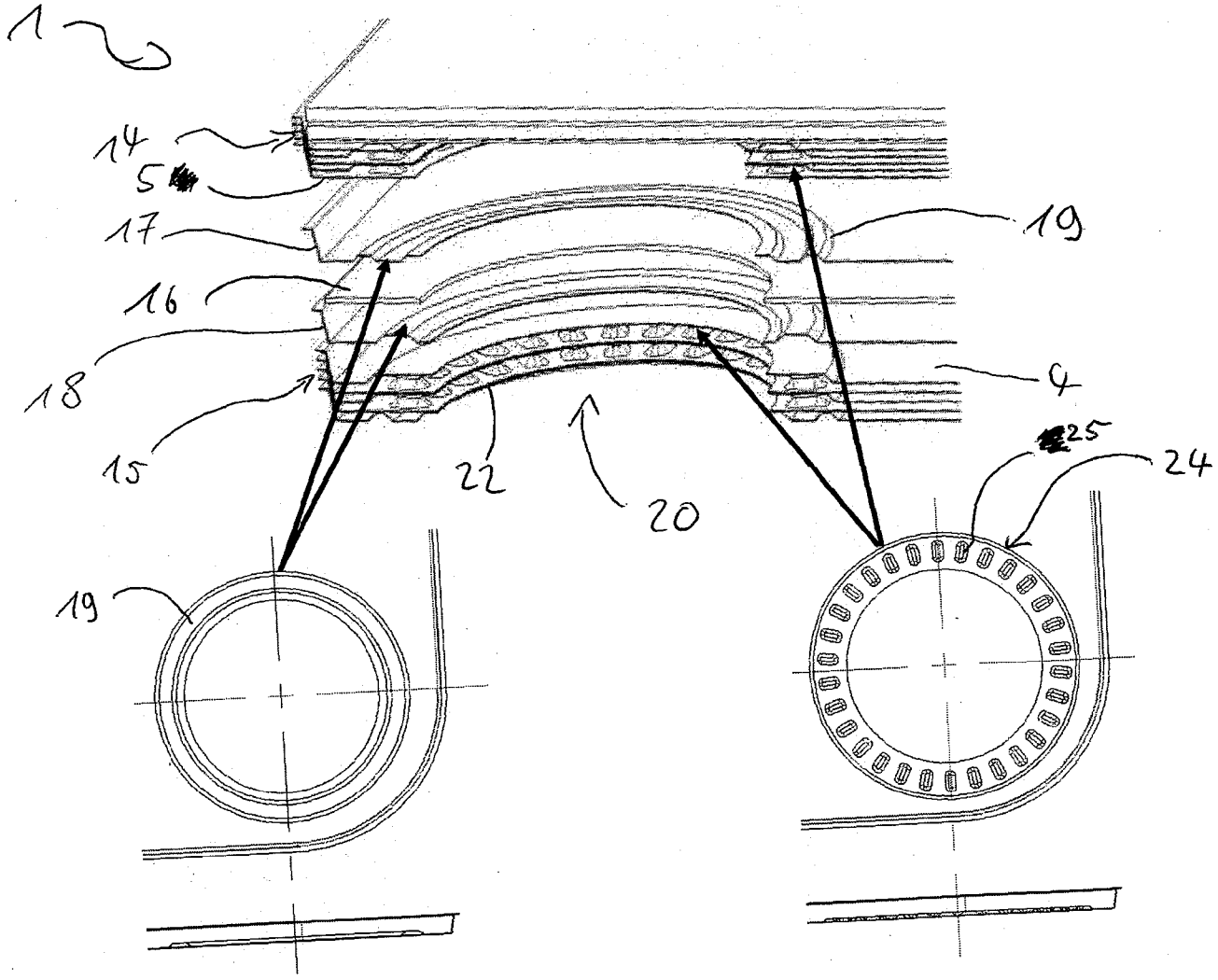

Fig. 8

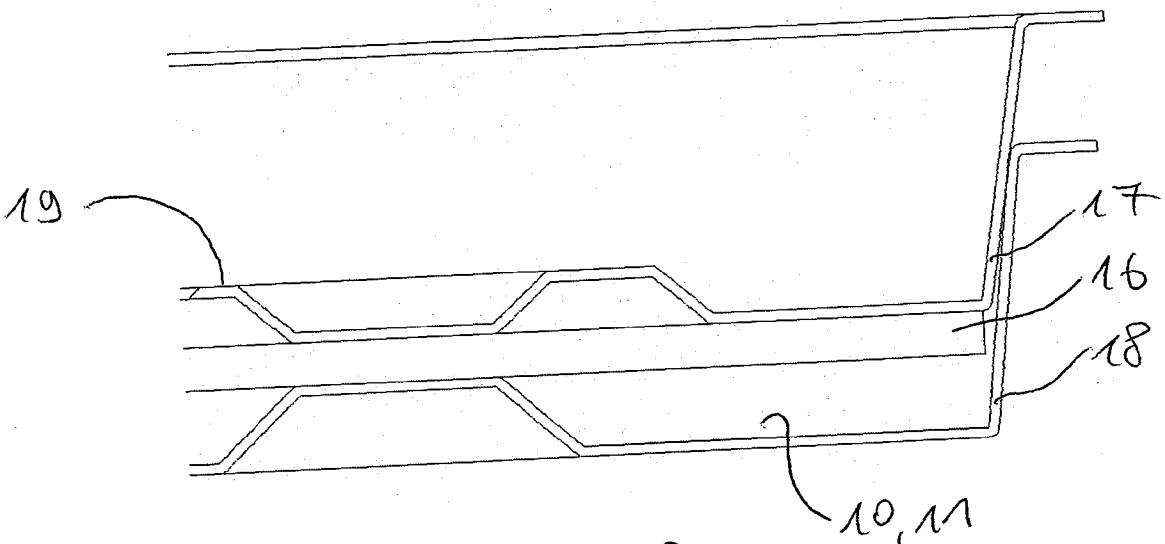

Fig. 9

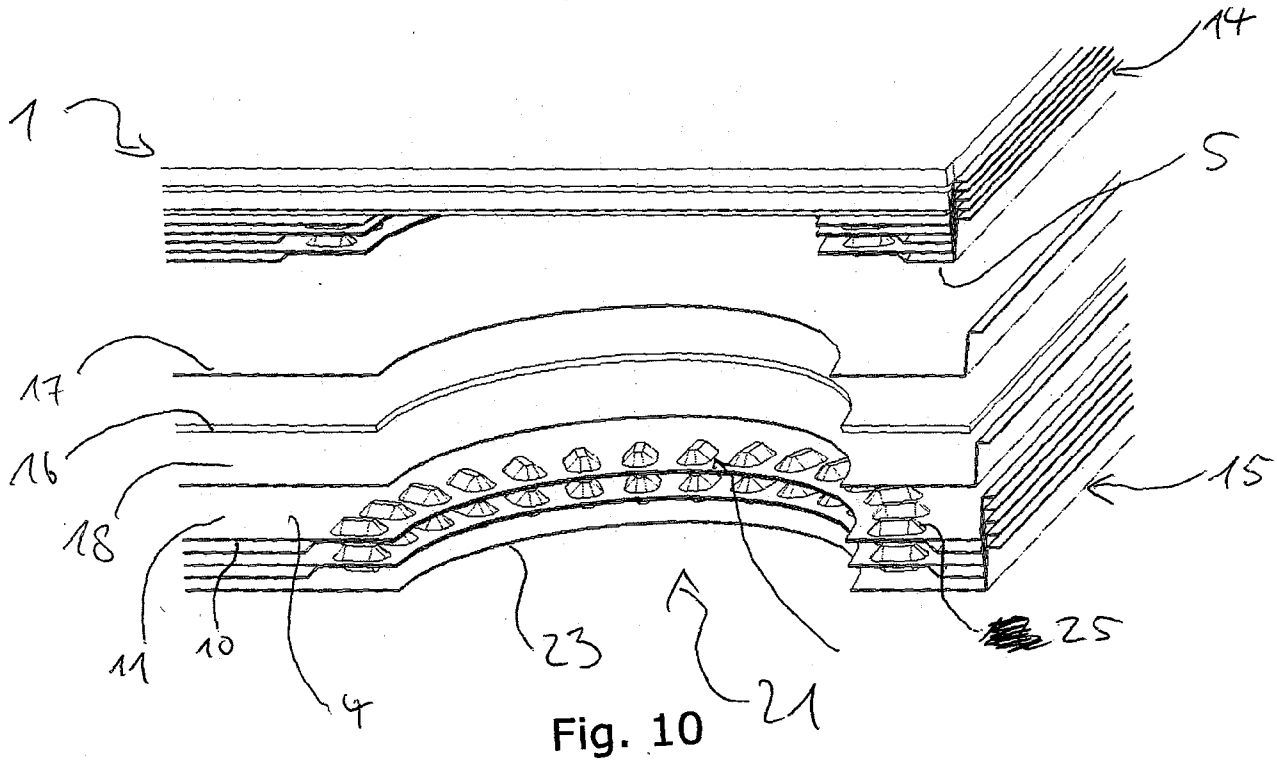

Fig. 10

DANISH PATENT AND TRADEMARK OFFICE

SEARCH REPORT - PATENT	Application No. PA 2017 00141

1. ☐ Certain claims were found unsearchable (See Box No. I).

2. ☐ Unity of invention is lacking prior to search (See Box No. II).

A. CLASSIFICATION OF SUBJECT MATTER

F 28 D 9/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

PCT-minimum documentation searched (classification system followed by classification symbols)

IPC, CPC: F28D; F28F

Documentation searched other than PCT-minimum documentation

DK, NO, SE, FI: IPC-classes as above.

Electronic database consulted during the search (name of database and, where practicable, search terms used)

EPODOC, WPI, FULL TEXT: ENGLISH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.
A	WO 2015/121536 A1 (EKOCOIL OY) 20.08.2015; see whole document, particularly page 10, line 32 to page 11, line 2; figures	1-10
A	US 2008/0110603 A1 (FELLAGUE K. A. et al.) 15.05.2008, paragraphs (0008), (0030), (0033); figure 7	1-10
A	US 3228464 A (STEIN W. J.) 11.01.1966, whole document	1-10
A	US 4044825 A (GUGENBERGER R. et al.) 30.08.1977, claims 7-8; figure 1	1-10
A	US 3759322 A (G. EL DIN NASSER et al.) 18.09.1973, whole document	1-10

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:	"P" Document published prior to the filing date but later than the priority date claimed.
"A" Document defining the general state of the art which is not considered to be of particular relevance.	"T" Document not in conflict with the application but cited to understand the principle or theory underlying the invention.
"D" Document cited in the application.	"X" Document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone.
"E" Earlier application or patent but published on or after the filing date.	"Y" Document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"L" Document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified).	"&" Document member of the same patent family.
"O" Document referring to an oral disclosure, use, exhibition or other means.	

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Date of completion of the search report
6 September 2017

Authorized officer
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SEARCH REPORT - PATENT		Application No. PA 2017 00141
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.

SEARCH REPORT - PATENT	Application No. PA 2017 00141

Box No. I Observations where certain claims were found unsearchable

This search report has not been established in respect of certain claims for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched, namely:

2. ☐ Claims Nos.:
because they relate to parts of the patent application that do not comply with the prescribed requirements to such an extent that no meaningful search can be carried out, specifically:

3. ☐ Claims Nos.:
because of other matters.

Box No. II Observations where unity of invention is lacking prior to the search

The Danish Patent and Trademark Office found multiple inventions in this patent application, as follows:

SEARCH REPORT - PATENT	Application No. PA 2017 00141

SUPPLEMENTAL BOX

Continuation of Box [.]