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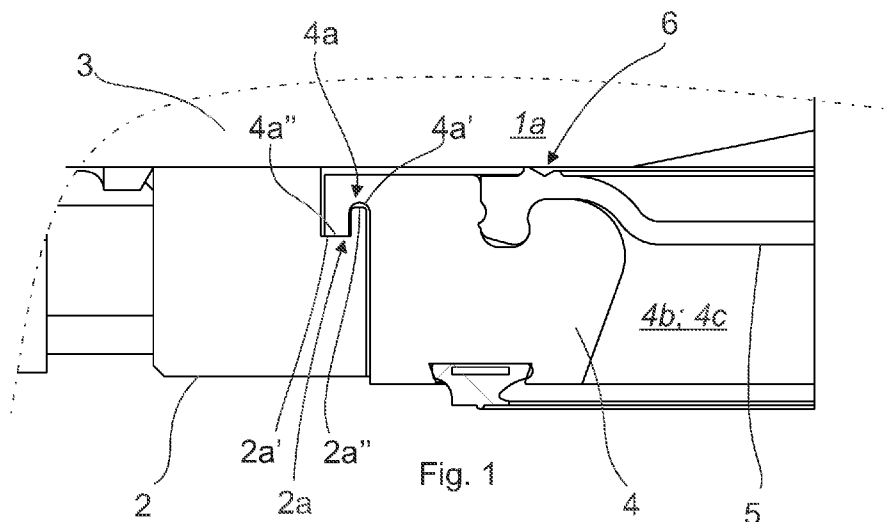
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(54) Title: A FILTER PLATE FRAME ASSEMBLY AND A HORIZONTAL FILTER PRESS, SUCH AS A TOWER PRESS, HAVING SUCH A PLATE FRAME ASSEMBLY



(57) Abstract: The present disclosure concerns a filter plate frame assembly (1) and a horizontal filter press, in which accidental overpressurization of the filter diaphragm (5) is prevented. A filter plate frame assembly (1) having a separate subframe (4) is provided with a limited vertical travel with respect to the filter frame (2) and the filter plate (3), such that the 5 subframe (4) is allowed to drop away from the filter plate (2) when the filter chamber is opened. This enables a diaphragm (5) to be attached to the subframe (4) such that an escape route is formed for a pressurized medium accidentally introduced between the filter plate (3) and the diaphragm (5). Moreover, the limited travel of the subframe (4) allows the subframe (4) to be pressed towards the filter plate (3) when the filter chamber is closed, 10 thereby allowing normal operation of the diaphragm (5) for squeezing a filter cake.

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A FILTER PLATE FRAME ASSEMBLY AND A HORIZONTAL FILTER PRESS, SUCH AS A TOWER PRESS, HAVING SUCH A PLATE FRAME ASSEMBLY

FIELD OF THE DISCLOSURE

The present disclosure relates to horizontal filter presses, such as tower presses, and more particularly to a filter plate frame assembly for such a filter press.

BACKGROUND OF THE DISCLOSURE

In horizontal filter presses, a horizontally extending filter chamber is formed between adjacent, superimposed filter plate frame assemblies. During the filtration cycle, the filter plate assemblies are pressed against each other to seal the filter chamber, and a slurry is introduced into the filter chamber, where filtrate is separated from the slurry by a filter medium. The filtrate is conducted to further processing, while the solids content of the slurry form a filter cake in the filter chamber. The filter cake is removed from the filter chamber by lifting the filter plate frame assemblies such that they move away from each other (i.e., opening the filter chamber). The filter medium, typically forming an endless loop in a zig-zag -pattern, is advanced and the filter cake is discharged by dropping it from on top of the filter medium that turns around a roller.

In order to remove as much as possible of the liquid content of the filter cake, a diaphragm is often provided for squeezing the filter cake in the filter chamber, so as to extract residual filtrate from the filter cake. Such a diaphragm is typically attached to a filter frame such that it resides vertically between the frame and a filter plate supported by the frame. A space between the diaphragm and the filter plate is sealed with a seal bead on the diaphragm, such that a pressurized medium can be introduced into the space. The pressurized medium inflates the diaphragm towards the filter chamber thereby squeezing the filter cake. The pressure used to inflate the diaphragm typically lies between the range of 8-20 bar over the ambient pressure. The diaphragm can withstand this pressure because the pressure prevailing in the filter chamber (and the filter cake) prevents excessive deformation of the diaphragm, which would lead to damage.

It has been found out that in exceptionally rare cases of malfunction or improper use of the filter press, pressurized medium may be led into the space between the filter plate and the diaphragm when the filter chamber is opened. As no counteracting pressure is in the filter chamber, this allows the diaphragm to be excessively inflated, causing damage to, or even catastrophic failure of the diaphragm. This poses a serious risk of injury as it could lead to the diaphragm exploding.

BRIEF DESCRIPTION OF THE DISCLOSURE

An object of the present disclosure is to provide a filter plate frame assembly and a horizontal filter press, in which accidental overpressurization of the filter diaphragm is prevented.

5 The object of the disclosure is achieved by a filter plate frame assembly and a horizontal filter press which are characterized by what is stated in the independent claims. The preferred embodiments of the disclosure are disclosed in the dependent claims.

10 The disclosure is based on the idea of providing a filter plate frame assembly having a separate subframe with a limited vertical travel with respect to the filter frame and filter plate such that the subframe is allowed to drop away from the filter plate when the filter chamber is opened.

15 This enables a diaphragm to be attached to the subframe such that an escape route is formed for a pressurized medium accidentally introduced between the filter plate and the diaphragm. Moreover, the limited travel of the subframe allows the subframe to be pressed towards the filter plate when the filter chamber is closed, thereby allowing normal operation of the diaphragm for squeezing a filter cake formed in the filter chamber.

An advantage of the disclosure is that operational safety is significantly increased, as accidental introduction of a pressurized medium into a space between a diaphragm and a filter plate does not cause the diaphragm to excessively inflate

20 BRIEF DESCRIPTION OF THE DRAWINGS

In the following the disclosure will be described in greater detail by means of preferred embodiments with reference to the accompanying drawings, in which

25 Fig. 1 schematically illustrates a filter plate frame assembly according to an embodiment of the present disclosure where the subframe is in a lowermost position, as seen as a partial cut-view;

Fig. 1a illustrates a detailed view of the subframe, diaphragm and filter plate of Fig. 1

Fig. 2 illustrates the filter late frame assembly of Fig. 1, where the subframe is in the uppermost position, and

Fig. 2a illustrates a detailed view of the subframe, diaphragm and filter plate of Fig. 2

30 DETAILED DESCRIPTION OF THE DISCLOSURE

According to a first aspect of the present disclosure, a filter plate frame assembly 1 for a horizontal filter press, such as a tower press, is provided.

The filter plate frame assembly 1 comprises a rigid filter plate frame 2 defining a closed periphery. The purpose of the frame 2 is to support against laterally (i.e. horizontally) directed forces caused by the pressure prevailing in the filter chamber during operation, and also, provide a structure which can be lifted and lowered for opening and closing a filter chamber formed by adjacent filter plate frame assemblies 1.

The filter plate frame assembly 1 further comprises a filter plate 3 attached onto the filter plate frame 2 on a plate side 1a of the filter plate frame assembly 1, and covering at least an area delimited by the filter plate frame. The purpose of the of the filter plate is to provide support against vertically directed forces caused by the pressure prevailing in the filter chamber during operation, and also, to provide a structure onto which a filtrate vat for collecting filtrate can be formed.

The filter plate frame assembly 1 further comprises a diaphragm 5 having a continuous seal bead 6 for sealing the diaphragm 5 against the filter plate 3, such that a space delimited by the seal bead 6 is defined between the diaphragm 5 and the plate 3. As discussed earlier, the purpose of the diaphragm is to squeeze residual liquid contents out from the filter cake formed in the filter chamber. Suitably, the seal bead 6 extends around the periphery of diaphragm 5.

Particularly, the filter plate frame assembly 1 further comprises a subframe 4 with a central opening 4b having a closed area defining a lateral boundary of an associated filter chamber 4c, when in use. The subframe 4 is nested within and laterally delimited by the closed periphery of the filter plate frame 2. This means that that the more rigid frame 2 support the subframe 4 against lateral forces exerted thereon by a pressure prevailing in the filter chamber. Consequently, the subframe can be constructed with a much more light-weight and less rigid structure, as compare to the frame 2.

The subframe 4 is vertically secured between the filter plate frame 2 and the filter plate 3, such that a vertical free play of the subframe 4 between the plate 2 and the frame 2 allows a limited vertical travel of the subframe 4 with respect to the frame 2 and the plate 3. It should be noted that, in the context of this disclosure, the free play and the limited vertical travel are distinguished from, and exceed, any possible manufacturing clearances.

The diaphragm 5 is attached to the subframe 4 such that it resides between the subframe 4 and the filter plate 3 and covers an area delimited by the sub-frame 4. Most suitably, the diaphragm 4 resides vertically between the subframe 4 and the filter plate, at least at where the diaphragm 5 is to be sealed against the plate 3.

As the diaphragm is attached to the subframe 4, it shares the same limited vertical travel with respect to the filter plate 3 as the subframe.

In an embodiment according to the first aspect, the subframe 4 has an uppermost position within the limited vertical travel. The uppermost position corresponds to a situation in which the subframe 4 is pressed towards the plate 3, i.e., when adjacent filter plate frame assemblies 1 are pressed against each other so as to close a filter chamber formed therebetween. Correspondingly, the subframe 4 also has a lowermost position within the limited vertical travel. The lowermost position corresponds to a situation in which the subframe 4 is not pressed towards the plate 3, i.e., when adjacent filter plate frame assemblies 1 are away from each other so as to open a filter chamber formed therebetween

Preferably, but not necessarily, the frame 2 comprises a first bearing surface 2a and the subframe 4 comprises a second bearing surface 4a. In the lowermost position, the subframe 4 is vertically supported by the first bearing surface 2a at the second bearing surface 4a. Moreover, in the uppermost position, the subframe 4 is not vertically supported by the by the first bearing surface 2a.

More preferably, but not necessarily, the first bearing surface 2a comprises a groove 2a' and a ridge 2a'' and the second bearing surface 4a comprises a groove 4a' and ridge (4a''). Particularly, the groove of the first bearing surface 2a' is configured to form fittingly receive the ridge 4a'' of the second bearing surface 4a. Correspondingly, the groove 4a' of the second bearing surface 4a is configured to from-fittingly receive the ridge 4a'') of the first bearing surface 2a.

Such a geometry of the bearing surfaces 2a, 4a helps retain the subframe laterally (i. e., horizontally) in place with respect to the frame 2 while allowing the limited vertical travel of the subframe 4. At the same time such a geometry allows transferring lateral forces between the subframe 4 and the frame 2, thus helping the subframe 4 to maintain its proper shape.

Although the embodiments illustrated in the appended drawings show the grooves 2a', 4a', and ridges 2a'', 4a'' of the first and second bearing surfaces 2a, 7a provided in staggered configuration, they could alternatively also be provided as a continuous curved contours, as inclined linear surfaces, or a combination of the above.

Preferably but not necessarily, the filter plate frame assembly can be configured such that, when the sub-frame 4 is the uppermost position, the seal 6 is engaged with the plate 3, and correspondingly, when the subframe 4 is in the lowermost position, the seal 6 is

disengaged from the plate 3. This ensures, that pressure can not build up in the space between the diaphragm 5 and the filter plate 3, when the filter chamber is open.

Alternatively, the filter plate frame assembly can be configured such that, when the subframe 4 is in the lowermost position, the seal bead 6 is engaged with the plate 3 so as to provide sealing against a first pressure differential, and to leak under a second pressure differential, which is higher than the first pressure differential. Moreover, the filter plate frame assembly can be configured such that, when the subframe 4 is in the uppermost position, the seal bead 6 engages with the plate 3 so as to provide sealing also against a third pressure differential, which is higher than the second pressure differential.

This allows using the first pressure differential (i.e. an underpressure in the space between the diaphragm 5 and the filter plate 5), to hold the diaphragm 5 up when the filter chamber is opened to facilitate discharge of the cake from the filter chamber, while preventing excessive inflation of the diaphragm 5 caused by an accidental pressurization exceeding the second pressure differential (i.e. an overpressure in the space between the diaphragm 5 and the filter plate 3) from damaging the diaphragm and causing a risk of injury to operating personnel. Moreover, a sufficient third pressure differential (i.e., an overpressure in the space between the diaphragm 5 and the filter plate 3) is achieved for squeezing the filter cake, when filter chamber is closed.

Such a first pressure differential is conventionally much smaller than such a third pressure differential. Typically, the first pressure differential (i.e., the underpressure between the ambient pressure and the space between the diaphragm 5 and the filter plate 3) lies between 0.01 – 0.10 bar, while the third pressure differential (i.e., the overpressure between ambient pressure and the space between the diaphragm 5 and the filter plate 3) is between 8 – 20 bar. Furthermore, the second pressure differential (i.e., the overpressure between ambient pressure and the space between the diaphragm 5 and the filter plate 3) is generally only slightly higher than the first pressure differential, typically approx. 0,15 bar.

For example, this could be achieved by providing the seal bead 6 with two seal lips, one of which is elevated higher from the diaphragm 10 than the other. In such a case, only the higher elevated seal lip may be configured to engage with the filter plate 3 when the subframe 4 is in the lowermost position, so as to provide sealing against the first pressure differential and leak under the second pressure differential. Moreover, both the higher elevated and lower elevated seal lip may be configured to engage the filter plate 3 when the subframe 4 is in the uppermost position, so as to seal against the third pressure differential.

Most suitably a seal lip elevated higher is provided on a lateral outside of the diaphragm with respect to the seal lip elevated lower. Alternatively, or additionally, the seal lip elevated higher may have a directional self-sealing geometry against an overpressure prevailing on the lateral outside, while the seal lip elevated lower may have a directional self-sealing geometry against an overpressure prevailing on the lateral inside.

In an embodiment according to the present disclosure, the limited travel of the of subframe 4 is at least 0,5 mm. Preferably, the limited travel of the subframe is at least 1 mm.

Suitably, the limited travel of the subframe is less than 10mm. This is because it is undesirable to increase the vertical motion of adjacent plate frame assemblies required to open the filter chamber. The total vertical movement of the associated filter press required for opening all filter chambers is the required vertical travel between two adjacent plate frame assemblies multiplied by the number of filter chambers. Moreover, increasing the required vertical travel increases the cycle time of the filtration cycle.

It should be noted that the first aspect of the present disclosure encompasses any combination of two or more embodiments, or variants thereof, as discussed above.

According to a second aspect of the present disclosure, a horizontal filter press, such as a tower press, is provided.

Particularly, the filter comprises a plurality of filter plate frame assemblies according to the first aspect of the present disclosure, as discussed above.

The filter plate frame assemblies 1 are configured movable towards each other into a closed position in which a filter chamber 4c is formed between adjacent filter plate frame assemblies 1, and away from each to an open position in which adjacent filter plate frame assemblies 1 are spaced apart from each other.

The filter further comprises a filter medium arranged between adjacent filter plate frame assemblies 1.

The filter further comprises a translation arrangement for moving the filter plate frame assemblies 1 towards each other so as to form a filter chamber 4c between adjacent filter plate frame assemblies 1, and away from each other so as to open the filter chamber.

The filter further comprises a feed arrangement for feeding slurry into the filter chamber 4c, a recovering arrangement for recovering filtrate from the filter chamber 4c, and a discharge arrangement for discharging a filter cake formed within the filter chamber 4c.

In an embodiment according to the second aspect of the present disclosure, the filter press further comprises diaphragm inflation means for providing a pressurized medium into the

space between the diaphragm 5 and the filter plate 3 so as to inflate the diaphragm and squeeze a filter cake formed within the filter chamber 4c.

It should be noted that the second aspect of the present disclosure encompasses any combination of two or more embodiments, or variants thereof, as discussed above.

Fig. 1 schematically illustrates a filter plate frame assembly 1 according to an embodiment of the present disclosure, as seen as a partial cut view. Particularly, the subframe 4 is the lowermost position, corresponding to a situation in which the filter chamber 4c is opened. The seal bead 6 has two seal lips, the laterally outer seal lip being elevated higher from the remaining diaphragm 5 than the laterally inner seal lip. The laterally outer seal lip engages with the filter plate 3 such that a sufficient underpressure (with respect to the ambient pressure) may be exerted into the space between the diaphragm and the filter plate 3, so as to lift the diaphragm up to facilitate filter cake discharge. At the same time, the sealing provided by only the laterally outer seal lip is sufficiently weak to allow an accidental overpressure only slightly higher than the underpressure (with respect to the ambient pressure) to leak through the laterally outer seal lip. For example, the underpressure may be 0,05 – 0,10 bar, whereas the over pressure may be 0,15 bar or higher.

Fig. 1a illustrates a detailed view of the subframe 4, diaphragm 5 and filter plate 3 of Fig. 1

Fig. 2 illustrates the filter plate frame assembly 1 of Fig. 1, where the subframe 4 is in the uppermost position, corresponding to a situation in which the filter chamber 4c is closed. In the uppermost position of the subframe 4, both the laterally outer and laterally inner seal lip are engaged with the filter plate 3. This allows a sufficiently high over pressure (with respect to the ambient pressure) of typically between 8-20 bar to be formed in the space between the diaphragm 5 and the filter plate 3, so as to inflate the diaphragm into the filter chamber 4c during filtration, and squeeze residual liquid contents out of the filter cake. , and

Fig. 2a illustrates a detailed view of the subframe, diaphragm and filter plate of Fig. 2

LIST OF REFERENCE NUMERALS

- | | |
|----|--------------------------------------|
| 1 | filter plate frame assembly |
| 1a | plate side |
| 2 | filter plate frame |
| 2a | first bearing surface of plate frame |

	2a'	groove of first bearing surface
	2a''	ridge of first bearing surface
	3	filter plate
	4	subframe
5	4a	second bearing surface of subframe
	4a'	groove of second bearing surface
	4a''	ridge of second bearing surface
	4b	central opening of subframe
	4c	filter chamber formed in central opening
10	5	diaphragm
	6	seal bead

CLAIMS

1. A filter plate frame assembly (1) for a horizontal filter press, such as a tower press, comprising:
 - a rigid filter plate frame (2) defining a closed periphery, and
 - 5 a filter plate (3) attached onto the filter plate frame (2) on the plate side (1a) of the filter plate frame assembly (1), and covering at least an area delimited by the filter plate frame (2), and
 - a diaphragm (5) having a continuous seal bead (6) for sealing the diaphragm (5) against the filter plate (3), such that a space delimited by the seal bead (6) is defined
 - 10 between the diaphragm (5) and the plate (3),

characterized in that the filter plate frame assembly (1) further comprises a sub-frame (4) with a central opening (4b) having a closed area defining a lateral boundary of an associated filter chamber (4c), when in use, and

wherein the subframe (4) is nested within and laterally delimited by the closed

 - 15 periphery of the filter plate frame (2),

wherein the subframe (4) is vertically secured between the filter plate frame (2) and the filter plate (3), such that a vertical free play of the subframe (4) between the plate (2) and the frame (2) allows a limited vertical travel of the subframe (4) with respect to the frame (2) and the plate (3), and

 - 20 wherein the diaphragm is attached to the subframe (4), resides between the subframe (4) and the filter plate (3) and covers an area delimited by the sub-frame (4).
2. The filter plate frame assembly (1) according to Claim 1, **characterized** in that the subframe (4) has an uppermost position within the limited vertical travel corresponding to a situation in which the subframe (4) is pressed towards the plate (3), and a
 - 25 lowermost position within the limited vertical travel corresponding to a situation in which the subframe (4) is not pressed towards the plate (3).
3. The filter plate frame assembly (1) according to Claim 2, **characterized** in that the frame (2) comprises a first bearing surface (2a) and the subframe (4) comprises a second bearing surface (4a),
 - 30 wherein, in the lowermost position, the subframe (4) is vertically supported by the first bearing surface (2a) at the second bearing surface (4a), and
 - wherein, in the uppermost position, the subframe (4) is not vertically supported by the
 - by the first bearing surface.

4. The filter plate frame assembly (1) according to Claim 3, **characterized** in that the first bearing surface (2a) comprises a groove (2a') and a ridge (2a'') and the second bearing surface (4a) comprises a groove (4a') and ridge (4a''), wherein the groove of the first bearing surface (2a') is configured to form fittingly receive the ridge (4a'') of the second bearing surface (4a) and the groove (4a') of the second bearing surface (7a) is configured to from-fittingly receive the ridge (4a'') of the first bearing surface (2a)
5. The filter plate frame assembly according to any of the preceding Claims 2-4, **characterized** in that when the sub-frame (4) is the uppermost position, the seal (6) is engaged with the plate (3), and when the subframe (4) is in the lowermost position, the seal (6) is disengaged from the plate (3).
6. The filter plate frame assembly according to any of the preceding Claims 2-4, **characterized** in that, when the subframe (4) is in the lowermost position, the seal bead (6) is engaged with the plate (3) so as to provide sealing against a first pressure differential, and to leak under a second, higher pressure differential, when the subframe (4) is in the uppermost position, the seal bead (6) engages with the plate (3) so as to provide sealing also against the second pressure differential.
7. The filter plate frame assembly (1) according to any of the preceding Claims 1-7, **characterized** in that the limited travel of the of subframe (4) is at least 0,5 mm, and preferably at least 1mm.
8. A horizontal filter press, such as a tower press, **characterized** in that the filter comprises:
- a plurality of filter plate frame assemblies (1) according to any of the preceding Claims 1-8, wherein the filter plate frame assemblies (1) are configured movable towards each other into a closed position in which a filter chamber (4c) is formed between adjacent filter plate frame assemblies (1), and away from each to an open position in which adjacent filter plate frame assemblies (1) are spaced apart from each other;
 - a filter medium arranged between adjacent filter plate frame assemblies (1);

- a translation arrangement for moving the filter plate frame assemblies (1) towards each other so as to form a filter chamber (4c) between adjacent filter plate frame assemblies (1), and away from each other so as to open the filter chamber;
 - a feed arrangement for feeding slurry into the filter chamber (4c);
 - 5 --- a recovering arrangement for recovering filtrate from the filter chamber (4c), and
 - a discharge arrangement for discharging a filter cake formed within the filter chamber (4c).
9. The horizontal filter press according to Claim 9, **characterized** in that the filter press further comprises diaphragm inflation means for providing a pressurized medium into
- 10 the space between the diaphragm (5) and the filter plate (3) so as to inflate the diaphragm and squeeze a filter cake formed within the filter chamber (4c).

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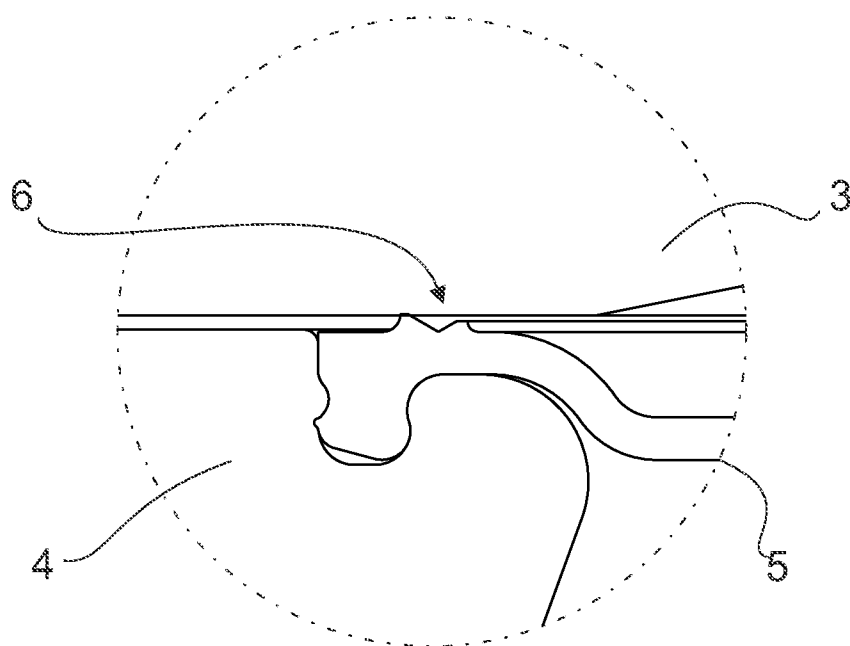
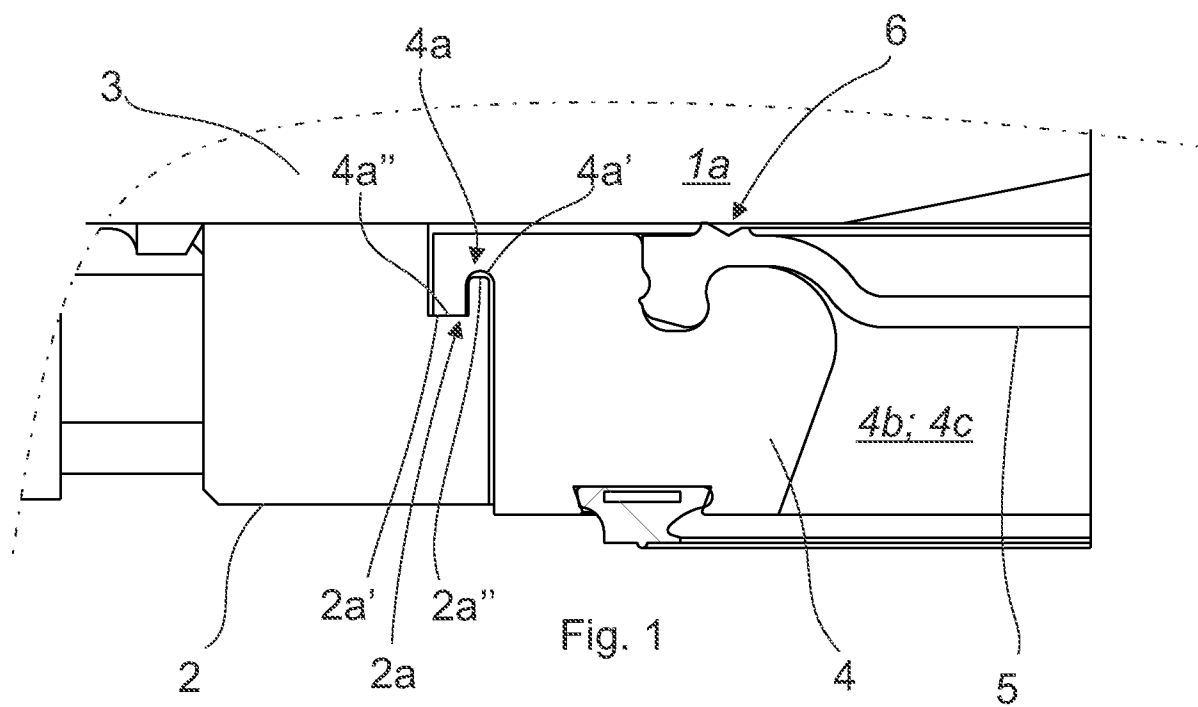


Fig. 1a

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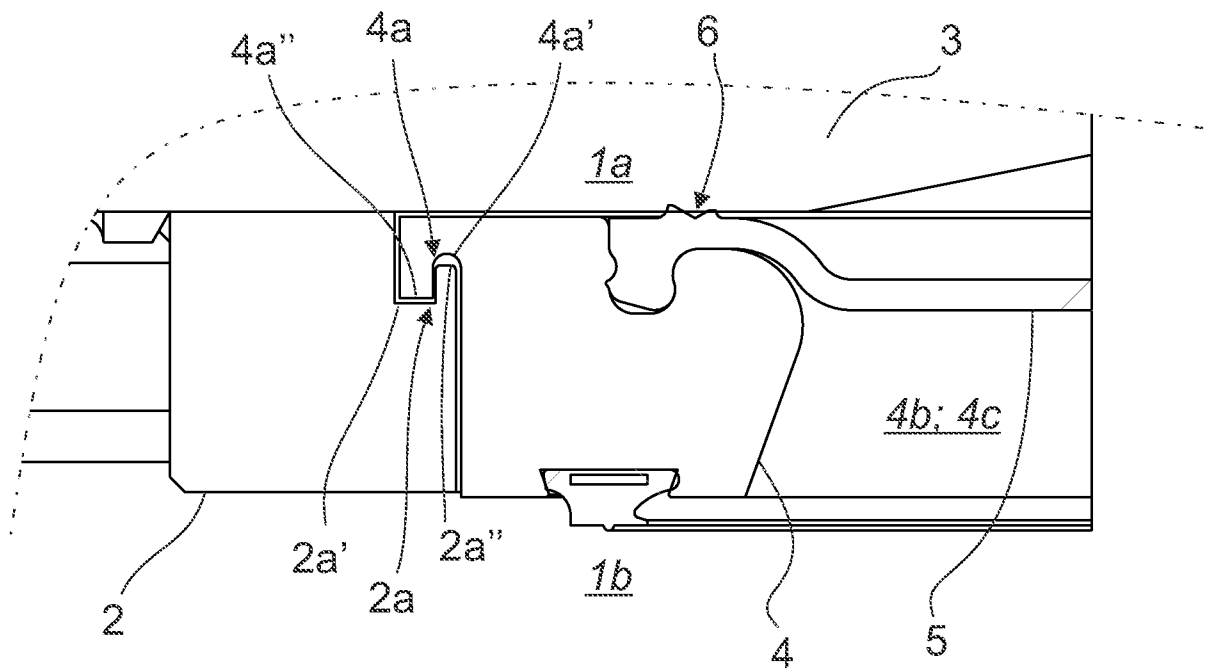


Fig. 2

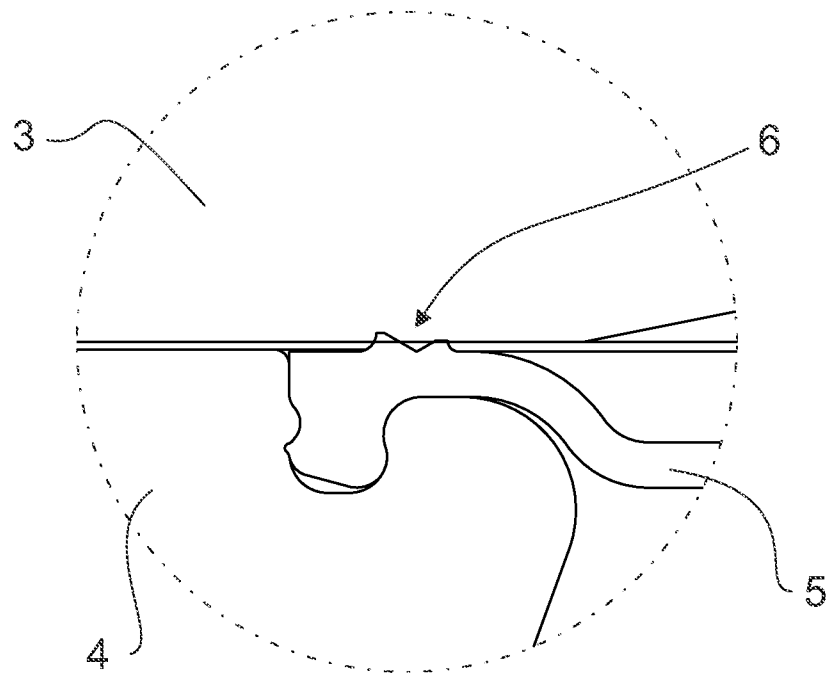


Fig. 2a

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2020/050251

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: B01D

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)

EPODOC, EPO-Internal full-text databases, Full-text translation databases from Asian languages, WPIAP

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4749482 A (BONN HEINZ [DE]) 07 June 1988 (07.06.1988) the whole document, especially column 5, line 9 – column 6, line 24; column 6, lines 54–63; figures 1–3 & abstracts [online] EPOQUENET EPODOC & WPI	1-9
A	DE 19905674 C1 (JV KUNSTSTOFFWERK [DE]) 09 March 2000 (09.03.2000) the whole document, especially figures 1 and 2 & abstracts [online] EPOQUENET EPODOC & WPI	1-9
A	US 2010163476 A1 (BONN HEINZ [DE]) 01 July 2010 (01.07.2010) the whole document, especially figures 1–4	1-9

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

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"D" document cited by the applicant in the international application	"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
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

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INTERNATIONAL SEARCH REPORT
Information on Patent Family Members

International application No.
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US 4749482 A	07/06/1988	DE 3520653 A1	11/12/1986
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		DE 102007027035 B4	02/07/2009
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