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(54) Title: A FILTER PLATE FRAME ASSEMBLY, A HORIZONTAL FILTER PRESS, SUCH AS A TOWER PRESS, HAVING SUCH A PLATE FRAME ASSEMBLY, AND A METHOD OF REPLACING WORN COMPONENTS OF HORIZONTAL FILTER PRESS

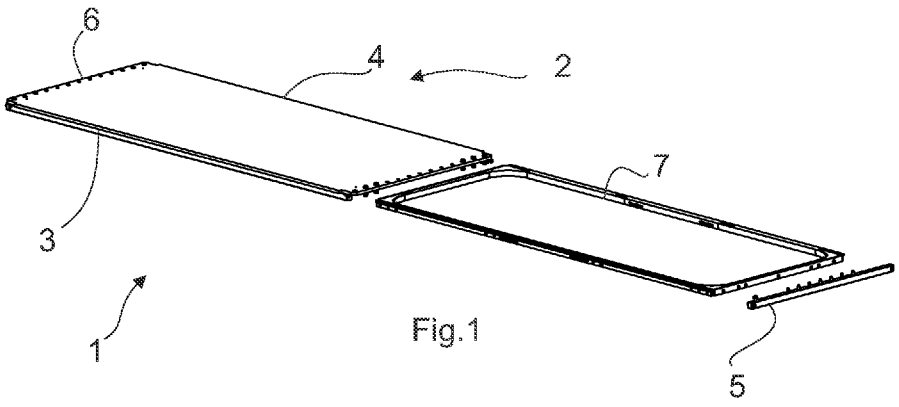

Fig.1

(57) Abstract: The disclosure is based on the idea of providing a filter plate frame assembly (1) with a filter plate frame (2) and a subframe (7) housed within the frame (2), such that the subframe (7) can be removed from the frame (2) without removing the frame (2) from the filter press. In this way, consumable components can be provided in connection with the subframe (7), which can be easily removed from the filter press. This, in turn, makes replacement of worn components faster, as the whole frame does not need to be removed from the filter press. The present disclosure further concerns an associated horizontal filter press and a method of replacing worn components of such a filter press.

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A FILTER PLATE FRAME ASSEMBLY, A HORIZONTAL FILTER PRESS, SUCH AS A TOWER PRESS, HAVING SUCH A PLATE FRAME ASSEMBLY, AND A METHOD OF REPLACING WORN COMPONENTS OF HORIZONTAL FILTER PRESS

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 with a filtration pressure typically ranging between 8 – 20 bar over the ambient pressure. The 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.

The filter plate frame assembly comprises multiple wearing components (such as seals and diaphragms) that must be replaced periodically. To replace these components the whole filter frame assembly has to be removed, which is time consuming and currently requires the filter press to be out of operation during replacement. Alternatively, worn components may be replaced in place (i.e. without removing the filter plate frame assembly). However, this requires additional precautionary safety measures and the operators must pay great attention to safety instructions and regulations. If the precautionary safety measures and instructions are not followed, a serious risk of injury may be posed as work is done under one or more suspended filter plate frame assemblies

BRIEF DESCRIPTION OF THE DISCLOSURE

An object of the present disclosure is to provide filter plate frame assembly and a filter press incorporating such a filter plate frame assembly, which provides for replacement of worn components with less downtime of the associated filter press and increase the safety of such an operation.

The object of the disclosure is achieved by a filter plate frame assembly and a 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.

The disclosure is based on the idea of providing a filter plate frame assembly with a filter plate frame having a sufficiently rigid structure to withstand the forces associated with the operation of the filter press, and a subframe housed within the frame, such that the subframe can be removed from the frame without removing the frame from the filter press.

In this way, consumable components can be provided in connection with the subframe, which can be easily removed from the filter press. This, in turn, makes replacement of worn components faster, as the whole frame does not need to be removed from the filter press. Moreover, as the subframe can be made with a less rigid structure than the frame itself, the subframe can be more easily manipulated when removed from the frame, further facilitating replacement of worn parts.

Finally, the arrangement according to the present disclosure enables the use of a replacement subframe, which can be hold in storage with new consumables already fitted thereon. This even further fastens the replacement process and reduces down time of the filter press, as all consumables can be replaced at once simply by removing the subframe from the frame and inserting a new one. After a new subframe has been installed, the old subframe can be refurbished by replacing worn components while the filter press can already be operated.

Furthermore, safety of the replacement procedure is increased, as the operators no longer would benefit from replacing worn component in place.

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

Fig. 1 schematically illustrates a filter plate frame assembly according to an embodiment of the present disclosure, as seen as a simplified, perspective exploded view;

Fig. 2 schematically illustrates a filter plate frame assembly according to an embodiment of the present disclosure, as seen as a plan view;

Fig. 3 schematically illustrates a filter plate frame assembly according to an embodiment of the present disclosure, as seen as a partial cross-sectional cut view where the subframe is in a lowermost position, and

Fig. 4 illustrates the filter plate frame assembly of Fig. 3, as seen as a partial cross-sectional cut view where the subframe is in an uppermost position.

DETAILED DESCRIPTION OF THE DISCLOSURE

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

The plate frame assembly comprises a rigid plate frame 2 having a first frame flank 3 and an opposing second frame flank 4 parallel to the first frame flank 5. The plate frame further comprises a first frame end 5 and an opposing second frame end 6 parallel to the to the first frame end 5. The frame flanks 3, 4 and frame ends 5, 6 of the filter frame 2 define a closed periphery of the filter frame 2.

Preferably but not necessarily, the frame 2 is attachable to a support structure of an associated filter press by the frame flanks 3, 4. Moreover, most suitably the frame flanks 3, 4 have a length greater than that of the frame ends 5, 6. That is, the frame 2 extends further in the direction of the flanks 3, 4 than in the direction of the frame ends 5, 6.

The filter plate frame assembly further comprises a subframe 7 nested within and laterally delimited by the filter plate frame 2. The subframe 7 has a central opening 8 having a closed area, and defining a lateral boundary of an associated filter chamber, when in use.

Particularly, either or both of the first frame end 5 and the second frame end 6 is an openable frame end, such that the subframe 7 is receivable into, and respectively, removable out from the filter plate frame 2 via the openable frame end 5. Moreover, the subframe 7 is secured within the filter plate frame 2 when the openable frame end 5 is closed.

For example, the frame 2 may be made of steel, whereas the subframe 7 may be made of a plastics material.

Preferably, but not necessarily, the openable frame end 5 is attachable at least to the remaining plate frame 2. More preferably, the openable frame end 5 is additionally attachable to the filter plate 9 supported by the frame 2.

In an embodiment according to the first aspect of the present disclosure, the openable frame end 5 is provided as a releasably fixed section of the periphery formed by the filter plate frame 2.

Alternatively, the periphery formed by the filter plate frame 2 may comprises an opening (not illustrated) at an end of the frame, such that the openable frame end covers the opening, when fixed to the filter plate frame 2.

In an embodiment according to the first aspect, the filter plate frame 2 comprises a first bearing surface 2a opening towards a plate side 1a of the filter plate frame assembly 1 and running at least along both the first frame flank 3 and the second frame flank 4. Correspondingly, the subframe 7 comprises a second bearing surface 7a opening towards the chamber side 1b of the filter plate frame assembly 1. Moreover, the first bearing surface 2a and the second bearing surface 7a are configured such that the filter plate subframe 7 is supported on and slidable along the first bearing 2a surface at the second bearing surface 7a. Particularly, the first bearing surface 2a supports the subframe at the second bearing surface 7a in a direction perpendicular to the horizontally extending filter inner opening, i.e. in a vertical direction against gravity, when in use.

In the context of the present disclosure, the plate side 1a is used to depict a side of the filter plate frame assembly 1, with respect to the planarity defined by the filter frame 2, on which a filter plate 9 associated to it resides or is to be provided. Moreover, in the context of the present disclosure, the chamber side 1b is used to depict a side of the filter plate frame assembly 1, with respect to the planarity defined by the filter frame 2, on which a filter chamber is formed, and towards which side the filter chamber is open. In other words, in the situation illustrated in Figs. 3 and 4, the filter plate side 1a is above the filter plate frame assembly 1, and the chamber side 1b is below the filter plate frame assembly 1.

For example, the first bearing surface2a could be provided by forming a shelf on the frame 2, which then receives and support a corresponding ledge formed on the subframe 7. Alternatively, the frame 2 could be provided with a geometry constituting a U- or L- shaped rail configured for receiving and supporting a laterally projecting part of the subframe. Naturally, other arrangements could be provided, as discussed below.

Preferably, but not necessarily, the first bearing surface 2a comprises a groove 2a' and a ridge 2a'' extending longitudinally along either or both of the first flank 3 or the second flank 4. Moreover, the second bearing surface 7a then also comprises a groove 7a' and ridge 7a'' extending longitudinally on a side or sides corresponding to either or both of the first flank 3 or the second flank 4. Particularly, wherein the groove 2a' of the first bearing surface 2a is configured to form fittingly receive the ridge 7a'' of the second bearing surface 7a, and the groove 7a' of the second bearing surface 7a is configured to from-fittingly receive the ridge 2a'' of the first bearing surface 2a. Most suitably, the groove 2a' and the ridge 2a'' of the first bearing surface 2a open and project, respectively, towards the plate side 1a of the plate frame 2, whereas the groove 7a' and the ridge 7a'' of the second bearing surface open and project towards the chamber side 1b of the subframe 7 .

Such a geometry of the bearing surfaces 2a, 7a helps retain the subframe laterally in place (i.e., in a direction coplanar with the frame 2 and subframe 7, and transverse to the longitudinal direction of the frame flanks 3, 4) while allowing the subframe 7 to be slid out of the frame 2. Moreover, such geometry of the bearing surface keep the subframe in proper orientation with respect to the frame during insertion of the subframe 7, thus preventing the latter from getting wedged within the frame 2. Finally, such a geometry of the bearing surfaces 2a, 7a provides for transferring lateral forces between the subframe and the frame, thus helping the subframe to maintain its proper shape.

Although the embodiments illustrated in Figs. 3 and 4 show the grooves 2a', 7a', and ridges 2a", 7a" of the first and second bearing surfaces 2a, 7a provided in staggered configuration, they could alternatively also be provided as a continuous curved contour, as inclined linear surface, or a combination of the above.

In an embodiment according to the first aspect, the filter plate frame 2 is provided with a generally rectangular shape, i.e., the frame ends 5, 6 are provided transverse to the frame flanks 3, 4. Preferably also the subframe is similarly of a generally rectangular shape.

In an embodiment according to the first aspect, the filter plate frame assembly 1 further comprises a filter plate 9 attached onto the filter plate frame 2 on the plate side 1a of the filter plate frame assembly 1, such that the filter plate 9 covers at least an area delimited by the filter plate frame 2. The purpose of the filter plate 9 is to support a filtrate vat, into which filtrate is received from filer chamber formed by an adjacent filter plate frame assembly 1 during operation.

Preferably, but not necessarily, the subframe 7 is secured in a direction perpendicular to a plane defined by the filter plate frame assembly (i.e., in the vertical direction) between the filter plate frame 2 and the filter plate 9, such that a free play of the filter plate subframe 7 is allowed in said direction with respect to the filter frame 2 and the filter plate 9. This help removal and replacement of the subframe from the frame.

More preferably, but not necessarily, the filter plate frame assembly 1 further comprises a diaphragm 10 having a flexible structure (i.e. being able to yield without permanent deformation so as to squeeze a filter cake formed in the filter chamber). The diaphragm 10 covers an area delimited by the subframe 7. That is, the diaphragm 10 extends over the lateral boundaries of the filter chamber formed within the subframe 7. Moreover, the diaphragm 10 is attached to the subframe 7 and resides, in a vertical direction, between the subframe 7 and the filter plate 9.

Most preferably, but not necessarily, the diaphragm 10 comprises a continuous seal bead 11 for sealing the diaphragm 10 against the filter plate 9. Suitably, the seal bead 11 runs around the periphery of the diaphragm 10. Moreover, the free play between the subframe 7 and the filter plate 9 allows the seal 11 to be detached from the plate 9, when the subframe is not pressed towards the filter plate (i.e., when the subframe 7 is in a lowermost position of its free play) , and further, allows the seal 11 to abut the filter plate 9 when the subframe is pressed towards the filter plate (i.e., when the subframe 7 is in an uppermost position of its free play).

Alternatively, the diaphragm 10 comprises a continuous seal bead 11 for sealing the diaphragm 10 against the filter plate 9. Suitably, the seal bead 11 runs around the periphery of the diaphragm 10. Moreover, the free play between the subframe 7 and the filter plate 9 allows the seal 11 to engage with the filter plate 9 so as to provide sealing against a first pressure differential and to leak under a second, higher pressure differential, when the subframe 7 is not pressed towards the filter plate 9 (i.e., when the subframe 7 is in a lowermost position of its free play). Moreover, the free play between the subframe 7 and the filter plate 9 allows the seal 11 to engage with the filter plate 9 so as to provide sealing also against the second pressure differential when the subframe is pressed towards the filter plate (i.e., when the subframe 7 is in an uppermost position of its free play).

For example, this could be achieved by providing the seal bead with two seal lips, one of which is elevated higher from the diaphragm 10 than the other. 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 first aspect, the filter plate frame assembly 1 further comprises a sealing strip 12 attached onto the subframe 7 on the frame side thereof for sealing the filter chamber formed on central opening of the subframe against a filter plate of an adjacent filter plate frame assembly 1 below the subframe 7. As the sealing strip 12 is attached to the subframe 7, it can also be replaced without removal of the whole filter plate frame assembly 1.

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.

The filter press comprises a plurality of filter plate frame assemblies 1 to the first aspect, such that the filter plate frame assemblies 1 are configured movable towards each other into a closed position in which a filter chamber 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 press further comprises a filter medium arranged between adjacent filter plate frame assemblies 1.

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

The filter press further comprises a feed arrangement for feeding slurry into the filter chamber a recovering arrangement for recovering filtrate from the filter chamber.

The filter press further comprises a discharge arrangement for discharging a filter cake formed within the filter chamber.

According to a third aspect of the present disclosure, a method of replacing worn components on the filter press according to the second aspect of the present disclosure is provided.

The method comprises comprising the following succession of steps:

- opening a filter chamber by moving an associated upper filter plate frame assembly 1 away from an associated lower filter plate frame assembly 1 with the translation arrangement;
- opening an openable end of the associated lower plate frame assembly 1;
- removing a subframe 7 having worn components from the frame 2 of the lower plate frame assembly 1 via the openable end;
- inserting a subframe 7 having unworn or refurbished components into the frame 2 of the lower plate frame assembly 1 via the openable end, and
- closing the openable end of the lower plate frame assembly 1.

Fig. 1 schematically illustrates a filter plate frame assembly according to an embodiment of the present disclosure, as seen as a perspective exploded view. It should be noted, that

Fig. 1 represent a simplified drawing of the filter plate frame assembly, for the purpose of illustrating that the subframe 7 is removable from the frame 2. Particularly, the details of the filter plate have been omitted. That is, the openable frame end 5 has been removed from the frame 2 and the subframe 7 has been completely withdrawn from the plate frame 2

Fig. 2 schematically illustrates a filter plate frame assembly according to an embodiment of the present disclosure in a non-exploded configuration, as seen as a plan view. It should be noted that particularly the details of the filter plate illustrated in Fig. 2 represent only an exemplary configuration, and that other configurations are encompassed by the present disclosure. The line and arrows running across the first frame flank 3 indicate the section along which the view of Fig. 3 is cut.

Fig. 3 schematically illustrates a filter plate frame assembly according to an embodiment of the present disclosure, as seen as a partial cross-sectional cut view where the subframe 7 is in a lowermost position (i.e., when adjacent filter frame assemblies are spaced apart from each other). The filter diaphragm 10 is attached to a profiled groove on the subframe 7 with a correspondingly profiled bead of the diaphragm 10. The filter subframe 7, in turn, is attached to a filter frame 2 in a manner allowing a limited vertical travel. The filter frame 2, in turn is fixed with respect to filter plate 9, against which the seal bead 11 of the diaphragm 10 engages. Particularly, in the lowermost position of Fig. 3, only a laterally outer seal lip of the bead 11 engages against the filter plate 9. This allows an underpressure to be exerted into the space between the diaphragm 10 and the filter plate 9, thereby lifting a central portion of the diaphragm 10 up so as to facilitate removal of the filter cake from the filter chamber. Moreover, as only the laterally outer seal lip is engaged against the filter plate 9, accidental overpressurization of the space between the diaphragm 10 and the filter plate 9 would cause the seal bead 11 to leak, thus preventing the overpressure from excessively inflating the diaphragm.

Fig. 4 illustrates the filter plate frame assembly of Fig. 3, as seen as a partial cross-sectional cut view where the subframe is in an uppermost position (i.e., when the filter chamber is closed and adjacent filter plate frame assemblies 1 are pressed towards each other. In this situation a filter plate 9 of an adjacent filter plate below that of Fig. 4 pushes the subframe 7 upwards to an uppermost position of its limited travel. Consequently, both the laterally outer seal lip and the laterally inner seal lip of the bead 11 are engaged against the filter plate 9. As a result, a sufficient overpressure can be introduced into the space between the diaphragm 01 and the filter plate 9, so as to squeeze remaining liquid contents out of a filter cake.

LIST OF REFERENCE NUMERALS

1	filter plate frame assembly
1a	plate side
1b	frame 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	first frame flank
4	second frame flank
5	first frame end
6	second frame end
7	subframe
7a	second bearing surface of subframe
7a'	groove of second bearing surface
7a''	ridge of second bearing surface
8	central opening of subframe
9	filter plate
10	diaphragm
11	seal bead of diaphragm
12	sealing strip

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) having a first frame flank (3) and an opposing second frame (4) flank parallel to the first frame flank (3), and a first frame end (5) and an opposing second frame end (6) parallel with the first frame end (5), wherein the frame flanks (3, 4) and frame ends (5, 6) of the filter frame define a closed periphery, and

a subframe (7) nested within and laterally delimited by the filter plate frame,

characterized in that, the subframe (7) has a central opening (8) having a closed area defining a lateral boundary of an associated filter chamber, when in use

wherein either or both of the first frame end (5) and the second frame end (6) is an openable frame end, and

wherein the subframe (7) is receivable into, and respectively, removable out from the filter plate frame (2) via the openable frame end (5), and

wherein the subframe (7) is secured within the filter plate frame (2) when the openable frame end (5) is closed.

2. The filter plate frame assembly (1) according to Claim 1, **characterized** in that the openable frame end (5) is provided as a releasably fixed section of the periphery formed by the filter plate frame (2).

3. The filter plate frame assembly (1) according to Claim 1, **characterized** in that the periphery formed by the filter plate frame (2) comprises an opening at an end (5, 6) of the frame, wherein the openable frame end covers the opening, when fixed to the filter plate frame (2).

4. The filter plate frame assembly (1) according to any of the preceding Claims 1-3, **characterized** in that the filter plate frame (2) comprises a first bearing surface (2a) opening towards a plate side (1a) of the filter plate frame assembly (1) and running at least along both the first frame flank (3) and the second frame flank (4),

wherein the subframe (7) comprises a second bearing surface (7a) opening towards the chamber side (1b) of the filter plate frame assembly (1), and

the filter plate subframe (7) is supported on and slidable along the first bearing (“a) surface at the second bearing surface (7a).

5. The filter plate frame assembly (1) according to Claim 4, **characterized** in that

the first bearing surface (2a) comprises a groove (2a') and a ridge (2a") extending longitudinally along either or both of the first flank (3) or the second flank (4),

the second bearing surface (7a) comprises a groove (7a') and ridge (7a") extending longitudinally on a side or sides corresponding to either or both of the first flank (3) or the second flank (4),

wherein the groove of the first bearing surface (2a') is configured to form fittingly receive the ridge (7a") of the second bearing surface (7a) and the groove (7a') of the second bearing surface (7a) is configured to from-fittingly receive the ridge (7a") of the first bearing surface (2a)

6. The filter plate frame assembly according to any of the preceding Claim 1-5, **characterized** in that the filter plate frame (2) is of a generally rectangular shape.

7. The filter plate frame assembly (1) according to any of the preceding Claims 1-6, **characterized** by further comprising a filter plate (9) 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).

8. The filter plate frame assembly (1) according to Claim 7, **characterized** in that the subframe (7) is secured in a direction perpendicular to a plane defined by the filter plate frame assembly between the filter plate frame (2) and the filter plate (9), such that a free play of the filter plate subframe is allowed in said direction.

9. The filter plate frame assembly according to Claim 8, **characterized** by further comprising a diaphragm (10) covering an area delimited by the subframe (7), wherein the diaphragm (10) is attached to the subframe and resides between the subframe (7) and the filter plate (9).

10. The filter plate frame assembly according to Claim 9, **characterized** in that the diaphragm (10) comprises a continuous seal bead (11) for sealing the diaphragm (10) against the filter plate (9), wherein the free play allowed between the subframe (7) and the filter plate (9) allow the seal (11) to be detached from the plate when the subframe is not pressed towards the filter plate, and the seal to abut the filter plate when the subframe is pressed towards the filter plate.

11. The filter plate frame assembly according to Claim 9, **characterized** in that the diaphragm comprises a continuous seal bead (11) for sealing the diaphragm against

the filter plate, wherein the free play allowed between the subframe and the filter plate allow the seal bead to

- when the subframe (7) is not pressed towards the filter plate (9), engage therewith so as to provide sealing against a first pressure differential, and to leak under a second, higher pressure differential, and
- when the subframe (7) is pressed towards the filter plate (9), engage therewith so as to provide sealing against the second pressure differential

12. The filter plate frame according to any of the preceding Claims 1-10, **characterized** in that the filter plate frame assembly (1) further comprises a sealing strip (12) for sealing the filter chamber formed on central opening (8) of the subframe (7) against a filter plate of an adjacent filter plate frame assembly below the subframe (7), wherein the sealing strip (12) is attached to the subframe (7), on the frame side (1b) thereof.

13. 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 1-11, wherein the filter plate frame assemblies (1) are configured movable towards each other into a closed position in which a filter chamber 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 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;
- a recovering arrangement for recovering filtrate from the filter chamber, and
- a discharge arrangement for discharging a filter cake formed within the filter chamber.

14. A method of replacing worn components on the filter press according to Claim 12, **characterized** by comprising the steps of:

- opening a filter chamber by moving an associated upper filter plate frame assembly (1) away from an associated lower filter plate frame assembly (1) with the translation arrangement,
- opening an openable end of the associated lower plate frame assembly (1)
- removing a subframe (7) having worn components from the frame (2) of the lower plate frame assembly (1) via the openable end
- inserting a subframe (7) having unworn or refurbished components into the frame (2) of the lower plate frame assembly (1) via the openable end, and
- closing the openable end of the lower plate frame assembly (1).

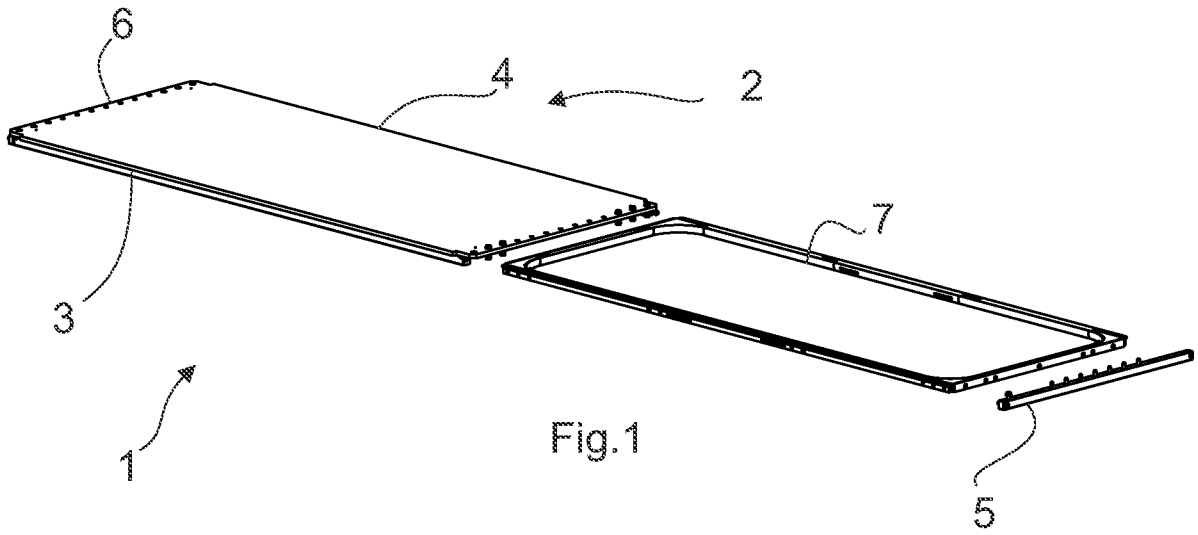

Fig.1

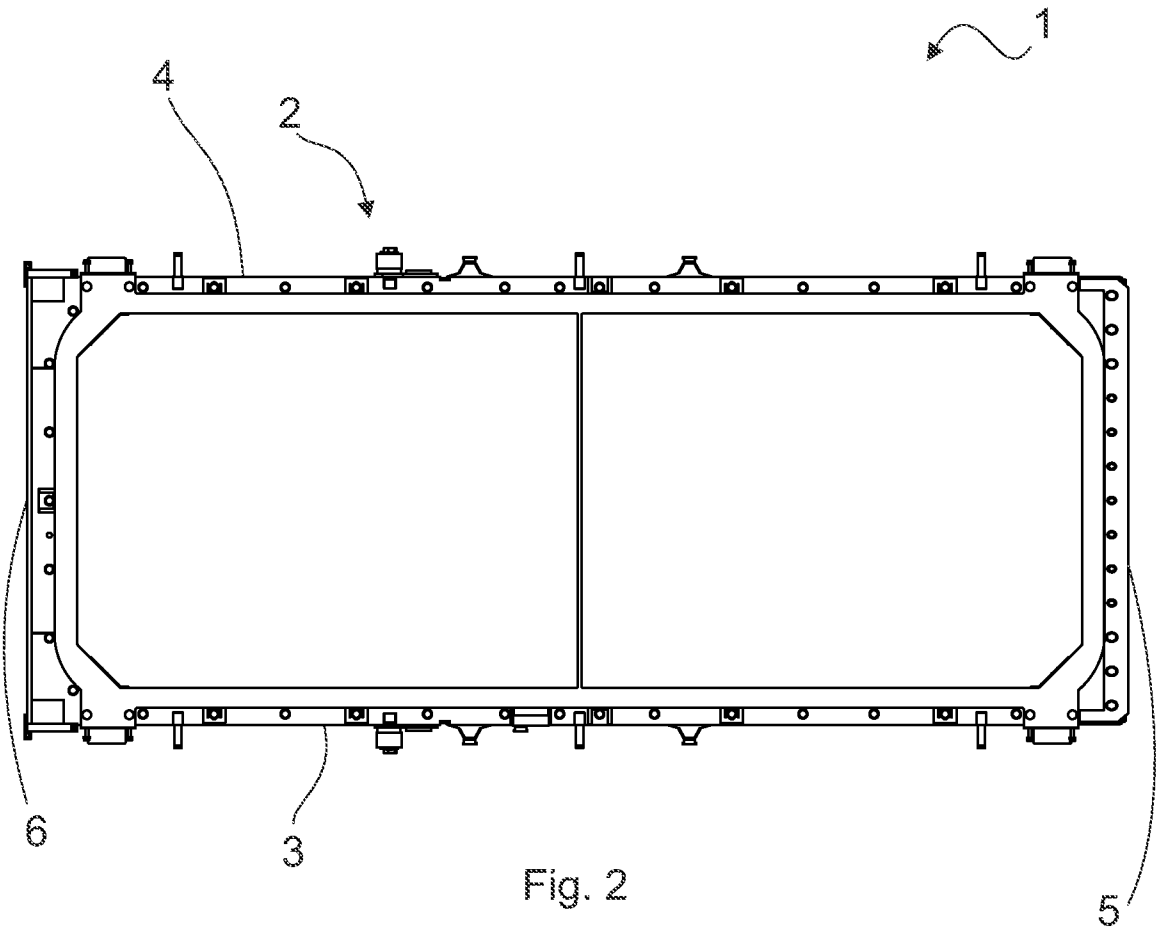

Fig. 2

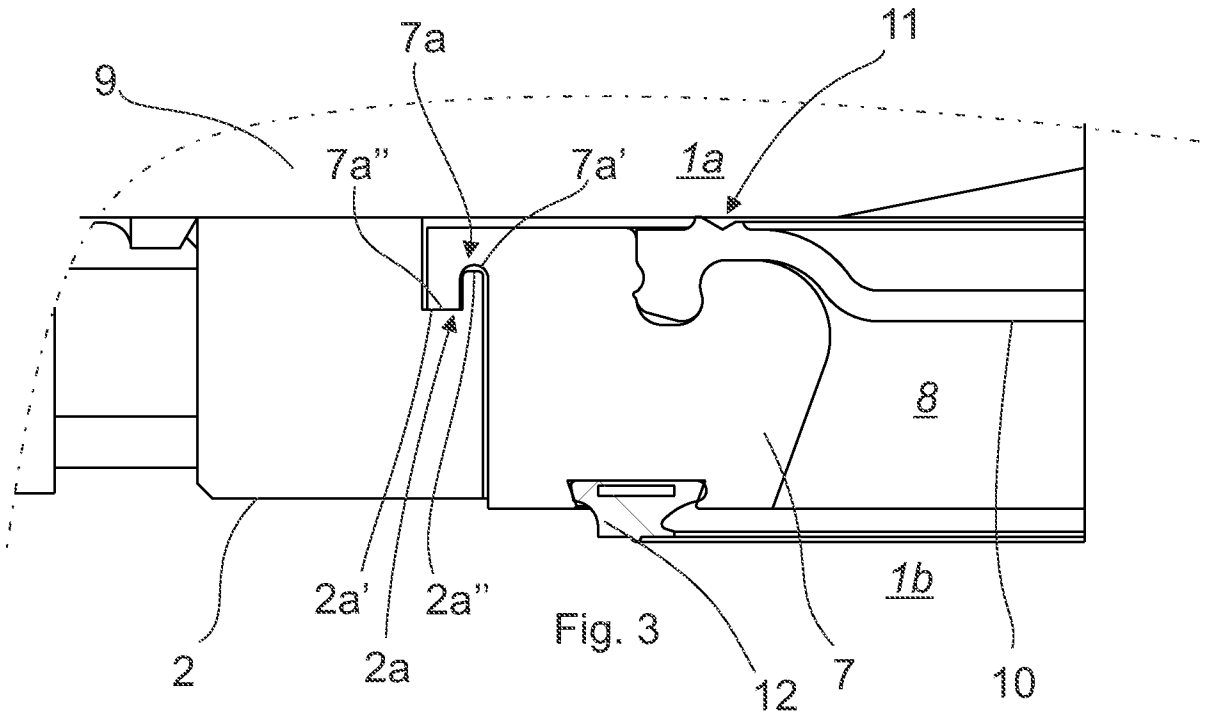
7a
11
9
7a''
7a'
1a
8
1b
2a'
2a''
2
2a
12
7
10

Fig. 3

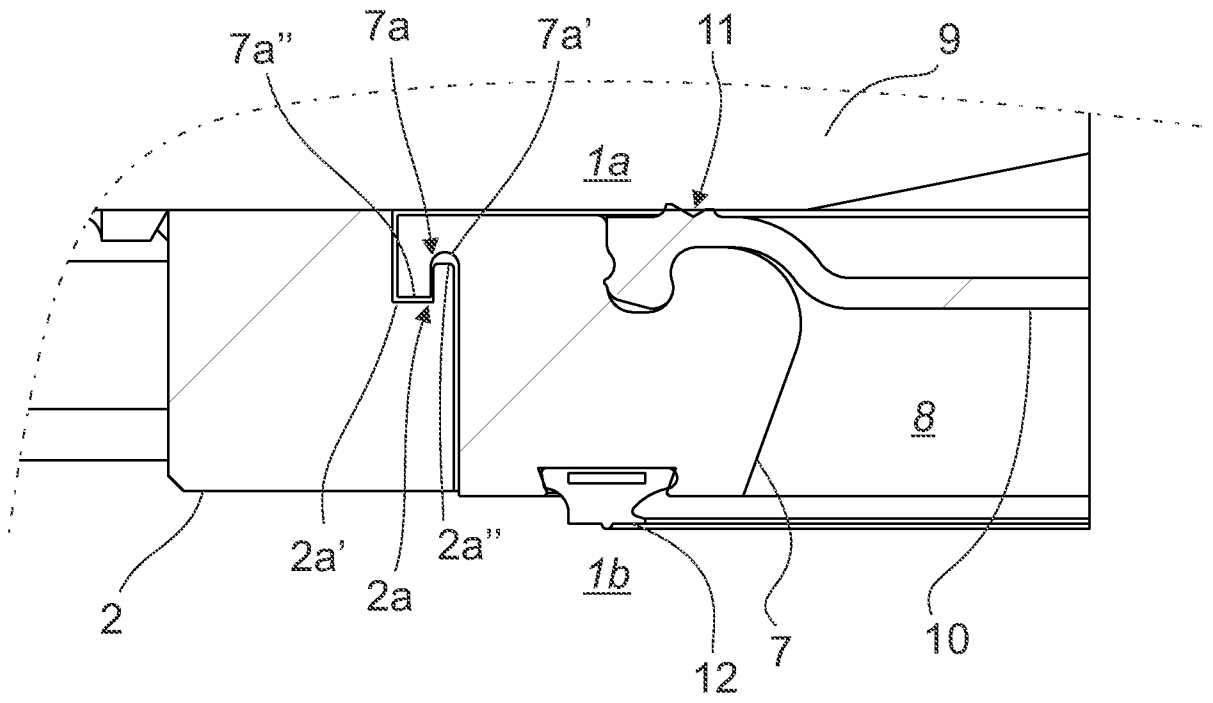
7a''
7a
7a'
11
9
1a
8
1b
2a'
2a''
2
2a
12
7
10

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2020/050256

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 3, lines 1–28; column 5, lines 9–24; column 6, lines 27–53; figures 1–3	1-14
A	EP 0145399 A2 (HEATON HERBERT MARSHALL) 19 June 1985 (19.06.1985) the whole document, especially page 3, line 34 – page 4, line 16; page 5, lines 1–20; figures 1 and 2	1-14
A	CN 102225259 B (NEW MATERIAL RES INST SHANDONG ACADEMY OF SCIENCES) 10 April 2013 (10.04.2013) especially figures 1, 3, and 4 & abstracts [online] EPOQUENET EPODOC & WPI & the whole machine translation into English by EPO [online] EPOQUENET TXPCNEB	1-14

☒ 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
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"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		

Date of the actual completion of the international search	Date of mailing of the international search report
14 July 2020 (14.07.2020)	15 July 2020 (15.07.2020)

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2020/050256

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

International application No.
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CLASSIFICATION OF SUBJECT MATTER

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B01D 25/127 (2006.01)
B01D 25/168 (2006.01)