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(54) **Plate heat exchanger**

(57) A plate heat exchanger (10,82,106), a second means (43,83,113) adapted for use in such a plate heat exchanger and a first means (41,81,111) adapted for use in connection with such a second means are provided. The plate heat exchanger (10,82,106) comprises a first end plate (12,84,126) having an inner surface (14,104,125) and an outer surface (16,105,127) and a second end plate (18,86,122) having an inner surface (20,102, 123) and an outer surface (22,103,124). A set of heat exchanger plates (50) is arranged between the inner surface (14,104,125) of the first end plate (12,84,126) and the inner surface (20,102,123) of the second end plate (18,86,122). Further, the first means (41,81,111) engages with the first end plate (12,84,126) and the second means (43,83,113) engages with the second end plate (18,86,122). The first means (41,81,111) further engages with the second means (43,83,113) for connecting the first end plate (12,84,126) and the second end plate (18,86,122). The second means (43,83,113) partly encloses the first means (41,81,111). The plate heat exchanger (10,82,106) is characterized in that a first part (43a,83a,113a) of the second means (43,83,113) projects from the inner surface (20,102,123) of the second end plate (18,86,122).

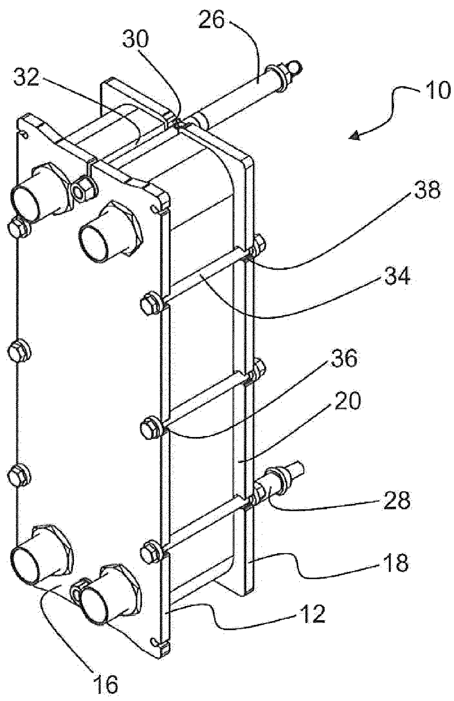


Fig. 1a

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## Description

### TECHNICAL FIELD OF THE INVENTION

**[0001]** The present invention relates to a plate heat exchanger comprising a first end plate having an inner surface and an outer surface and a second end plate having an inner surface and an outer surface. A set of heat exchanger plates is arranged between the inner surface of the first end plate and the inner surface of the second end plate. Further, a first means engages with the first end plate and a second means engages with the second end plate. The first means further engages with the second means for connecting the first end plate and the second end plate and the second means partly encloses the first means. The invention also relates to a second means for use in such a plate heat exchanger and a first means adapted for use in connection with such a second means.

### BACKGROUND ART

**[0002]** Plate heat exchangers, or PHEs, typically consist of two end plates in between which a number of heat exchanger plates are arranged in an aligned manner. In one type of well-known PHEs, the so called gasketed plate heat exchangers, gaskets are arranged between the heat exchanger plates. The end plates, and therefore the heat exchanger plates, are pressed towards each other whereby the gaskets seal between the heat exchanger plates. The gaskets define parallel flow channels between the heat exchanger plates through which channels two fluids of initially different temperatures can flow for transferring heat from one fluid to the other. These gasketed PHEs are often openable and separable. More particularly, by releasing the pressure between the end plates of a gasketed plate heat exchanger, the heat exchanger plates can be separated from each other and from the rest of the PHE to enable e.g. cleaning, removal, addition and replacement of plates which is desired in connection with some PHE applications.

**[0003]** The end plates of a gasketed plate heat exchanger are normally referred to as frame plate and pressure plate. The frame plate is often fixed to a support surface such as the floor while the pressure plate is movable in relation to the frame plate. A carrying bar for carrying the pressure plate as well as the heat exchanger plates extends from an upper part of the frame plate while a guiding bar for guiding the pressure and heat exchanger plates extends from a lower part of the frame plate. Further, the frame and pressure plates are connected to each other by means of a number of pair wise cooperating first and second means, in the form of bolts and nuts, respectively. The bolts typically extend through respective openings in the pressure plate and the frame plate with the bolt heads engaging with an outside surface of the frame plate and the nuts engaging with the bolts and with the outside surface of the pressure plate. By rotating these nuts, the pressure between the frame and pressure plates can be regulated.

**[0004]** As mentioned above, gasketed plate heat exchangers can be opened up by releasing the pressure between the frame and pressure plates whereby the heat exchanger plates can be separated and individually accessed to enable maintenance operations. This is performed by rotating the nuts, normally counter-clockwise, such that the nuts are displaced from the bolt heads in an axial direction. In connection with such opening, complete dismounting is often undesirable since the plate heat exchanger often should be reclosed after the desired maintenance operations have been performed. Therefore, the carrying and guiding bars are normally relatively long such that the pressure plate and the heat exchanger plates can be separated from each other and from the frame plate while still hanging from the carrying bar and being threaded onto the guiding bar. The length of the bolts determines whether complete removal of the nuts from the bolts is necessary in connection with the opening or not. If the bolts are sufficiently long, the PHE can be opened and the heat exchange plates separated and accessed without having to remove the nuts from the bolts. This means that the pressure plate remains threaded onto the bolts during the opening which facilitates subsequent reclosing of the PHE. On the contrary, if the bolts are relatively short, the nuts and probably also the pressure plate and some of the heat exchanger plates must be removed from the rest of the PHE to enable the desired maintenance operations. In connection with reclosing of PHE after finished maintenance work, the nuts are again tightened or rotated on the bolts, normally in the clockwise direction, such that the nuts are displaced towards the bolt heads in the axial direction.

**[0005]** Arranged in succession and as close to each other as possible without being pressed together, the heat exchanger plates together with the gaskets form a stack with the thickness $t_{open}$, see figures 6a and 6b illustrating a plate heat exchanger according to prior art. As mentioned above, when the nuts are tightened, the frame and pressure plates are forced towards one another which leads to deformation of the gaskets arranged between the heat exchanger plates. When the PHE is ready for use, the thickness of the stack is $t_{closed}$, where $t_{open} > t_{closed}$. If the total thickness of the frame and pressure plates is $2\times T_{plate}$, and the dimension of the bolt heads in the axial direction is $T_{bolt\ proj}$, then the length $L_{bolt}$ of the bolts should be larger than $t_{open}$ + $\mathbf{2\times T}_{plates}$ + $\mathbf{T}_{bolt\ proj}$ + $\partial$, where $\partial$ is the projection of the bolts from the outside surface of the pressure plate necessary for the nuts to be able to engage with the bolts. If the length of the bolts was less than this, it would be very hard to attach the nuts to the bolts since the stack of exchanger plates and gaskets first would have to be compressed to make the bolts project from the outside surface of the pressure plate. Similarly, the length of the carrying and guiding bars should be at least such that a stack of thickness $t_{open}$ can be carried and guided by the bars.

**[0006]** Thus, the bolts are longer than required for the very clamping of the heat exchanger plates and the gaskets between the frame and pressure plates. The excessive length of the bolts is mainly for enabling closing of the PHE. When the PHE is in use, the excess bolt lengths as well as the carrying and guiding bars project from the outside surface of the pressure plate, which makes the plate heat exchanger unnecessary bulky.

**SUMMARY OF THE INVENTION**

**[0007]** An object of the present invention is to provide a plate heat exchanger and parts adapted for use in such a plate heat exchanger which, at least partly, eliminate potential limitations of prior art. The basic concept of the invention is to let the second means extend between the end plates to enable first means-second means engagement between the outer surfaces of end plates instead of, like previously, on the outside of the end plates. Thereby the plate heat exchanger can be made considerably less bulky.

**[0008]** The plate heat exchanger and the parts for achieving the object above are defined in the appended claims and discussed below. For the sake of clarity it should be said that the section below describes the plate heat exchanger in a closed state.

**[0009]** A plate heat exchanger according to the present invention comprises a first end plate having an inner surface and an outer surface, a second end plate having an inner surface and an outer surface and a set of heat exchanger plates arranged between the inner surface of the first end plate and the inner surface of the second end plate. A first means engages with the first end plate and a second means engages with the second end plate. The first means further engages with the second means for connecting the first end plate and the second end plate. The second means partly encloses the first means. The plate heat exchanger is characterized in that a first part of the second means projects from the inner surface of the second end plate.

**[0010]** The plate heat exchanger can be of different types, for example of the type initially described, i.e. a gasketed plate heat exchanger.

**[0011]** By inner surface is meant that surface of the end plates that faces the heat exchanger plates. Further, by outer surface is meant that surface of the end plates that is turned away from the heat exchanger plates.

**[0012]** The number of heat exchanger plates in the set may vary and is dependent on the intended application of the plate heat exchanger. The heat exchanger plates are arranged in a stack, the top surface of the first heat exchanger plate in the stack facing the first end plate and the bottom surface of the last heat exchanger plate in the stack facing the second end plate.

**[0013]** The first and second means are pair wise cooperating components and they can be of different types. For example, they can so arranged as to perform the function of the above described bolts and nuts, i.e. the function of forcing the inner surface of the first end plate and the inner surface of the second end plate against each other. In this context, as described by way of introduction, when the inner surfaces of the first and second end plates are forced against each other, the stack of heat exchanger plates are pressed together and clamped between the first and second end plates. Due to this pressing, the thickness of the stack of heat exchanger plates is reduced. The closer the end plates come, the more reduced the stack thickness is. As another example, the first and second means could be so arranged as to perform the function of carrying and guiding the heat exchanger plates, in which case they would replace the above described conventional carrying and guiding bars. In accordance herewith, the first and second means could be arranged so as to not be active in reducing the thickness of the stack.

**[0014]** The first and second means can be arranged to engage both directly and indirectly with the first and second end plates, respectively, and with each other. Further, the first and second means may be formed as one respective single piece or they may be composed of several assembled respective pieces.

**[0015]** In the following discussion, the first means cooperating with the second means is referred to as the connection element. For the previously known, above described, plate heat exchanger, there is a direct relationship between the stack thickness reduction and how much of the first means or bolts that projects from the outer surface of the second end plate. Obviously, the more the stack thickness is reduced, the more the first means or bolts project from the outer surface of the second end plate. In the known plate heat exchanger, the first means or bolts extend all the way from the first end plate to the second end plate. In other words, the portion of the connection element extending from the inner surface of the first end plate to the inner surface of the second end plate is completely composed of a portion of the first means.

**[0016]** In connection with a PHE according to the present invention, since the first part of the second means extends between the first and second end plates, the portion of the connection element extending from the inner surface of the first end plate to the inner surface of the second end plate comprises a portion of the second means. It is not necessary, but however possible, for the first means to extend all the way from the first end plate to the second end plate for connection of the end plates and it is possible to construct the PHE such that no portion of the first means, or a relatively short portion of the first means, extends beyond the outer surface of the second end plate. Thereby, the PHE can be made less space demanding.

**[0017]** In accordance with one embodiment of the present invention the second means comprises a sleeve arranged to receive a distal end of the first part of the first means.

**[0018]** By distal end is meant the "free" end, i.e. the end not connecting with the rest of the first means.

**[0019]** The sleeve can be open in both ends or closed in one end.

**[0020]** The complete second means or just one or more portions thereof may be sleeve shaped.

**[0021]** This embodiment, where the first means is partly housed within the sleeve, makes the PHE even more compact and mechanically simple.

**[0022]** The above sleeve can be constructed so as to have an internal thread adapted for mutual cooperation with an external thread provided on the first means. Such thread connections are robust and mechanically un-complicated.

**[0023]** The internal thread above can be arranged to extend only partly along the sleeve. This is beneficial since it becomes easier to screw the first means into the sleeve. If the internal thread would extend along the complete sleeve, the friction between the sleeve and the first means would be higher and it would be harder to screw the first means into the sleeve.

**[0024]** In accordance with one embodiment of the present invention, the plate heat exchanger is constructed such that the distal end of the first part of the first means is arranged within the sleeve. In other words, the distal end of the first part of the first means never extend beyond the sleeve which enables an even more space efficient plate heat exchanger.

**[0025]** The inventive plate heat exchanger may be designed such that an outer part of the second means has a partly edgy contour. This outer part may project from the outer surface of the second end plate to enable maneuvering of the second means from the outside of the plate heat exchanger. This outer part may also be arranged in a recess of the second end plate so as to not protrude from an outer surface thereof to enable an even more compact PHE. An edgy contour, such as an edgy outer shape, of the outer part of the second means makes it easier to firmly engage with the second means, for example by means of a tool in the form of an adjustable spanner or the like, for rotating the second means in relation to the first means.

**[0026]** According to one embodiment of the present invention, essentially the complete first part of the first means is arranged within the sleeve when the plate heat exchanger is ready for use. Such a solution enables an optimization in view of space efficiency.

**[0027]** The PHE may be so designed that the first part of the first means projects from the inner surface of the first end plate. Such a design enables first means-second means engagement between the inner surfaces of the end plates. Further, since the first part of both the first and the second means extend between the first and second end plates, the portion of the connection element extending from the inner surface of the first end plate to the inner surface of the second end plate will comprise one portion of the first means and one portion of the second means.

**[0028]** According to a further embodiment of the plate heat exchanger according to the present invention, a distal end of the first part of the second means is arranged to abut against an abutment surface of the plate heat exchanger so as to indicate a preferred distance ($t_{closed}$) between the inner surfaces of the first and second end plates when the plate heat exchanger is ready for use.

**[0029]** In connection with the above embodiment the abutment surface could be part of the inner surface of the first end plate. This means that the distal end of the first part of the second means contacts the inner surface of the first end plate when the PHE is ready for use. Thus, the length of the first part of the second means is equal to the preferred distance between the inner surfaces of the end plates.

**[0030]** Alternately, in connection with the above embodiment, the abutment surface could be part of the first means. This means that the distal end of the first part of the second means contacts the first means when the PHE is ready for use. This contact can take place in different ways, for example flush with the outer surface of the first end plate or between the inner and outer surfaces of the first end plate.

**[0031]** A second means according to the present invention is adapted for use in a plate heat exchanger according to the present invention.

**[0032]** A first means according to the present invention is adapted for use in connection with a second means according to the present invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0033]** The invention will be described in more detail with reference to the appended schematic drawings, which show prior art as well as a presently non-limiting preferred embodiment of the invention.

Figure 1 a is perspective view of a plate heat exchanger according to a first embodiment of the present invention.

Figure 1b is a side view of the plate heat exchanger in figure 1 b.

Figure 2a is an enlargement of a part of figure 1b illustrating a first and a second means, i.e. a connection element.

Figure 2b is a cross section of the part in figure 2a, taken parallel to the figure plane of figure 2a.

Figure 2c is an enlargement of a part of a pressure plate of the plate heat exchanger according to the first embodiment, in a side view seen in the direction D illustrated in figure 2a, which part contains an area of engagement between the pressure plate and a connection element according to figures 2a and 2b.

Figure 3a corresponds to figure 2a and illustrates the bar, the tightening means and a number of heat exchanger plates when the plate heat exchanger is closed and ready for use.

Figure 3b illustrates the bar, the tightening means and the heat exchanger plates when the plate heat exchanger is open.

Figure 3c illustrates the bar, the tightening means and a, for this connection element, maximum number of heat exchanger plates in an open PHE state.

Figure 4a illustrates a first and a second means, i.e. a connection element, to be used in connection with a second embodiment of the present invention.

Figure 4b is a cross section of the part in figure 4a, taken parallel to the figure plane of figure 4a.

Figure 4c corresponds to figure 2c and illustrates a part of a pressure plate of the plate heat exchanger according to the second embodiment, in a side view seen in the direction D illustrated in figure 4a, which part contains an area of engagement between the pressure plate and a connection element according to figure 4a.

Figure 5a is a side view of a plate heat exchanger according to a third embodiment of the present invention.

Figure 5b is a cross section of a part of the plate heat exchanger in figure 5a in a first state.

Figure 5c is a cross section of a part of the plate heat exchanger in figure 5a in a second state. Figure 6a corresponds to figures 3a and 4a and illustrates a portion of a known plate heat exchanger ready for use.

Figure 6b corresponds to figure 3b and illustrates the above portion of the known plate heat exchanger in an open state.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

**[0034]** In figure 1 a and 1 b a gasketed plate heat exchanger 10 according to a first embodiment of the present invention is shown. It comprises a first end plate hereinafter referred to as frame plate 12. The frame plate 12 has an inner surface 14 and an outer surface 16. The plate heat exchanger 10 further comprises a second end plate hereinafter referred to as pressure plate 18. The pressure plate 18 has an inner surface 20 and an outer surface 22. A set of heat exchanger plates are arranged between the inner surface 14 of the frame plate 12 and the inner surface 20 of the pressure plate 18. The heat exchanger plates are not individually shown in figures 1 a and 1 b but further ahead in the drawings. They are all of the same kind, i.e. essentially rectangular sheets of stainless steel provided with a certain pattern or profile and a number of fluid inlet and outlet ports, and arranged in succession with a top surface of one heat exchanger plate facing the bottom surface of a neighboring heat exchanger plate. Every second heat exchanger plate is rotated 180 degrees in relation to a reference orientation. The heat exchanger plates are separated from each other by gaskets which are not individually shown in figures 1 a and 1 b but further ahead in the drawings. The heat exchanger plates together with the gaskets form parallel channels arranged to receive two fluids for transferring heat from one fluid to the other. To this end, a first fluid is arranged to flow in every second channel and a second fluid is arranged to flow in the remaining channels. For the channels to be leak proof, the heat exchanger plates must be pressed against each other whereby the gaskets are deformed and seal between the heat exchanger plates. When assembled the heat exchanger plates and the gaskets forms a package 24 arranged between the frame and pressure plates 12 and 18, respectively.

**[0035]** A carrying bar 26 is fixed to, and extends in the horizontal direction from, an upper portion of the frame plate 12. Further, a guide bar 28 is fixed to, and extends in the horizontal direction from, a lower portion of the frame plate 12. The free ends of the carrying and guide bars 26 and 28, respectively, could be fixed to a support for increased stability but this is not illustrated herein. As implied by the name, the carrying bar 26 is arranged to carry the pressure plate 18 as well as the heat exchanger plates. To this end the pressure plate and the heat exchanger plates are each provided, in a top edge thereof, with a recess 30 and 32, respectively, arranged to receive and engage with the carrying bar 26. Similarly, as implied by the name, the guiding bar 28 is arranged to guide and align the pressure plate 18 as well as the heat exchanger plates. To this end the pressure plate and the heat exchanger plates are each provided, in a bottom edge thereof, with a recess (not shown), respectively, arranged to receive and engage with the guiding bar 28.

**[0036]** The plate heat exchanger 10 further comprises a number of connection elements 34, here six, for connecting the frame plate 12 and the pressure plate 18. The frame plate 12 is provided with the same number of recesses 36 along its side edges which recesses are arranged for engagement with the connection elements 34. Similarly, the pressure plate 18 is provided with corresponding recesses 38 along its side edges which recesses are arranged for engagement with the connection elements 34.

**[0037]** The plate heat exchanger 10 is openable to enable maintenance and cleaning operations. Thus, the plate heat exchanger 10 has an open state and a closed state, the latter being illustrated in figures 1 a and 1 b. The frame plate 12 is secured to the floor and arranged to be stationary. The pressure plate 18 and the heat exchanger plates are movable in relation to the frame plate 12 to enable opening and closing of the plate heat exchanger 10. To open the plate heat exchanger 10 the connection elements 34 are released and the pressure plate 18 is displaced in a direction from the frame plate 12. To enable opening of the plate heat exchanger 10 without complete dismounting of the same, the carrying and guide bars 26 and 28 are relatively long such that the pressure plate theoretically can be displaced a distance x while still being supported by the carrying and guide bars. However, in order not to risk that the pressure plate accidentally disengages with the rest of the plate heat exchanger in connection with opening of the same, the carrying and guiding bars are each provided with a stopping means 40 limiting the displacement of the pressure plate. When the plate heat exchanger 10 is in the open state, also the heat exchanger plates can be displaced from the frame plate and separated from each other while still engaging with the carrying bar 26 and the guiding bar 28. The general functioning and design of a gasketed plate heat exchanger is well known and will not be described in further detail herein.

**[0038]** The essence of the present invention lies within the connection elements 34 for connecting the frame plate to the pressure plate. One of these connection elements is illustrated in more detail in figures 2a and 2b which correspond to the area marked with broken lines in figure 1 b. In figure 2c an area of the outer surface 22 of the pressure plate 18 is shown, which area is arranged for engagement with the connection element (the connection element not being illustrated in the figure). The connection element 34 comprises a first means 41 and a second means 43, which means are arranged to engage with each other to connect the frame and pressure plates, 12 and 18.

**[0039]** The first means 41 comprises a solid bolt 42 and a bolt washer/fixing means 46 arranged to surround the bolt 42 in an area of engagement with the frame plate 12. The bolt 42 has a bolt bar 42ab and a bolt head 42c. The bolt bar 42ab has a cylindrical outer contour while the bolt head 42c instead has an edgy outer contour, here a hexagonal outer shape, to facilitate firm tool engagement in connection with tightening and releasing of the connection element. The bolt washer/fixing means 46 has a fixing part 46b arranged to be positioned within the frame plate 12, between a wall of the recess 36 and the bolt bar 42ab for securing the same in the frame plate, and a washer part 46c arranged to be positioned between the bolt head 42ab and the outer surface 16 of the frame plate 12. The first means 41 has a first part 41 a arranged to extend from the inner surface 14 of the frame plate 12, which first part is constituted of a portion of the bolt bar 42ab. Further, the first means 41 has a second part 41 b arranged to be positioned between the inner and outer surfaces 14 and 16, respectively, of the frame plate, which second part is constituted of a portion of the bolt bar 42ab and the fixing part 46b of the bolt washer/fixing means 46. Thus, the second part 41 b of the first means 41 is arranged to be positioned in a respective one of the recesses 36 of the frame plate 12, which recesses are similar to the recesses 38 of the pressure plate 18, of which one is shown in figure 2c. Finally, the first means 41 has a third part 41 c arranged to extend from the outer surface 16 of the frame plate, which third part is constituted of the bolt head 42c and the washer part 46c of the washer/fixing means 46.

**[0040]** Similarly, the second means 43 comprises a sleeve 44 and a sleeve washer/fixing means 48 arranged to surround the sleeve 44 in an area of engagement with the pressure plate 18. The sleeve 44 is open in both ends and has a casing 44ab which is internally partly threaded and a sleeve head 44c. The casing 44ab has a cylindrical outer contour while the sleeve head 44c instead has an edgy outer contour, here a hexagonal outer shape, to facilitate firm tool engagement in connection with tightening and releasing of the connection element. The sleeve washer/fixing means 48 has a fixing part 48b arranged to be positioned within the pressure plate 18, between a wall of the recess 38 and the casing 44ab for securing the same in the pressure plate, and a washer part 48c arranged to be positioned between the sleeve head 44c and the outer surface 22 of the pressure plate 18. The second means 43 has a first part 43a arranged to be positioned between the frame plate 12 and the pressure plate 18, which first part is constituted of a portion of the casing 44ab. Further, the second means 43 has a second part 43b arranged to be positioned between the inner and outer surfaces 20 and 22, respectively, of the pressure plate, which second part is constituted of a portion of the casing 44ab and the fixing part 48b of the sleeve washer/fixing means 48. Thus, the second part 43b of the second means 43 is arranged to be positioned in a respective one of the recesses 38 of the pressure plate 18. Finally, the second means 43 has a third part 43c arranged to extend from the outer surface 22 of the pressure plate 18, which third part is constituted of the sleeve head 44c and the washer part 48c of the washer/fixing means 48. In figure 2b the borders between the different parts of the first and second means of the connection element have been illustrated by means of narrow broken vertical lines.

**[0041]** Thus, as illustrated most clearly in the cross section of figure 2b, for closing the plate heat exchanger, the first means 41 is arranged to engage with the frame plate 12, the second means 43 is arranged to engage with the pressure plate 18 and the first and second means are further arranged to engage with each other. For the engagement between the first and second means, the first part 41 a of the first means, i.e. the above mentioned portion of the bolt bar 42ab, is provided with an external thread 42a', and the first part 43a of the second means, i.e. the above mentioned portion of the casing 44ab, is provided with an internal thread 44a'. The external thread 42a' extends along the complete bolt bar 42ab while the internal thread 44a' extends along only a portion 44a" of the first part of the second means 43. The sleeve 44 is arranged to receive a free or distal end 41 a' of the first part 41 a of the first means 41, i.e. the distal end of the bolt 42, for enabling mutual cooperation between the threads 42a' and 44a' by rotation or screwing of the bolt in relation the sleeve. Since the internal thread 44a' extends along only the portion 44a" of the sleeve 44 it is easier to screw the bolt into the sleeve than would have been the case if the internal thread extended along essentially the complete sleeve.

**[0042]** Figure 3a corresponds to figure 2a but illustrates also the heat exchanger plates 50, here 28 in number, and the gaskets 52, here 27 in number, of the package 24 shown in figures 1 a and 1 b. While figure

3a illustrates a part of the plate heat exchanger 10 in a closed state, figure 3b illustrates the same part of the plate heat exchanger in an open state. Prior to assembly of the plate heat exchanger, the heat exchanger plates 50 of the specific set are all provided with a respective one of the gaskets 52 but for one of the heat exchanger plates arranged to be positioned closest to the frame plate 12 since the package 24 should begin and end with a respective one of the heat exchanger plates 50. The gasket provision is performed by attaching, by adhesive or clips, the gaskets in grooves of the heat exchanger plates. This is well known within the art and will not be further described herein.

**[0043]** In connection with heat exchanger assembly, the heat exchanger plates 50 as well as the pressure plate 18 are threaded, through the recesses in the top edge and bottom edge thereof, onto the carrying bar 26 and the guiding bar 28 (shown in figures 1 a and 1 b). Further, the bolt 42 and the bolt washer/fixing means 46, i.e. the first means 41, is arranged in engagement with the frame plate 12, the sleeve 44 and the sleeve washer/fixing means 48, i.e. the second means 43, is arranged in engagement with the pressure plate 18 and the bolt is arranged in engagement with the sleeve, in the above described way. When the plates are arranged such that each of the gaskets is undeformed and contacts two of the heat exchanger plates, and the pressure and frame plates contact one end heat exchanger plate each, without application of external forces, which state is shown in figure 3b, the package 24 has a thickness $t_{open}$. In this state the bolt 42 is screwed into the sleeve 44 the distance d. For closing the plate heat exchanger 10, the bolt is screwed further into the sleeve, the distance $\Delta t$, whereby the frame and pressure plates are pressed towards each other and the gaskets 52 are deformed between the heat exchanger plates 50. The bolt is rotated until a distal end 43a' of the first part 43a of the second means 43, i.e. the distal end of the sleeve 44, contacts the inner surface 14 of the frame plate 12 and the distal end 41 a' of the first part 41 a of the first means 41, i.e. the distal end of the bolt 42, arrives flush with an outer edge 44c' of the sleeve head 44c. The contact between the sleeve and frame plate inner surface is established along an abutment surface 45 of the inner surface, which abutment surface surrounds the recess 36. Then, no further bolt rotation is possible and the desired distance between the frame and pressure plates for the plate heat exchanger in the closed state has been achieved. In this state, which is shown in figure 3a, the package 24 has a thickness $t_{closed} = t_{open} - \Delta t$.

**[0044]** Thus, the length of the connection element 34 when used in the plate heat exchanger can be varied by rotation of the bolt in relation to the sleeve between a minimum length shown in figure 3a and discussed above and a maximum length shown in figure 3c. When the connection element has its maximum length, the bolt is screwed into the sleeve as little as possible, $\partial$, while still assuring engagement between the bolt and the sleeve.

**[0045]** In order to hold together the frame and pressure plates when the plate heat exchanger 10 is in the closed state, the maximum length of the connection element 34 must be at least $\mathbf{L = 2 \times T_{plate} + t_{closed} + T_{1st\ means\ proj}} + \mathbf{T_{2nd\ means\ proj}} + \partial$, where $\mathbf{T_{plate}}$ is the thickness of the pressure and frame plates, $\mathbf{t_{closed}}$ is, as previously discussed, the thickness of the package 24 when the plate heat exchanger is in the closed state, $\mathbf{T_{1st\ means\ proj}}$ is the projection of the first means from the outer surface of the frame plate, i.e. the extension of the third part 41 c of the first means 41, and $T_{2nd\ means\ proj}$ is the projection of the second means from the outside surface of the pressure plate, i.e. the extension of the third part 43c of the second means 43. However, if the connection elements had exactly this maximum length L, it would be very hard, if not impossible, to assemble the plate heat exchanger since the connection element could not be used in compressing the package 24 to its desired state-of-use-thickness, $t_{closed}$. By constructing, as above described, the connection element with a maximum length enabling connection of the pressure and frames plates without compression of the package 24, i.e. $\mathbf{L} \geq \mathbf{2} \times \mathbf{T_{plate}} + t_{open} + T_{1st\ means\ proj} + \mathbf{T_{2nd\ means\ proj}} + \partial$, the plate heat exchanger can be transferred from its open to its closed state by simply rotating the bolt in relation to the sleeve. No additional means for forcing the pressure plate towards the frame plate are necessary.

**[0046]** Figure 3c illustrates that additional heat exchanger plates 50' and gaskets 52' (illustrated with broken lines) could be added to the plate heat exchanger 10 while still keeping this functionality of the connection element 34. For the sake of clarity it should be said that addition of exchanger plates 50' and gaskets 52' would result in increased package thicknesses $t_{open}$ and $t_{closed}$. Consequently, the distal end of the sleeve contacting the inner surface of the frame plate could not, without adjustments, be used as a sign that the desired distance between the frame and pressure plates for the plate heat exchanger in the closed state has been achieved. More particularly, if more heat exchanger plates 50' and gaskets 52' were added to the heat exchanger 10, the distal end of the sleeve would never (without over-tightening the connection element 34) contact the inner surface 14 of the frame plate 12.

**[0047]** In accordance with the present invention, since both the first and second means, more particularly the bolt and the sleeve, extend between the pressure plate and frame plate, a connection element is formed that is very compact. The portion of the connection element that extends between the pressure and frame plate consists not only of a portion of the bolt but of portions of both the bolt and the sleeve. The bolt and the sleeve can be arranged essentially after one another with only a short "overlap" to enable mutual engagement and give the connection element a maximum length, or the sleeve can be arranged to "swallow" a portion of the bolt to give the connection element a minimum length. Further, the maximum length of the connection element is sufficient to connect the frame and pressure plates even when the package of heat exchanger plates and gaskets arranged between the frame and pressure plates is completely uncompressed. Additionally, the minimum length of the connection element is suited to the desired measures of the plate heat exchanger in the closed, ready-for-use, stage. More particularly, the first part of the second means extends from the inner surface of the frame plate to the inner surface of the pressure plate in the closed state of the PHE, the length of this first part being equal to the desired thickness of the package, $t_{closed}$.

**[0048]** Figures 4a-c correspond to figures 2a-c and illustrate parts of a gasketed plate heat exchanger 82 (not shown in its entirety but to a very large extent similar to the one shown in figures 1 a & b) according to a second embodiment of the present invention. This PHE 82 is similar to the PHE 10 according to the previous figures except for when it comes to the connection between the frame plate 84 and pressure plate 86, which plates are connected by means of connection elements 88. Thus, a fully detailed description of the PHE 82 is considered redundant and will not be given. Further, components of the connection elements that are similar (except for dimensionally) for the first and second embodiments will not be described again.

**[0049]** The connection element 88 comprises a first means 81 and a second means 83. The first means 81 has first, second and third parts, 81a-c, and comprises a solid bolt 90, having an external thread 90a', and a bolt washer/fixing means 92. The second means 83 has first, second and third parts, 83a-c, and comprises a sleeve 94, having an internal thread 94a', and a sleeve washer means 96. The sleeve washer means 96 is similar to the sleeve washer/fixing means 48 of the previously described connection element 34 except for that it lacks a fixing part. Thus, the third part 83c of the second means 83 contains the sleeve washer means 96 corresponding to the washer part 48c of the sleeve washer/fixing means 48 while the second part 83b of the second means is constituted of a portion of the sleeve 94 only.

**[0050]** In figure 4b the borders between the different parts of the first and second means of the connection element have been illustrated by means of narrow broken vertical lines.

**[0051]** Thus, the second part 81 b of the first means 81 is arranged to be positioned in a respective recess 98 of the frame plate 84 while the second part 83b of the second means 83 is arranged to be positioned in a respective recess 100 of the pressure plate 86. One of the recesses 100 of the pressure plate 86, which is similar to the recesses 98 of the frame plate (not further shown), is illustrated in more detail in figure 4c. The shape of the recesses 98 and 100 of the plate heat exchanger 82 according to the second embodiment of the present invention is different from the shape of the recesses 36 and 38 of the plate heat exchanger 10 according to the first embodiment of the present invention. In connection with the recesses 98 and 100, the first and second means 81 and 83, respectively, must be inserted into and removed from the frame and pressure plates in a direction parallel to the arrow D. However, in connection with the recesses 36 and 38, the first and second means 41 and 43, respectively, can also be inserted into and removed from the frame and pressure plates in a direction perpendicular to the arrow D.

**[0052]** Also, the dimensions of the first and second means differ between the first and second embodiment of the present invention. In particular, the outer diameter of the sleeve 94 is larger than of the sleeve 44 such that the second part 83b of the second means 83 takes up essentially the whole corresponding recess 100. Consequently, there is no need for a fixing part like the fixing part 48b described with reference to figure 2a and 2b.

**[0053]** Additionally, like above described, the plate heat exchanger is closed by screwing the bolt 90 into the sleeve 94. The bolt 90 is rotated until a distal end 83a' of the first part 83a of the second means 83, i.e. the distal end of the sleeve 94, contacts a fixing part 92b of the bolt washer/fixing means 92, and a distal end 81 a' of the first part 81 a of the first means 81, i.e. the distal end of the bolt 90, arrives flush with an outer edge 94c' of a sleeve head 94c of the sleeve 94. The contact between the sleeve and the bolt washer/fixing means is established along an abutment surface 95 of the fixing part 92b, which abutment surface, obviously, is annular. Then, no further bolt rotation is possible and the desired distance between the frame and pressure plates for the plate heat exchanger in the closed state has been achieved.

**[0054]** Thus, in the closed, ready-for-use state of the PHE 82, the distal end of the sleeve 94 extends a distance $\xi$ into the recess 98 of frame plate 84. In this state, the connection element 88 has its minimum length. This minimum length is suited to the desired measures of the plate heat exchanger in the closed, ready-for-use, stage. More particularly, the first part 83a of the second means 83 extends from the inner surface 102 of the pressure plate to the fixing part 92b of the bold washer/fixing means in the closed state of the PHE, the length of this first part minus $\xi$ being equal to the desired distance between inner surfaces 102 and 104 of the pressure and frame plates, respectively. The outer surfaces of the pressure and frame plates are denoted 103 and 105, respectively.

**[0055]** Above described are embodiments of the present invention where the first and second means, i.e. the connection elements, are used to force the frame and pressure plates towards one another for compressing the package of gaskets and heat exchanger plates and closing the plate heat exchanger. However, the inventive connection elements can also be used for other types of applications. Figure 5a show a gasketed plate heat exchanger 106 according to a third embodiment of the present invention. The PHE 106 is similar to the PHE shown in figures 1 a & 1 b except for when it comes to its carrying bar and its guiding bar, which bars are essentially similar and constructed as a respective connection element 108 according to the present invention. Another difference is that the first means of connection elements are arranged to engage with the pressure plate while the second means of the connection elements are arranged to engage with the frame plate, which will be further described below. In accordance with the previously described first and second embodiments, it is the other way around. A fully detailed description of the PHE 106 is considered redundant and will not be given. Further, components of the carrying and guiding bars, i.e. the connection elements 108, similar (except for dimensionally) to what has already been described, both in connection with the carrying and guiding bars 26 and 28 and the connection elements 34 and 88, will not be described again.

**[0056]** Figures 5b and 5c show a part of a cross section through the plate heat exchanger 106 taken along line A-A in figure 5a, in a first and second PHE state, respectively. In figures 5b and 5c, the connection element 108, here in the form of the carrying bar, is illustrated in more detail. The connection element 108 comprises a first means 111 and a second means 113. The first means 111 has a first, a second and a third part, of which only the first part 111 a, with the distal end 111 a', has been given a reference numeral in the figures. The first means 111 comprises a bolt 110, having an external thread 110a', and a bolt washer/fixing means 112. The second means 113 has a first and a second part, 113a-b, and comprises a solid bolt 114, a sleeve 116 (drawn transparent for illustrative purposes) and a bolt washer means 118. The sleeve 116 has an internal thread 116a' extending along the complete sleeve. The bolt 114 is arranged to be inserted through the bolt washer means 118 and through a recess 120 in the frame plate 122, which frame plate has an inner surface 123 and an outer surface 124, before being screwed into the sleeve 116 to attach the same to the frame plate. Arranged like this, the bolt head 114b is housed within the frame plate 122, i.e. it does not project from the outer surface 124 thereof. Attached to the frame plate 122, the sleeve 116 can carry a load such as a number of heat exchanger plates provided with gaskets (not shown) and a pressure plate 126 having an inner surface 125 and an outer surface 127.

**[0057]** As apparent from figure 5c the bolt 110 is considerably shorter than the bolts 42 and 90 of the previously described connection elements 34 and 88, respectively. The bolt 110 is not screwed into the sleeve 116 until the package of heat exchanger plates and gaskets has been compressed into its desired final thickness. Thus, the connection element 108 is not used for reducing the thickness of the plate/gasket package but for maintaining the desired final thickness of the package.

**[0058]** The connection elements 34 and 88 are not suitable for use as carrying and guiding bars. If, for example, the connection element 34 was used as a carrying bar in the PHE 106, in the open state of the same, the bolt 42 would be screwed a certain distance into the sleeve 44 and some of the heat exchanger plates would hang from the bolt while the rest of the heat exchanger plates would hang from the sleeve. In connection with closing of the PHE, problems would arise, since the sleeve and the bolt have different outer diameters resulting in a misalignment of the heat exchanger plates. In accordance with the third embodiment of the present invention, this problem is solved by instead using the connection element 108 as carrying bar together with an extension element 128 during the plate/gasket package reduction.

**[0059]** The extension element 128 comprises a connection part 128a and a carrying part 128b. The connection part 128a is externally threaded and adapted to be screwed into the sleeve 116. The outer diameter of the carrying part 128b is equal to the outer diameter of the sleeve 116 such that the extension element and the sleeve, when connected, forms a bar 130 of uniform thickness from which the heat exchanger plates can hang while being aligned even in an open state of the PHE. The first state illustrated in figure 5b is such an open state. The extension element 128 is connected to the sleeve during assembly of the PHE up until the plate/gasket package has been reduced to its final desired thickness. Thus, the heat exchanger plates and the pressure plate are threaded onto the bar 130, the plate/gasket package is compressed, for example by means of connection elements like the ones according to the first or the second embodiment, resulting in a transfer of all the heat exchanger plates to the sleeve 116, and then the extension element 128 is disconnected from the sleeve. Then, the second state illustrated in figure 5c prevails. Finally, the bolt 110 is screwed into the sleeve 116 which completes the closing of the PHE 106. In the closed ready-for-use state of the PHE 106 the sleeve 116 extends into the recess 132 of the pressure plate 126 without contacting the bolt washer/fixing means 112.

**[0060]** Figures 6a and 6b correspond to figures 3a & 3b but illustrate a connection element 54 of a known PHE. The connection element 54 comprises a threaded bolt 56 arranged to engage with a nut 58 for connecting two end plates 60 and 62 and clamping a package 64 of heat exchanger plates 66, here 28, separated by gaskets 68, here 27, there between. The connection element 54 further comprises a bolt washer/fixing means 70 and a nut washer/fixing means 72. The known PHE has conventional carrying and guiding bars (not shown) which are attached to the end plate 60.

**[0061]** In connection with assembly of the known PHE, the heat exchanger plates 66 provided with the gaskets 68 and the end plate 62 are threaded onto the carrying and guiding bars and shoved towards the end plate 60 to assume the uncompressed state illustrated in figure 6b. Thereafter, the threaded bolt 56 and the bolt washer/fixing means 70 is arranged in a recess 74 of the end plate 60 such that the bolt extends along the package 64 and further through a recess 76 of the end plate 62. Then, the nut 58 is screwed onto the bolt 56. Obviously, it is essential that the bolt 56 is long enough to extend somewhat from an outer surface 78 of the end plate 62 to enable bolt-nut engagement. Finally, the nut 58 is rotated in relation to the bolt 56 to force the end plates 60 and 62 closer to each other. When the end plate 62 has been displaced the distance Δt in relation to the end plate 60, the PHE has reached its ready-for-use state.

**[0062]** Figure 6a shows the connection element 54 when the PHE is in the closed, ready-for-use, state. Obviously, the feature that the connection element defines desired distance between the end plates of the PHE in the ready-to-use state, which feature is available with the present, above described, invention, is missing for this known PHE. When the PHE is in the ready-for-use state it is actually possible to rotate the nut 58 even further in relation to the bolt 56. To assure that the known PHE is in the ready-for-use stage, the distance between the end plates must be measured in a separate operation. If the distance is not the desired one, there is a risk of the PHE not working properly.

**[0063]** Rotation of the nut 58 for transferring the PHE from the open to the closed state makes the bolt 56 extend more and more from the outer surface 78 of the end plate 62 and eventually also an outer edge 80 of the nut 58. When the known PHE is in the closed state, the bolt extends the distance p from the outer edge 80 of the nut 58. This should be compared with the inventive PHE according to figure 3a where the bolt does not extend beyond the outer edge 44c' of the sleeve 44. Obviously, the PHE constructed in accordance with the present invention is much more compact and neat as compared to known PHEs. In connection with larger PHEs with more heat exchanger plates as well as gaskets, the difference in space demand between a known PHE and a PHE constructed in accordance with the present invention would be even larger.

**[0064]** Above, both for the inventive PHE and the prior art PHE, only one connection element per PHE has been described. However, each of the PHEs comprises several connection elements, and it should be said that these several connection elements are not necessarily the same.

**[0065]** Above, there has been a lot of talk around rotation of for example a bolt for PHE opening and closing. Even if not stated in every single case, by rotation is meant relative rotation. Thus, when it comes to a bolt and a sleeve, either one could be rotated in relation to the other for screwing the bolt into and out of the sleeve.

**[0066]** The above described embodiments of the present invention should only be seen as examples. A person skilled in the art realizes that the embodiments discussed can be varied and combined in a number of ways without deviating from the inventive conception.

**[0067]** As an example, above, both completely and partly threaded sleeves have been discussed together with completely threaded bolts. Of course, variations are conceivable. As an example, the bolts could be only partly threaded.

**[0068]** As another example, in the described embodiments, the second means of the connection elements are tailored for a specific number and type of heat exchanger plates and gaskets. Naturally, more heat exchanger plates and gaskets could be added to the above described inventive PHEs, at least the ones according to the first and second embodiments, without changing the design of the second means. Such an addition would, however, probably remove the functionality, if any, of the second means defining the desired distance between the frame and pressure plates of the PHEs in the ready-to-use state. While addition of heat exchanger plates and gaskets to the above PHEs is possible, removal of heat exchanger plates and gaskets from the PHEs may not be possible without adjustments. This is because it might not be possible to achieve a sufficient compression of such a reduced plate/gasket package before the connection element reaches its minimum length.

**[0069]** Similarly, in the described embodiments, the first means of the connection elements are tailored for the respective specific second means. Naturally, addition of heat exchanger plates and gaskets to the above described inventive PHEs would be possible, at least for the ones according to the first and second embodiments, without changing the design of the first means. However, removal of heat exchanger plates and gaskets from the PHEs would probably require amendments to the first means to make sure that it does not protrude beyond the outer edge of the second means in the PHE state of use.

**[0070]** Further, the second means of the different connection means described above are arranged to either contact, or extend past, the inner surface of the frame plate when the respective PHE is in its state of use. Naturally, the second means could instead be shorter so as to never reach the inner surface of the frame plate.

**[0071]** The first and second means previously described engage with the frame and pressure plates, respectively, by being inserted through respective recesses in these frame and pressure plates. The first and second means could, however, be designed to engage with the frame and pressure plates in other ways. As an example, the first and/or the second means could be attached to the inner surface of the respective plate, i.e. not extend through, or into, the plate.

**[0072]** Naturally, the herein disclosed shapes of the recesses in the frame and pressure plates are just exemplary and many other recess shapes are conceivable in connection with the present invention. As an example, the recesses could be formed as curved grooves, the connection elements being automatically arranged in the bottom of the grooves due to gravity.

**[0073]** The first means of the connection element of the third embodiment is arranged to project from an inner surface of the frame plate when the PHE is closed. However, according to an alternative embodiment, the first means is so short that it does not extend through the complete frame plate and, therefore, does not protrude from the inner surface thereof.

**[0074]** Finally, the plate heat exchangers in the above described exemplary embodiments are gasketed PHEs. Naturally, the present invention could be used in connection with other types of PHEs, such as semi-welded PHEs.

**[0075]** It should be stressed that a description of details not relevant to the present invention has been omitted and that the figures are just schematic and not drawn according to scale.

**Claims**

1. A plate heat exchanger (10, 82, 106) comprising a first end plate (12, 84, 126) having an inner surface (14, 104, 125) and an outer surface (16, 105, 127), a second end plate (18, 86, 122) having an inner surface (20, 102, 123) and an outer surface (22, 103, 124), a set of heat exchanger plates (50) arranged between the inner surface (14, 104, 125) of the first end plate (12, 84, 126) and the inner surface (20, 102, 123) of the second end plate (18, 86, 122), a first means (41, 81, 111) engaging with the first end plate 12, 84, 126), a second means (43, 83, 113) engaging with the second end plate (18, 86, 122), said first means (41, 81, 111) further engaging with said second means (43, 83, 113) for connecting the first end plate (12, 84, 126) and the second end plate (18, 86, 122), said second means (43, 83, 113) partly enclosing said first means (41, 81, 111), **characterized in that**
a first part (43a, 83a, 113a) of said second means (43, 83, 113) projects from the inner surface (20, 102, 123) of the second end plate (18, 86, 122).

2. A plate heat exchanger (10, 82, 106) according to claim 1, wherein said second means (43, 83, 113) comprises a sleeve (44, 94, 116) arranged to receive a distal end (41 a', 81 a', 111 a') of a first part (41 a, 81 a, 111 a) of said first means (41, 81, 111).

3. A plate heat exchanger (10, 82, 106) according to claim 2, wherein the sleeve (44, 94, 116) has an internal thread (44a', 94a', 116a') and the first means (41, 81, 111) has an external thread (42a', 90a', 110a'), said internal and said external threads being arranged for mutual cooperation.

4. A plate heat exchanger (10, 82, 106) according to claim 3, wherein the internal thread (44a', 94a', 116a') extends only partly along the sleeve (44, 94, 116).

5. A plate heat exchanger (10, 82, 106) according to any of claims 2-4, wherein the distal end (41 a', 81 a', 111 a') of the first part (41 a, 81a, 111 a) of said first means (41, 81, 111) is arranged within the sleeve (44, 94, 116).

6. A plate heat exchanger (10, 82, 106) according to any of claims 2-5, wherein an outer part (43c, 83c, 113b) of said second means (43, 83, 113) has a partly edgy contour.

7. A plate heat exchanger (10, 82, 106) according to any of claims 2-6, wherein essentially the complete first part (41 a, 81 a, 111 a) of said first means (41, 81, 111) is arranged within the sleeve (44, 94, 116) when the plate heat exchanger is ready for use.

8. A plate heat exchanger (10, 82, 106) according to any of claims 2-7, wherein the first part (41 a, 81 a, 111 a) of said first means (41, 81, 111) projects from the inner surface (14, 104, 125) of the first end plate (12, 84, 126).

9. A plate heat exchanger (10, 82) according to any of the preceding claims, wherein a distal end (43a', 83a') of the first part (43a, 83a) of said second means (43, 83) is arranged to abut against an abutment surface (45, 95) of the plate heat exchanger so as to indicate a preferred distance ($t_{closed}$) between the inner surfaces (14, 20 and 104, 102) of the first end plate (12, 84) and the second end plate (18, 86), when the plate heat exchanger is ready for use.

10. A plate heat exchanger (10, 82) according to claim 9, wherein the abutment surface (45, 95) is part of the inner surface (14, 104) of the first end plate (12, 84).

11. A plate heat exchanger (10, 82) according to claim 9, wherein the abutment surface (45, 95) is part of the first means (41, 81).

12. A second means (43, 83, 113) adapted for use in a plate heat exchanger (10, 82, 106) according to any one of the preceding claims.

13. A first means (41, 81, 111) adapted for use in connection with a second means (43, 83, 113) according to claim 12.

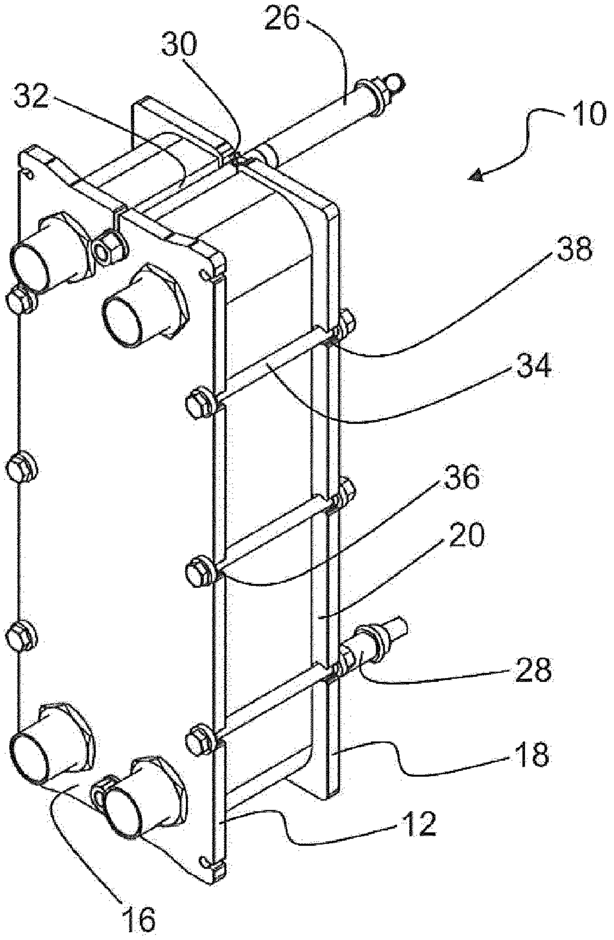


Fig. 1a

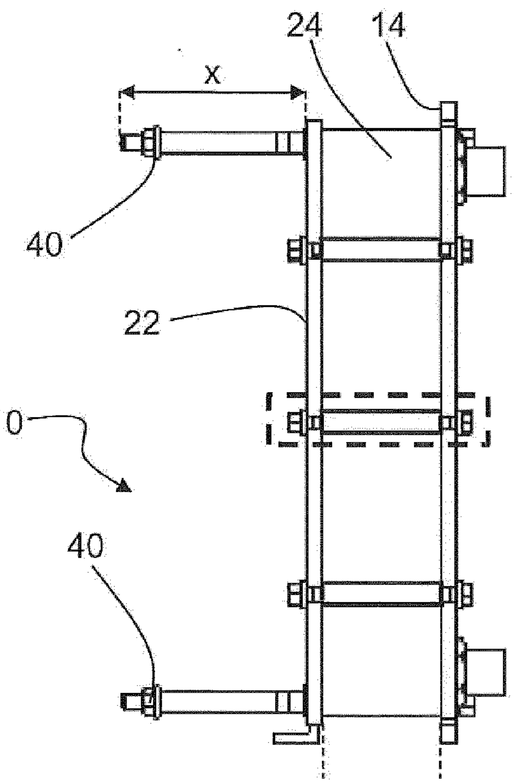


Fig. 1b

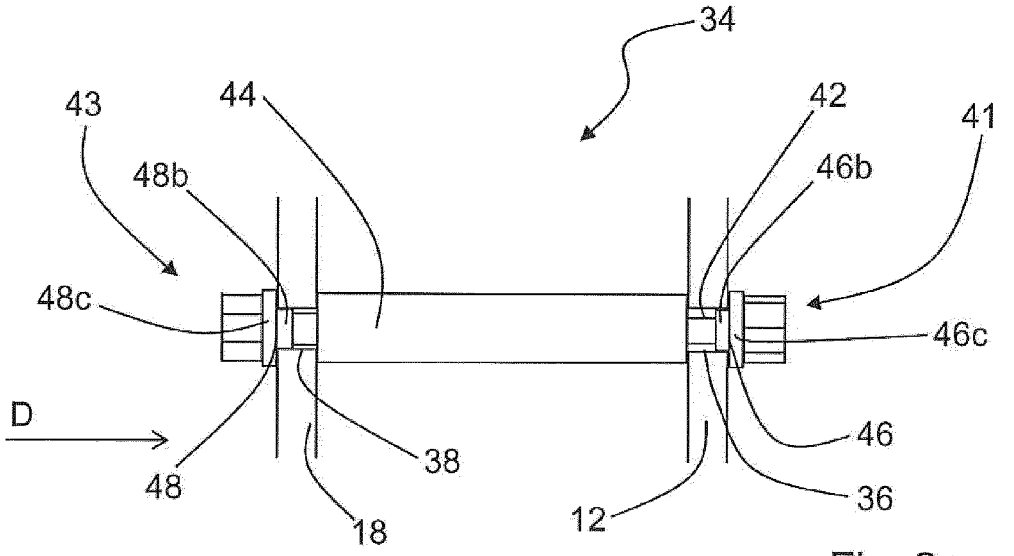


Fig. 2a

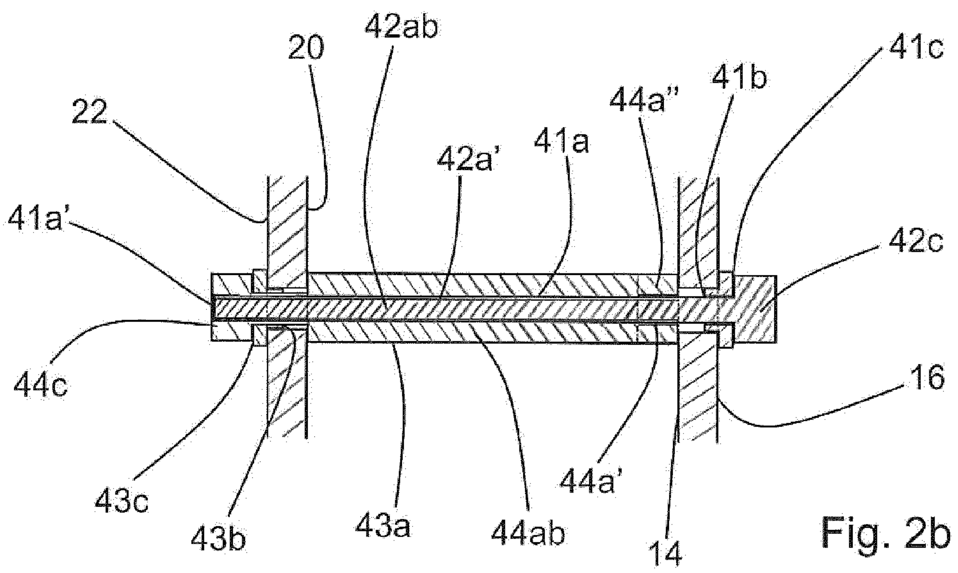


Fig. 2b

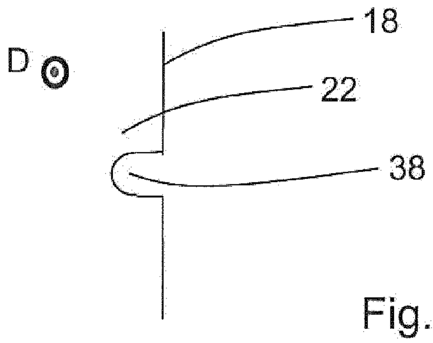


Fig. 2c

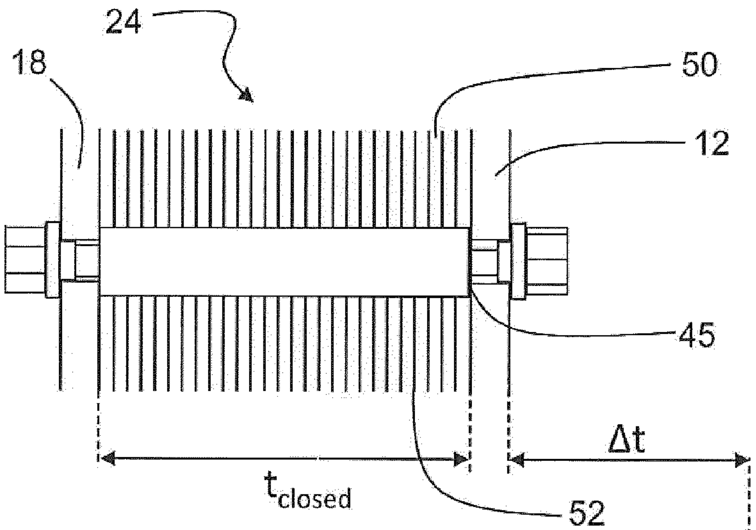


Fig. 3a

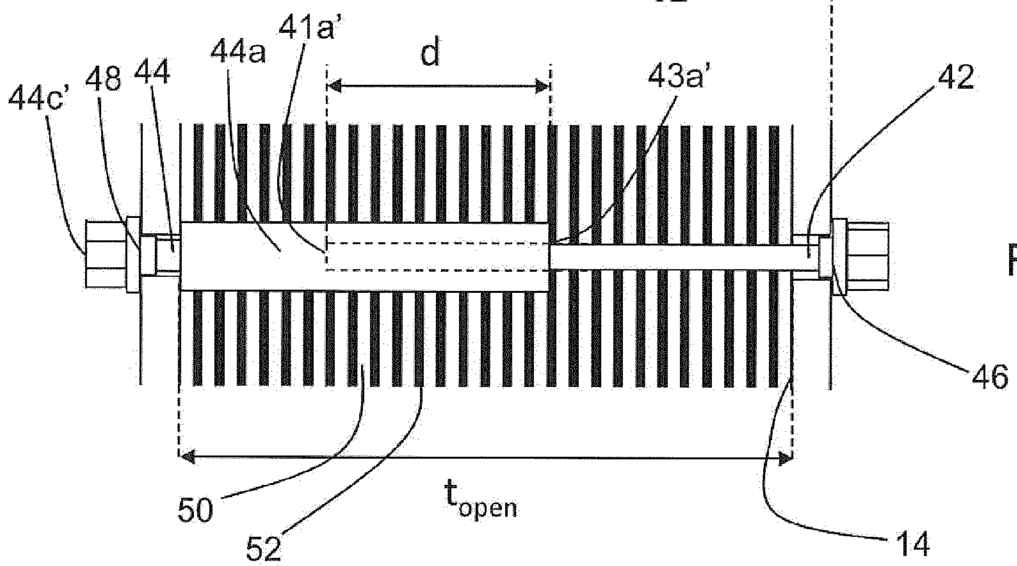


Fig. 3b

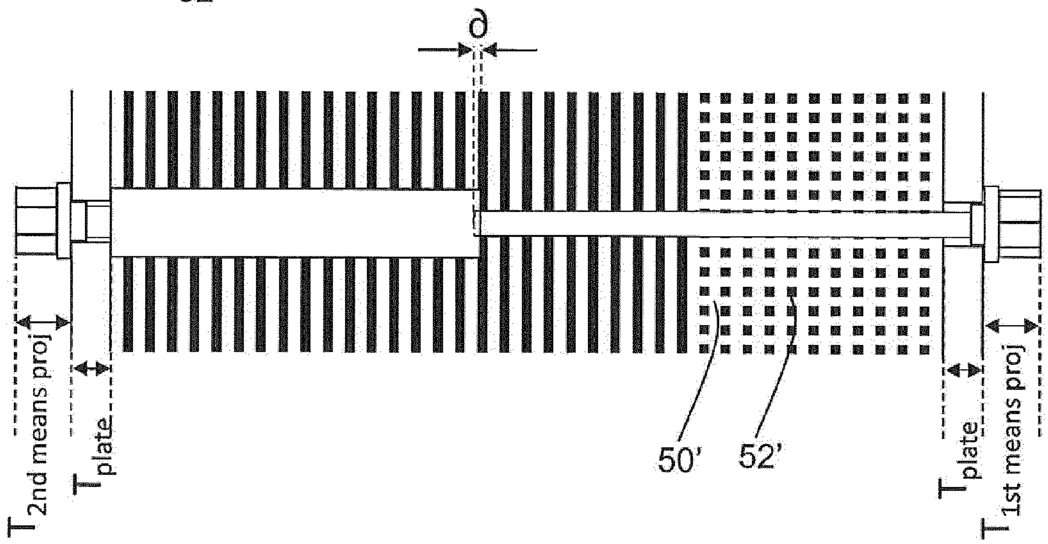


Fig. 3c

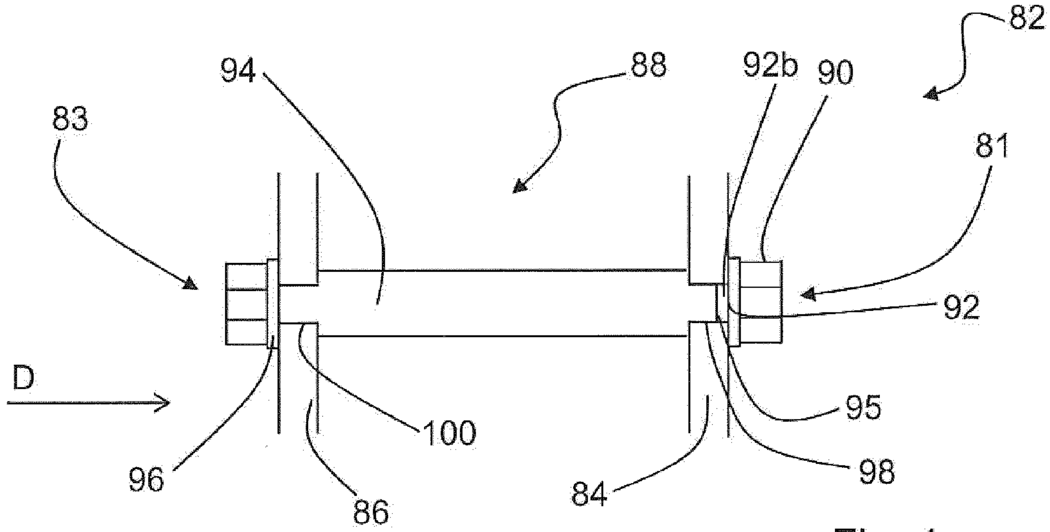


Fig. 4a

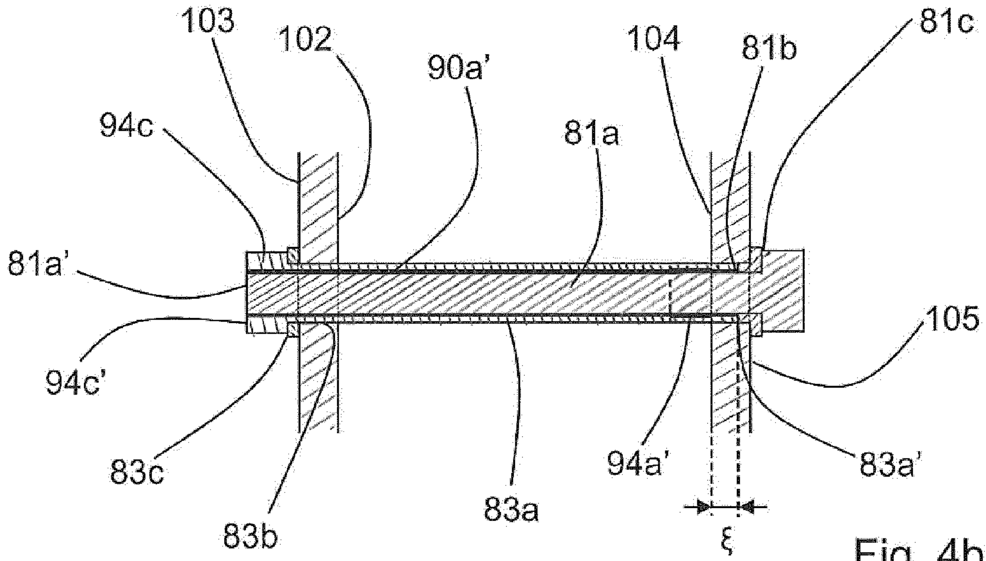


Fig. 4b

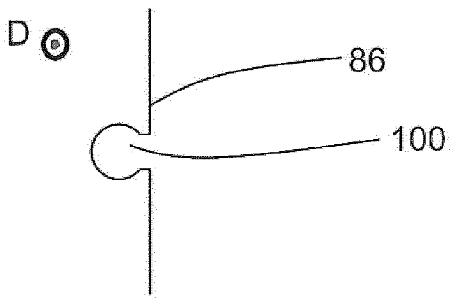


Fig. 4c

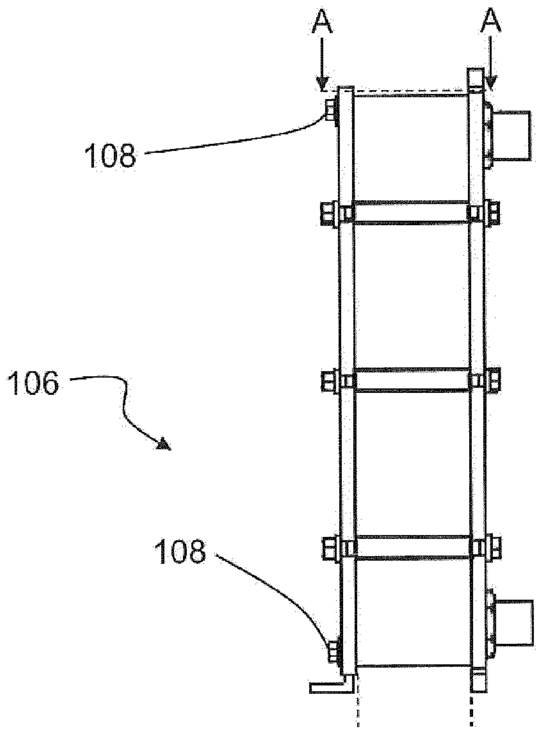


Fig. 5a

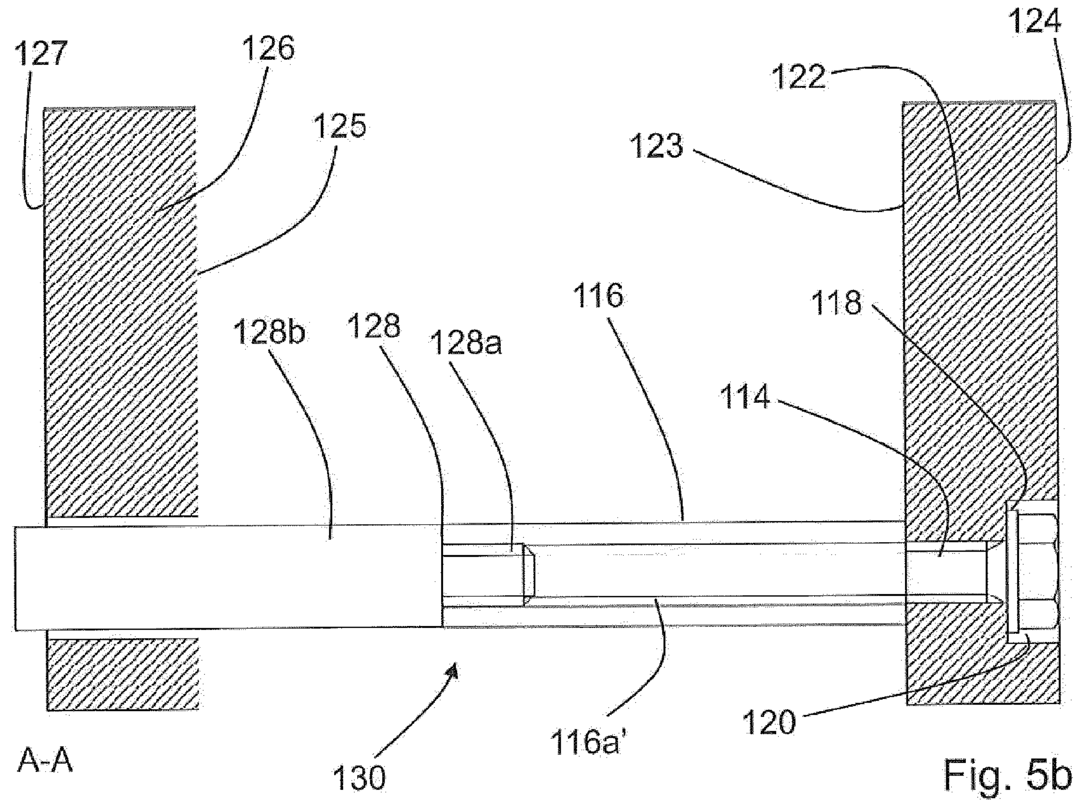
127
126
125
124
122
123
128b
128
128a
116
118
114
A-A
130
116a'
120

Fig. 5b

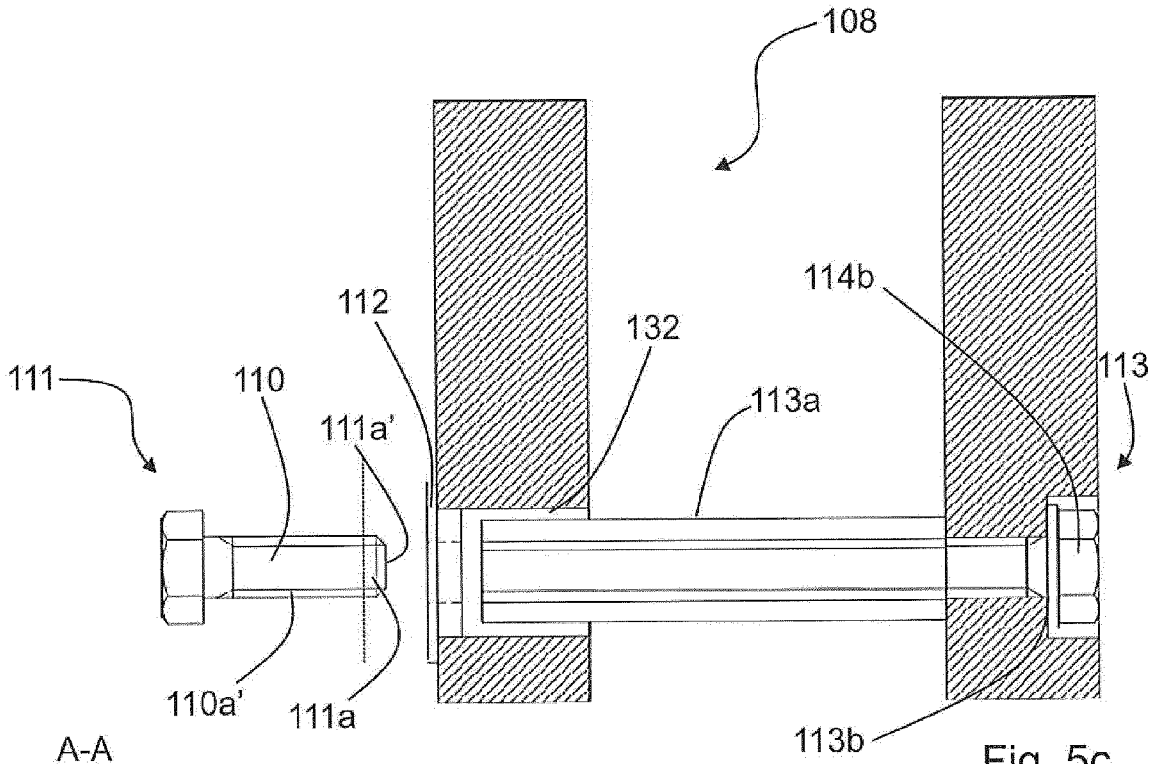
108
112
132
114b
113
111
110
111a'
113a
110a'
111a
A-A
113b

Fig. 5c

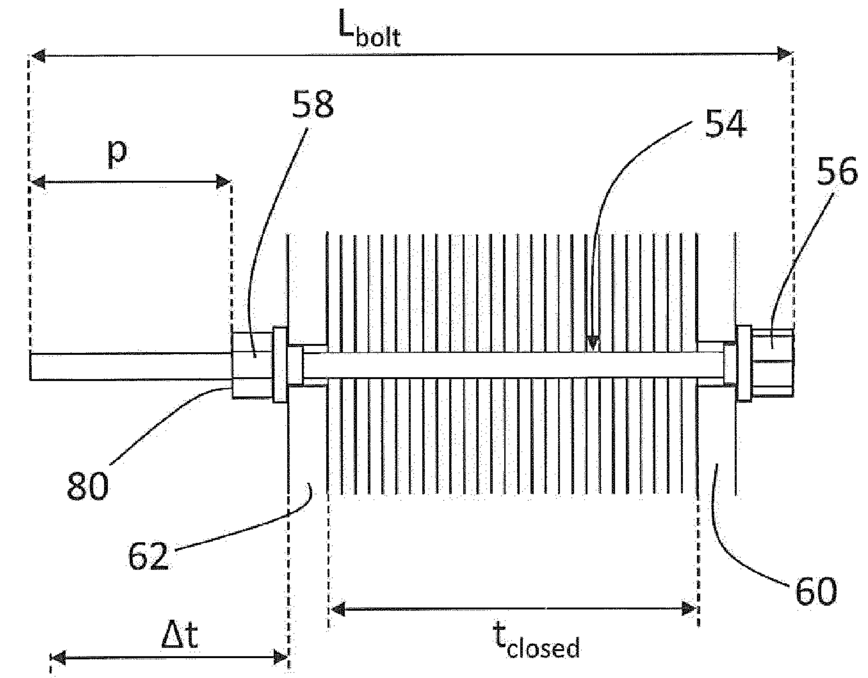
L bolt
58
54
56
p
80
62
60
t closed
Δt

Fig. 6a

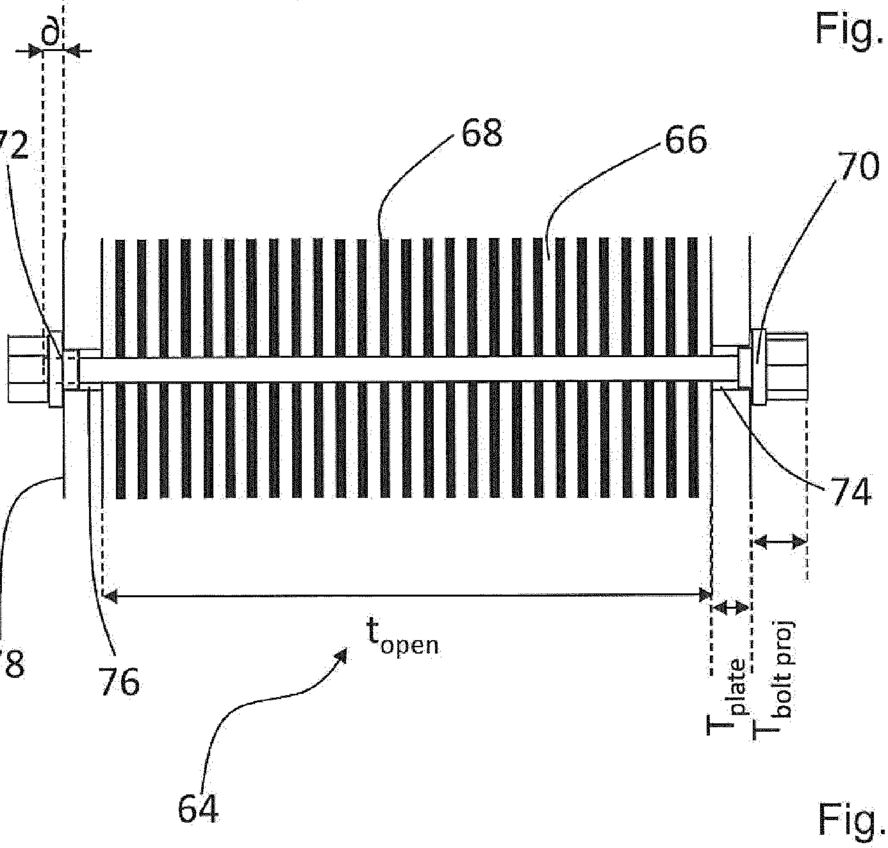
∂
72
68
66
70
74
78
76
t open
T plate
T bolt proj
64

Fig. 6b

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# EUROPEAN SEARCH REPORT

Application Number
EP 11 18 7796

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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
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| Place of search | Date of completion of the search | Examiner |
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| The Hague | 13 April 2012 | Mootz, Frank |

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CATEGORY OF CITED DOCUMENTS

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