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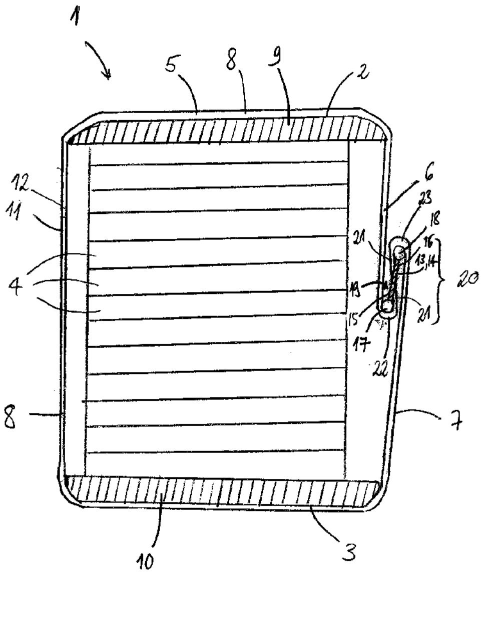

Fig. 1

(57) Abstract: The application relates to a cell stack, comprising several cell units stacked between a first end of the stack of the cell stack and the second end of the stack of the cell stack and at least one tensioning element, with which a tensioning force for clamping of the cell units can be introduced between the first end of the stack and the second end of the stack, with the at least one tensioning element comprising a first partial section starting from the first stack end and extending in the direction of the second stack end and a second partial section starting from the second stack end and extending in the direction of the first stack end, where the at least one tensioning element comprises at least one resilient element being loaded with compression force which links the first partial section with the second partial section, characterized in that the first partial section of the at least one tensioning element and the second partial section of the at least one tensioning element overlap with each other in an overlapping area between the two ends of the stack.

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Cell stack

The invention relates to a cell stack comprising several cell units stacked between a first end of the stack of the cell stack and the second end of the stack of the cell stack. This cell stack comprises at least one tensioning element for clamping of the cell units between the ends of the stack. The at least one tensioning element comprises a first partial section starting from the first stack end and extending in the direction of the second stack end and a second partial section starting from the second stack end and extending in the direction of the first stack end. The at least one tensioning element further comprises at least one resilient element loaded with compression force which links the first partial section with the second partial section.

Cell stacks of this kind comprise several cell units, which are typically designed in a planar manner, which are stacked one upon the other between a first stack end of the cell stack and a second stack end of the cell stack. These cell units are for instance cells of electrochemical systems or cells for humidifiers for electrochemical systems. The cell stack or the cell units, respectively, can for instance be part of a humidifier for an electrochemical system or of an electrochemical system, such as electrochemical energy storage, a redox-flow battery, an electrochemical compressor or part of a fuel cell system.

During the use of such cell stacks, it is necessary to compress the cell units of the cell stack against each other, e.g. in order to produce the required sealing and/or contact forces between the cell units. To this end, tension forces are transmitted between the stack ends using one or several tensile elements so that the cell units are pressed one upon the other.

The total height of the cell stack, thus the distance between the ends of the stack can change over time due to changes in the inner pressure of the cell units, to a contraction of the cell units or of other parts of the cell stack as well as due to a setting of the cell units or of other parts of the cell stack after the tensioning or the begin of operation. In order to balance this out and to maintain the tensioning forces as well as the contact and sealing forces between the cell units if possible in an admissible range, it is possible to install spring sets or beam arrangements between the cell units and at the stack ends of the cell stack. However, this causes a complex construction of the cell stack and increases the space required by the cell stack. In addition, mounting and tensioning of such spring sets or beam arrangements generally require additional or complex steps and are therefore time-demanding.

It is therefore the object of the present invention to create a cell stack of the kind described above which can be mounted and tensioned as simple and time-efficient as possible.

In order to solve this object, a cell stack according to the independent claim is proposed. Particular embodiments and variations of this cell stack and of the method of production proposed result with the dependent claims.

Accordingly, the cell stack comprises several cell units which are stacked between a first stack end of the cell stack and a second stack end of the cell stack, e.g. of the kind described at the beginning of this description. In addition, the cell stack comprises at least one tensioning element with which a tensioning force is transmitted or can be transmitted between the first stack end and the second stack end, e.g. in order to establish the sealing and/or contact forces between the cell units mentioned above.

The cell stack comprises one or several such tensioning elements. If in the following, only one of these at least one tensioning elements is addressed, the respective description can also be transferred to the respective other tensioning elements in case the cell stack comprises several such tensioning elements. Thus, several or all tensioning elements of the cell stack can comprise the respectively described characteristics but this does not need to be mentioned explicitly.

The tensioning element which typically connects the first stack end with the second stack end comprises a first partial section which starts from the first stack end and extends towards the second stack end as well as a second partial section which starts from the second stack end and extends towards the first stack end. The partial sections mentioned can be designed band-like or strip-like; they can be partial sections of a tensioning band of the tensioning element.

The tensioning element of the first cell stack in addition comprises at least one resilient element which can be loaded with a compression force, which connects the first partial section with the second partial section and produces the tensioning force. To this end, the resilient element loaded by a compression force exerts a force to the first partial section which is directed towards the second stack end and in the same way exerts a force to the second partial section which is directed towards the first stack end. Both forces have the same magnitude and are directed opposite to each other. A first end of a resilient element can for instance be connected with the connecting element of the first partial section. A second end of the resilient element opposite to its first end can correspondingly be connected with the second partial section via a second connecting element. Using these connecting elements, the forces of the resilient element mentioned can be transferred to the first and second partial section of the tensioning element. These connections between the ends of the resilient element and the first and second partial sections can be designed rigid or moveable along the partial sections. With respect to possible designs of this connection between the first and second partial sections and the connecting elements, it is referred to the description of the shortening element of the second cell stack, which will be described in the further course of this description. This shortening element comprises corresponding connections to the first and second partial section, which can also be designed for a connection between a resilient element and the partial sections.

It shall be stressed that although the tensioning element exerts a clamping force on the cell stack, the resilient element as such is loaded with a compression force. Thus, an increase of the compression of the cell stack goes along with a stretching of the resilient element and a decrease of the compression of the cell stack is accompanied with a compression of the resilient element.

In a preferred embodiment of the inventive cell stack, the tensioning element comprises a shortening element, into which at least a first connection element connected with the first partial section and a second connection element connected with the second partial section are integrated. The shortening element is tiltable between a first tilt orientation in which the first connection element is oriented towards the first stack end and the second connection element is oriented towards the second stack end and a second tilt orientation in which the first connection element is oriented towards the second stack end and the second connection element is oriented towards the first stack end. By tilting of the shortening element from the first tilt orientation to the second tilt orientation, the tensioning element can thus be shortened. The dimensions of the shortening element relative to the total length of the tensioning element and the height as well as the diameter of the cell stack have been selected in such a way that given that the shortening element is in the second tilt orientation, the tensioning element transmits the tensioning force mentioned. If the shortening element is in the first tilt orientation, the tensioning force mentioned is not transmitted and typically, no or only a considerably reduced tensioning force is produced.

A resilient element loadable by pressure can be integrated into the shortening element which in the second tilt orientation is loaded by a compression force and therefore produces the tensioning force. A first end of the resilient element can for instance be connected with the first connecting element and via the connecting element with the first partial section. A second end of the resilient element opposite to the first end of the resilient element can accordingly be connected with the second connecting element and via the second connecting element with the second partial section. By means of these connecting elements, the tensioning forces can be transmitted to the first and second partial section of the tensioning element.

The connections with the first and second partial section produced using the connecting elements can be designed in a manner non-moveable or moveable along the partial sections. In case of a non-moveable connection, this connection is typically realized between the first (or second) connecting element and a first (or second) terminal section or end of the first (or second) partial section. In case of a moveable, e.g. resting, shiftable and/or scrollable connection, this connection is typically realized between the first (or second) connecting element and a transition section of the tensioning element adjoining to or merging into the first (or second) partial section of the tensioning element. Then, the first partial section and/or the second partial section rests on or borders to the respective connecting element, as will be described in detail below. The connecting elements can for instance be designed as redirecting elements, in particular as rolls, roller bows, guide pulley, slide or also as anchorages, brackets, screw- or riveted connections, latching connections or the like. The connections mentioned can for instance be designed form-fit (anchored, looped, riveted, screwed or caught) and/or friction locked (clamped, screwed, etc.).

If the shortening element of the tensioning element of the second element is in the second tilt orientation, the first partial section of the tensioning element and the second partial section of the tensioning element overlap each other in an overlapping area between both stack ends. In the overlapping area, the first partial section also extends from the first stack end in the direction of the second stack end. Accordingly, the second partial section within the overlapping area extends from the second stack end in the direction of the first stack end. In the overlapping area, the first partial section and the second partial section thus extend one along the other.

If this overlap of the partial sections of the tensioning element does not exist, e.g. in the non-mounted and/or non-tensioned state, the tensioning element can have such a total length that it can be slid over the stacked cell units which may be pre-tensioned using a press or can be connected with both ends of the cell stack without problems and without the need of being tensioned itself. Only in a final step, the overlap of the partial sections of the tensioning element as described is established, e.g. by a corresponding tilting of the resilient element in case of the first cell stack. As this is comes along with a real shortening of the tensioning element, one can achieve simultaneously that the tensioning force is established and that the cell units are compressed against each other.

A further advantage achieved by the overlap of partial sections of the tensioning elements is given in that it allows for a spring movement of the tensioning element in a simple manner and without a high demand in space. This is for instance the case with a change in the height of the cell stack, e.g. due to a thermal expansion of the cell units or a change of the inner pressure of the cell units. The tensioning element can for instance be effectively shortened by an enlargement of the overlapping area or be effectively elongated by a reduction of the overlapping area. With this spring movement, the tensioning force can be maintained in a very simple manner in an almost constant range, so that on the one hand, the cell units can always be pressed one onto the other to the degree required but not too strongly. On the other hand, a damaging of further parts, such as the tensioning element, can be prevented from. If the overlapping area reduces, the resilient element is compressed. The resilient element accordingly expands if the overlapping area increases.

As already stressed above, the tensioning element of the cell stack can also comprise a shortening element for the contraction of this tensioning element. The resilient element of the tensioning element is loaded with compression force and produces the tensioning force mentioned to the stack if the shortening element is in the second tilting orientation. The at least one resilient element can also form part of the shortening element, thus be integrated into the latter. Accordingly, the first connecting element of the shortening element is preferably connected to the first end of the at least one resilient element and the second connecting element of the shortening element is connected to the second end of the at least one resilient element.

In a particularly compact embodiment, the at least one resilient element is arranged in the overlapping area of the tensioning element. The resilient element can for instance be situated between the first partial section of the tensioning element and the second partial section of the tensioning element.

In one embodiment, it is provided that the tensioning element comprises an intermediate section which extends within the overlapping area of the tensioning element between two connecting elements. This intermediate section connects the first partial section with the second partial section. Here, the first partial section in a first transition area passes into the intermediate section of the tensioning element mentioned and in turn, the intermediate section in a second transition area of the tensioning element passes into the second partial section. This way, the intermediate section in the transition area both overlaps with the first partial section and the second partial section. Therefore, the first partial section, the intermediate section and the second partial section together with the transition areas typically form a z-shaped or s-shaped arrangement, with the redirection required for this being realized in the transition areas. During the spring movement described above, the intermediate section between the connecting elements is tightened if the overlapping area is shortened and the intermediate section is lengthened if the overlapping area enlarges. The first and second partial sections, the intermediate area and the transition areas together can for instance form a continuous, coherent structure which connects both ends of the stack, such as a tensioning strap. In this case, the first and second connecting element is typically moveable along this structure, e.g. slidable or rollable. In the tensioned state of the cell stack, the first and the second connecting element typically comprise the redirection of the structure inside the transition areas mentioned beforehand due to the connecting elements which in this case act as deflecting elements. An increase or a reduction of the overlapping area typically corresponds to a movement of the first and second connecting element along this structure, a shift of the locations of the redirections mentioned or of the transition areas along this structure and optionally a simultaneous compression or stretching/decompression of the resilient element. The redirection described in particular requires a sufficient flexibility, meaning bendability of the above-mentioned sections of the tensioning element.

During the spring movement resulting from the increase or reduction of the overlapping area, preferably no effective change of length of the mentioned section of the tensioning element results, thus of the first partial section, the second partial section and optionally of the intermediate section, as well as of the first and second transition areas. Only a change of length of the resilient element is caused, thus a compression or stretching/decompression.

If steel is used as the material for the tensioning element, its tensile strength ranges between 900 and 1500 N/ mm. In a typical stack, 20 to 30 kN are allocated to 8 springs. The elastic force of the individual springs thus amounts to between about 2.5 and 3.75 kN. With a different amount of springs, their elastic force has to be adapted accordingly.

The first partial section and/or the second partial section of the tensioning element are preferably designed as a tensioning strap – either completely or at least in sections. The tensioning strap mentioned can be a metallic strap, a steel strap, a strap from stainless steel or a plastic strap, in particular a fiber-reinforced, especially a glass-fiber reinforced or carbon-fiber reinforced plastic strap. It is also possible that the first partial section and the second partial section have a different design, e.g. with respect to their material and/or to their structure. It is further possible that the first partial section and/or the second partial section along their course between the two ends of the stack show subsections with different designs, e.g. with respect to their material and/or to their structure.

The at least one resilient element of the tensioning element mentioned may be one or several compression springs, such as one or several spiral springs, one or several flat springs or one or several leg(s) or body/bodies being elastic with respect to bending.

In one embodiment, the shortening element comprises at least two resilient elements which together with the first and the second connecting elements of the shortening element form an annular arrangement and thus define a central passage opening of the shortening element or surround such. Then the intermediate section of the tensioning element mentioned above may extend through a central passage opening of the shortening element. In the first tilting orientation, the shortening element is then freely moveable along the tensioning element which is typically not or only slightly tensioned. In the second tilting orientation, the redirection of the tensioning element described above is established which causes the overlap of the first partial section with the second partial section and thus causes the effective shortening of the tensioning element and the compression of the cell stack.

In a particular embodiment, the resilient elements are designed as compression springs, e.g. as spiral springs. The compression springs or spiral springs can be guided by one alignment pin each, preferably centrally guided. The at least one alignment pin is moveable connected with the first and/or the second connecting element for an elastic movement between the first and the second connecting element.

The tensioning element typically comprises a fixation element for the fixation and/or stabilization of the reciprocal overlap of the first and second partial section of the tensioning element. The fixation element may for instance be designed in such a way that it fixes, keeps or stabilizes the shortening element in the second tilting orientation. The fixation element may for instance be designed as a clip, a sleeve, a resting element, a metal sheet, a bending latch, a screw, a pin or a hook or in such a way that it comprises at least one or several of these elements. In case of a sleeve, this sleeve may stabilize the first and the second partial section in the overlapping area and optionally encircle the shortening element and stabilize it this way.

The fixation element may further be formed from or comprise a partial area of the tensioning strap of the first or second partial section which partial area is deformed with hook-shape. This partial area may for instance realize the function of a hook, of a clip or of a latch.

For an adaptation of the compression and of the spring tension of the resilient element, respectively, the resilient element and/or the shortening element may comprise a suitably designed fixation and/or adjustment element, e.g. a screw or a clip. After the production of the above mentioned overlap, the resilient element can for instance be set under an extreme first compression using this fixation and/or adjustment element and subsequently be released to the elasticity range for the finally desired compression, e.g. by turning of the screw mentioned above or by a removal or release of the above-mentioned clip.

In one embodiment, the fixation element is arranged at the endplate of the cell stack. In this case, the overlapping section of the first and second partial section of the tensioning element directly adjoins to this endplate.

The at least one tensioning element may surround a first endplate of the cell stack located at the first end of the stack or a second endplate of the cell stack located at the second end of the stack. It is also possible that the tensioning element surrounds both of these endplates. The at least one tensioning element may comprise an annularly closed tensioning strap, which in particular incorporates the first partial section and the second partial section. In addition, the annularly closed tensioning strap can incorporate the intermediate section and the transition areas described beforehand. The annularly closed tensioning element or tensioning strap, respectively, may comprise two ends which are connected to each other by welding, brazing, gluing, riveting, hooking, clinching or crimping.

Instead of the surrounding of the endplates as described, it is however also possible that the first partial section of the tensioning element is fastened at the first endplate and that the second partial section of the tensioning element is fastened to the second endplate, e.g. by hooking-in, for instance using a suspension hook at the first and/or second endplate.

As already mentioned earlier, the cell stack and the cell units may form part of a humidifier for an electrochemical system or form part of an electrochemical system, such as of electrochemical energy storage, of a redox-flow battery of an electrochemical compressor or of a fuel cell system.

In addition to the description of the structural and functional characteristics of the cell stacks proposed as well as of the advantages that they allow for during the mounting and compression of such cell stacks, a method for mounting and compression of such a cell stack as proposed shall be explicitly described in the following. An optional first step of this method is the establishment of a first compression of the cell stack, e.g. by means of a press. Then, the at least one tensioning element, which may be annularly closed, is arranged in such a way that a first partial section of the tensioning element starts at the first end of the stack and extends in the direction of the second end of the stack and that a second partial section of the tensioning element starts at the second end of the stack and extends in the direction of the first end of the stack. In a subsequent step, the above-described overlap of these two partial sections in an overlapping area between the two ends of the stack is established and this way, the tensioning element is shortened and at the same time, the compression or an elevated first compression of the cell stack is established. This can be realized in such a way that the tensioning element surrounds the latter and shifts from the first tilting orientation to the second tilting orientation. Tilting is advantageously realized using a suited tilting device of a production machine in an automatic way.

The overlap can subsequently be fixed and/or maintained using the fixation element described. Further a press that might be used can be opened and the cell stack can be taken out of this press. Finally, the compression effected using the resilient element can be reset or adjusted using the fixation and/or adjustment element, e.g. from an increased first compression to the desired final compression value, as described above.

In the following, the invention is explained on the basis of the embodiments schematically shown in figures 1 to 15. It is shown in

Figure 1:	A front view of a cell stack according to the invention, where a tiltable shortening element is in the second one of two tilting orientations;
Figure 2:	A lateral view of the cell stack shown in figure 1;
Figure 3:	A front view of a cell stack according to the invention, where a tiltable shortening element is in the first one of two tilting orientations;
Figure 4:	A front view of a further cell stack according to the invention, where an alternative tiltable shortening element is in the second one of two tilting orientations;
Figure 5:	A front view of the cell stack shown in figure 4 where the shortening element is in the first one of two tilting orientations;

Figures 6 to 8:	Partial front views of further cell stacks according to the invention where in each figure a tiltable shortening element is in the second one of two tilting orientations;
Figure 9:	A partial view of a particular embodiment of a tensioning element of a cell stack according to the invention where a shortening element is in the first one of two tilting orientations;
Figure 10:	A partial view of a particular further embodiment of a tensioning element of a cell stack according to the invention where a shortening element is in the second one of two tilting orientations;
Figures 11 to 14:	Several particular embodiments of shortening elements of tensioning elements of cell stacks according to the invention; and
Figure 15:	In four schematic drawings the difference between a spring loaded with tension and a spring loaded with compression force both in the 1st and 2nd tilting orientation.

Recurring reference numbers refer to identical or functionally identical characteristics.

A cell stack 1 according to the invention thus comprises a plurality of cell units 4, such as fuel cells, which are stacked between a first end of stack 2 of the cell stack 1 and a second end of stack 3 of the cell stack 1, as can be seen in the schematic front or lateral view given in figures 1 and 2. The cell stack 1 is thus part of a fuel cell system. However, the cell units 4 may also form other electrochemical cells or cells for humidifiers for electrochemical systems. The cell stack or the cell units may thus also form part of a humidifier for an electrochemical system or be part of another electrochemical system, such as of electrochemical energy storage, of a redox-flow battery, of an electrochemical compressor or of a fuel cell system.

The cell stack 1 further comprises two tensioning elements 5 of identical design, although in figure 1, only one of them is visible. With these tensioning elements, a tensioning force for the compression of the cell units 4 is transmitted between the first end of stack 2 and the second end of stack 3, in order to establish the sealing forces and/or contact forces between the cell units 4 required for the operation of the cell stack 1. Alternative embodiments are possible with the cell stack 1 comprising only one or more than two tensioning elements.

Both tensioning elements 5 of the cell stack have identical construction. The following description therefore equally relates to both tensioning elements 5. In figure 2, the left one of the two tensioning elements for the sake of clearness is shown without reference numbers. The tensioning element 5 connects the two ends of the stack, 2 and 3 and comprises a first partial section 6 which starts at the first end of stack 2 and extends in the direction of the second end of stack 3 as well as a second partial section 7 which starts at the second end of stack 3 and extends in the direction of the first end of stack 2. The partial sections mentioned are linear. They are designed as partial areas of a tensioning strap 8 of the tensioning element 5.

The tensioning strap 8 is a metallic strap, e.g. a steel strap, preferably a strap made from spring steel. It could however also be designed as a plastic strap, in particular as a fiber-reinforced, especially as a glass-fiber reinforced or carbon-fiber reinforced plastic strap. It is important that the tensioning strap is as resistant against stretching as possible. It surrounds a first endplate 9 of the cell stack 1 located at the first end of stack 2 as well as a second endplate 10 of the cell stack 1 located at the second end of stack 3. Further, the tensioning strap 8 is designed annularly with the two ends 11, 12 of the tensioning strap 8 being connected to each other by welding. The ends 11, 12 can however also be connected to each other by brazing, gluing, riveting, hooking, clinching or crimping.

The tensioning element 5 of the cell stack comprises two resilient elements 13, 14 to be compressed by compression force. However, a different amount of resilient elements is possible, too. The resilient elements 13, 14 connect the first partial section 6 with the second partial section 7 and provide for the tensioning force. To this end, each of these resilient elements 13, 14 loaded by compression force exerts a force to the first partial section 6 directed to the second end of stack 3 and a force to the second partial section directed to the first end of stack 2. These two forces have the same magnitude and are directed in opposite direction. A first end 15 of a resilient element 13, 14 may for instance be connected to the first partial section 6 through a first connecting element 17. Accordingly, a second end 16 of the resilient element opposite to the first end 15 of the resilient element 13, 14 may be connected to the second partial section 7 through a second connecting element 18, as becomes obvious from figure 1. With these connecting elements, the tensioning forces established by the resilient elements 13, 14 can be transmitted. These connections between the ends 15, 16 of the resilient elements 13, 14 and the first and second partial section 6, 7 in this embodiment of the tensioning element 5 and of the connecting elements 17, 18 are designed to be moveable along the partial sections 7, 6, as will be described in detail below.

The resilient elements 13, 14 and the connecting elements 17, 18 of the tensioning element 5 are part of a shortening element 19 of the tensioning element 5. As becomes obvious in a comparison of figure 1 with figure 3, the shortening element 19 can be tilted between a first tilting orientation shown in figure 3 and a second tilting orientation shown in figures 1 and 2. In the first tilting orientation, the first connecting element 17 and the first end 15 of the resilient element 13, 14 point towards the first end of stack 2 while the second connecting element 18 and the second end 16 of the resilient element 13, 14 point towards the second end of stack 3. In the second tilting orientation, the first connecting element 17 and the first end 15 of the resilient element 13, 14 point towards the second end of stack 3 while the second connecting element 18 and the second end 16 of the resilient element 13, 14 point towards the first end of stack 2. By tilting the shortening element 19 from the first tilting orientation to the second tilting orientation, the tensioning element 5 may thus be shortened. The dimension of the shortening element 19 has been chosen in such a way that the tensioning element transmits an optimal tensioning force if the shortening element 19 is in the second tilting orientation. In case the shortening element is in the first tilting orientation, the tensioning force mentioned is not transmitted and therefore, typically no or only a considerably reduced tensioning force is produced. In the second tilting orientation, the resilient elements 13, 14 are loaded with compression force and therefore produce the tensioning force but not in the first tilting orientation.

As can be seen in figure 1, the first partial section 6 of the tensioning element 5 and the second partial section 7 of the tensioning element 5 overlap with each other in an overlapping area 20 between the first ends of stack 2, 3, if the shortening element of the tensioning element of the cell stack 1 is in the second tilting orientation. An increase of the height of the cell stack, e.g. due to a thermal expansion of the cell units or to an increase of the inner pressure of the cell units leads to a reduction of the overlapping area 20 and to an effective increase of the partial sections 6, 7 of the tensioning element 5. In return, a reduction of the height of the cell stack causes an increase of the overlapping area 20 and an effective shortening of the tensioning element 5. The reduction or increase of the overlapping area 20 comes along with a compression or release of the spring. As a consequence, the tensioning force is maintained in an acceptable range. If the overlapping area 20 is reduced, the resilient elements 13, 14 arranged in the overlapping area 20 between the first and second partial sections 6, 7 are compressed. Accordingly, the resilient elements 13, 14 extend if the overlapping area increases. As a consequence, the tensioning force of the tensioning element 5 remains essentially constant.

If this overlapping of the partial sections 6, 7 of the tensioning element 5 is not given, for instance as the shortening element is in the first tilting orientation, as shown in figure 3, the tensioning element 5 shows such a large total length that it effectively does not produce any compression of the cell stack 1.

In the example shown in figures 1 to 3, the tensioning element 5 comprises an intermediate section 21 of the tensioning strap 8 which extends in the overlapping area 20 of the tensioning element 5, which connects the first partial section 6 with the second partial section 7. Here, the first partial section 6 in a first transition area passes into this intermediate section 21 and the intermediate section 21 in a second transition area finally passes into the second partial section 7. As a consequence, the intermediate section 21 in the overlapping area 20 both overlaps with the first partial section 6 and the second partial section 7. As becomes obvious from figure 1, the first partial section 6, the intermediate section 21 and the second partial section 7 together with the transition areas 22, 23 form a z-shaped or s-shaped arrangement.

With the elastic movement described above, the intermediate section 21 additionally shortens when the overlapping area 20 reduces and the intermediate section 21 lengthens if the overlapping area increases. To this end, the first and second connecting element 17, 18 are moveably connected with the intermediate section 21 along the tensioning strap 8; it can for instance be shifted or wound. Figure 1 shows the compressed state of the cell stack 1. Here,the connecting elements 17, 18 cause a redirection of the tensioning strap 8 within the transition areas 22, 23,namely at the connecting elements 17, 18 . An increase or reduction of the overlapping area 20 therefore corresponds to a movement of the first and second connecting element 17, 18 along the tensioning strap 8, to a shift of the locations of the redirections mentioned and of the transition areas 22, 23 along the tensioning strap 8 and to a simultaneous compression or stretching of the resilient element 13. 14. To this end, the tensioning strap additionally is designed as bendable and flexible but at the same time as resistant against stretching as possible. The connecting elements 17, 18 in this example are thus designed as redirecting rolls, which rest against the transition areas 22, 23 and delimit the first and the second partial sections 6, 7. They could however also be designed as rolls, roller bows or guide pulleys.

The further embodiment of the cell stack according to the invention shown in figures 4 and 5 essentially distinguishes from the example shown in figure 1 only be the design of the tensioning elements 5, in particular by the design of the tensioning strap 8 and the connecting elements 17, 18 of the shortening element 19. In this example, the connecting elements 17, 18 are rigidly, thus non-moveably connected to the ends 24, 25, of the first and second partial sections 6, 7. The tensioning strap is thus not annularly closed. The first and second partial section 6, 7 therefore are not connected to each other via an intermediate section 21 of the tensioning strap 8, but only by the tiltable shortening element 19. In this example, the connecting elements 17, 18 are anchoring elements, which are tightly anchored in the terminal loops of the ends 24, 25 of the first and second partial sections 6, 7. As an alternative, one could use clips, screwing- or riveting connections or resting connections as the connecting elements 17, 18. The tensioning strap 8 extends as a single piece from connecting element 17 to connecting element 18.

In figure 4, the shortening element 19 is in the second tilting orientation, thus, the compression of the stack has been established. In contrast, in figure 5, the shortening element 19 is in the first tilting orientation so that no compression results.

The particular embodiments of cell stacks according to the invention shown in figures 6 to 8 differ from the example shown in figures 4 and 5 essentially only by the design of the tensioning elements 5, which in the examples of figures 6 to 8 connect the endplates 9. 10 of the cell stack with each other and exert tension to them, but they do not surround these endplates. It is for instance possible that the tensioning straps 8 of the tensioning elements 5 at their ends are connected to the end plates 9, 10 using latches, which are however not shown.

In addition, in figures 6 to 8, fixation elements 26 of the tensioning elements 5 are shown, which are not shown in figures 1 to 5 for the sake of clearness. The fixation elements 26 serve for the fixation and stabilization of the reciprocal overlap of the first partial section 6 and the second partial section 7 of the respective tensioning element 5 and have been designed in such a way that they fix and maintain the respective shortening element 19 in the second tilting orientation, as is shown in figures 6 to 8.

The fixation element may for instance comprise one or several hook(s) or latch(es) connected to the first endplate 9. In this embodiment, a sufficient length of the hook(s) is essential which should account for the maximum increase of the total length of the cell stack 1. The fixation element may for instance comprise a screw connected to the first endplate 9 as shown in figure 7 or connected to the first and/or second partial section 6, 7 as shown in figure 8. Such a screw additionally may serve as a fixation and/or adjustment means 27. With this, a fixation point of the resilient element 13, 14 and/or a tension of the resilient element 13, 14, may be reset or adjusted.

In figures 9 to 14, several embodiments of shortening elements 19 for cell stacks according to the invention are given, such as for the examples of cell stacks shown in figures 1 to 8. The shortening element 19 in figures 1 to 3 may thus be designed according to one of the shortening elements 19 given in figures 9 and 11 to 14. Further, each of the shortening elements 19 shown in figures 4 to 8 may be designed according to one of the shortening elements 19 given in figures 9 and 11 to 14.

The shortening elements given in figures 9 and 11 to 14 correspond to each other in view of the fact that each of them comprises two resilient elements 13, 14, which together with the first and second connecting element 17, 18 of the shortening element 19 form an annular arrangement and define a central passage opening 28 of the shortening element 19 or enclose such. As in the embodiment of figures 1 to 3, the intermediate section 21 of the tensioning element 5 can extend through this central passage opening 28 of the shortening element 19.

In the example shown in figure 9, the shortening element 19 comprises several fixation elements 26, namely bending latches arranged at the resilient elements 13, 14 as well as a partial area of the tensioning strap 8 in the first partial area 6, which is deformed as a hook in order to provide the function of a hook, of a clip or of a latch for the fixation of the shortening element 19 in the second tilting orientation.

In the shortening elements shown in figures 9 to 14, the resilient elements 13, 14 are designed as compression springs. In figures 9, 13 and 14, they are realized as legs being elastic with respect to bending, in figure 10 as a leaf spring and in figures 11 and 12 as spiral springs. The spiral springs additionally are each centrally guided by an alignment pin 29, with the alignment pins 29 being connected to the first and second connecting element, respectively, in a moveable manner. In figure 12, the shortening element additionally shows a fixation and/or adjustment element 27 which is designed as a threaded sleeve. This threaded sleeve allows to adjusting the length of the respective section of the alignment ping 29, which regulates the compression of the spiral springs.

The connecting elements 17, 18 are designed as redirecting rolls in figure 9 and as roller bows in figures 11 to 13. As shown in figure 10, the first partial section 6 and the second partial section 7 along their extension between the two ends of stack 2, 3 may comprise subsections with different design. In this respect, the end 24 of the first partial section 6 is thus designed as a plastic strap with fiber reinforcement and the end 25 of the second partial section is designed as a metal holder, which surrounds the resilient element 13 laterally if the shortening element 19 is in the second tilting orientation.

The embodiments shown in the figures can be mounted and compressed with the method described in the following. In order to produce an increased first compression of the cell stack by means of a press, the tensioning elements 5 are arranged in such a way that the first partial section 6 of the tensioning element 5 starts at the first end of stack 2 and extends in the direction of the second end of stack 3 and that the second partial section 7 of the tensioning element 5 starts at the second end of stack 3 and extends in the direction of the first end of stack. With an annularly closed tensioning strap 8 as shown in figures 1 to 3, or with an annularly closed tensioning element 5 as shown in figures 4 and 5, the tensioning element 5 can for instance be dragged over the end plates 9, 10. In the examples shown in figures 6 to 8, the two partial sections 6, 7 can be mounted to the end plates 9, 10, e.g. by hooking-in or screwing.

In a subsequent step the overlap described beforehand of the two partial sections 6 and 7 in the overlapping area 20 between the two ends of the stack is realized by tilting the shortening element 19 from the first tilting orientation to the second tilting orientation, e.g. by means of a tilting device of a production machine constructed to this end. Next, the overlap is fixed using the fixation element 26, the press is opened and the cell stack 1 is taken out of the press. After that, the tension effected by the resilient elements 13, 14 can be reset or adjusted by means of the fixation and/or adjustment element 27, e.g. from an increased first compression to a desired final value of compression.

Figure 15 shows in four schematic drawings the difference between a spring loaded with tension (A, B), thus a spring arrangement of a conventional cell stack, and a spring loaded with compression force (C, D), which is in the second tilting orientation. Both springs are once shown in a situation where a higher tension (A, C) and in a situation where a lower tension (B, D) is given in a cell stack according to the invention. The actual spring loaded with tension (A, B) is shortened to the same degree between the situation with higher tension (A) and the situation with lower tension (B), as the actual spring loaded with compression force (C, D) is elongated between the situation with higher tension (C) and the situation with lower tension (D). The figure demonstrates that with the spring arrangement according to the invention, the same elongation/compression of the spring as such allows for a more efficient compression/elongation of clamping system of the cell stack using the spring loaded with compression force in the second tilting orientation than does a clamping system according to the state of the art using a spring loaded with tension.

List of reference numbers

1 cell stack
2 first end of stack
3 second end of stack
4 cell unit
5 tensioning element
6 first partial section
7 second partial section
8 tensioning strap
9 first endplate
10 second endplate
11 end of tensioning strap
12 end of tensioning strap
13 resilient element
14 resilient element
15 first end of resilient element
16 second end of resilient element
17 first connecting element
18 second connecting element
19 shortening element
20 overlapping section
21 intermediate section
22 first transition area
23 second transition area
24 end of first partial section
25 end of second partial section
26 fixation element
27 fixation and/or adjusting element
28 passage opening
29 alignment pin

Claims

1. Cell stack (1), comprising several cell units (4) stacked between a first end of the stack (2) of the cell stack (1) and the second end of the stack (3) of the cell stack (1) and at least one tensioning element (5), with which a tensioning force for clamping of the cell units (4) can be introduced between the first end of the stack (2) and the second end of the stack (3), with the at least one tensioning element (5) comprising a first partial section (6) starting from the first stack end (2) and extending in the direction of the second stack end (3) and a second partial section (7) starting from the second stack end and extending in the direction of the first stack end (2), where the at least one tensioning element (5) comprises at least one resilient element (13, 14) being loaded with compression force which links the first partial section (6) with the second partial section (7), characterized in that the first partial section (6) of the at least one tensioning element (5) and the second partial section (7) of the at least one tensioning element (5) overlap with each other in an overlapping area (20) between the two ends of the stack (2, 3).

2. Cell stack (1) according to claim 1, characterized in that the at least one resilient element (13, 14) is arranged in the overlapping area (20) of the at least one tensioning element (5).

3. Cell stack (1) according to claim 2, characterized in that the at least one resilient element (13, 14) is arranged between the first partial section (6) of the tensioning element (5) and the second partial section (7) of the tensioning element (5).

4. Cell stack (1) according to one of the preceding claims, characterized in that the at least one tensioning element (5) comprises an intermediate area extending in the overlapping area (20) of the tensioning element (5) which links the first partial section (6) with the second partial section (7).

5. Cell stack (1) according to claim 4, characterized in that the first partial section (6), the intermediate section (21) and the second partial section (7) together for a z-shaped or s-shaped arrangement.

6. Cell stack (1) according to one of the preceding claims, characterized in that the first partial section (6) and/or the second partial section (7) of the at least one tensioning element (5) as a whole or partially are designed as a tensioning strap (8).

7. Cell stack (1) according to claim 6, characterized in that the tensioning strap (6) is a metallic strip, a steel strip, a strip from spring steel or a plastic strip, in particular a fiber-reinforced, especially glass-fiber or carbon-fiber reinforced plastic strip.

8. Cell stack (1) according to one of the preceding claims, characterized in that the at least one resilient element (13, 14) comprises at least one compression spring, in particular at least one spiral spring, at least one flat spring or at least one leg being elastic with respect to bending.

9. Cell stack (1) according to one of the preceding claims, characterized in that the at least one tensioning element (5) comprises a shortening element (19) for shortening of the tensioning element (5), with the shortening element (19) comprising a first connecting element (17) connected to the first partial section (6) and a second connecting element (18) connected to the second partial section (7), with the shortening element (19) being tiltable between a first tilting orientation , in which the first connecting element (17) points towards the first end of stack (2) and the second connecting element (18) points towards the second end of stack (3) and a second tiltable orientation, in which the first connecting element (17) points towards the second end of the stack (3) and the second connection element (18) points towards the first end of stack (2), with the at least one resilient element (13, 14) being loaded with pressure in order to produce a pre-tension if the shortening element (19) is in the second tilting orientation.

10. Cell stack (1) according to claim 9, characterized in that the at least one resilient element (13, 14) of the at least one tensioning element (5) forms one part of the shortening element (19) of the at least one tensioning element (5), with the first connecting element (17) of the shortening element (19) being connected to a first end (15) of the at least one resilient element (13, 14) and that the second connecting element (18) of the shortening element (19) is connected with a second end (16) of the at least one resilient element (13, 14).

11. Cell stack (1) according to one of claims 9 or 10, characterized in that the first connecting element (17) of the shortening element (19) is rigidly or moveably connected with one end (24) of the first partial section of the at least one tensioning element (5) and that the second connecting element of the shortening element (19) is rigidly or moveably connected with one end (25) of the second partial section of the at least one tensioning element (5).

12. Cell stack (1) according to one of claims 9 to 11, characterized in that the shortening element (19) comprises at least two resilient elements (13, 14), which together with the first and the second connecting element (17, 18) of the shortening element (19) form an annular arrangement.

13. Cell stack (1) according to claim 12, characterized in that the intermediate area of the tensioning element (5) extends through a central passage opening (28) of the shortening element (19).

14. Cell stack (1) according to one of claims 9 to 13, characterized in that the resilient elements (13, 14) are designed as compression springs, with the compression springs being guided through at least one alignment pin (29), with the at least one alignment pin (29) being connected moveable with the first and/or the second connecting element (17, 18) for a spring movement between the first and second connecting element (17, 18).

15. Cell stack (1) according to one of claims 9 to 14, characterized in that the first connecting element (17) and/or the second connecting element (18) or the shortening element is/are designed as redirecting element, with the first partial section (6) and/or the second partial section (7) of the at least one tensioning element resting on or adjoining to the respective redirecting element.

16. Cell stack (1) according to one of claims 9 to 15, characterized in that the at least one tensioning element (5) comprises a fixation element (26) for the fixation of the shortening element (19) in the second tilting orientation.

17. Cell stack (1) according to claim 16, characterized in that the fixation element (26) comprises a clip, a sleeve, a resting element, a metal sheet, a bending ear, a screw, a pin or a hook.

18. Cell stack (1) according to one of claims 16 or 17, as far as this claim refers to claim 6, characterized in that the fixation element (26) comprises a hook-shaped deformed partial area of the tensioning strap (8) of the first or second partial section (6, 7).

19. Cell stack (1) according to one of claims 16 to 18, characterized in that the fixation element (26) is arranged at a first or second end plate (9, 10) of the cell stack (1) situated at the first end of stack (2) or second end of stack (3).

20. Cell stack (1) according to one of the preceding claims, characterized in that the at least one tensioning element (5) surrounds a first end plate (9) of the cell stack (1) situated at the first end of stack (2) or a second end plate (10) of the cell stack (1) situated at the second end of stack (3).

21. Cell stack (1) according to one of the preceding claims, characterized in that the at least one tensioning element (5) surrounds the first end plate (9) of the cell stack (1) situated at the first end of stack (2) and the second end plate (10) of the cell stack (1) situated at the second end of stack (3).

22. Cell stack (1) according to claim 21, characterized in that the at least one tensioning element is annularly closed or comprises an annularly closed tensioning strap (8), which comprises the first partial section (6) and the second partial section (7).

23. Cell stack (1) according to claim 22, characterized in that the at least one annularly closed tensioning element (5) comprises two ends with the two ends being connected to each other by welding, brazing, gluing, riveting, hooking, clinching or crimping.

24. Cell stack (1) according to one of the preceding claims, characterized in that the cell units are part of an electrochemical system, or a humidifier, of an electrochemical compressor or of a fuel cell system.

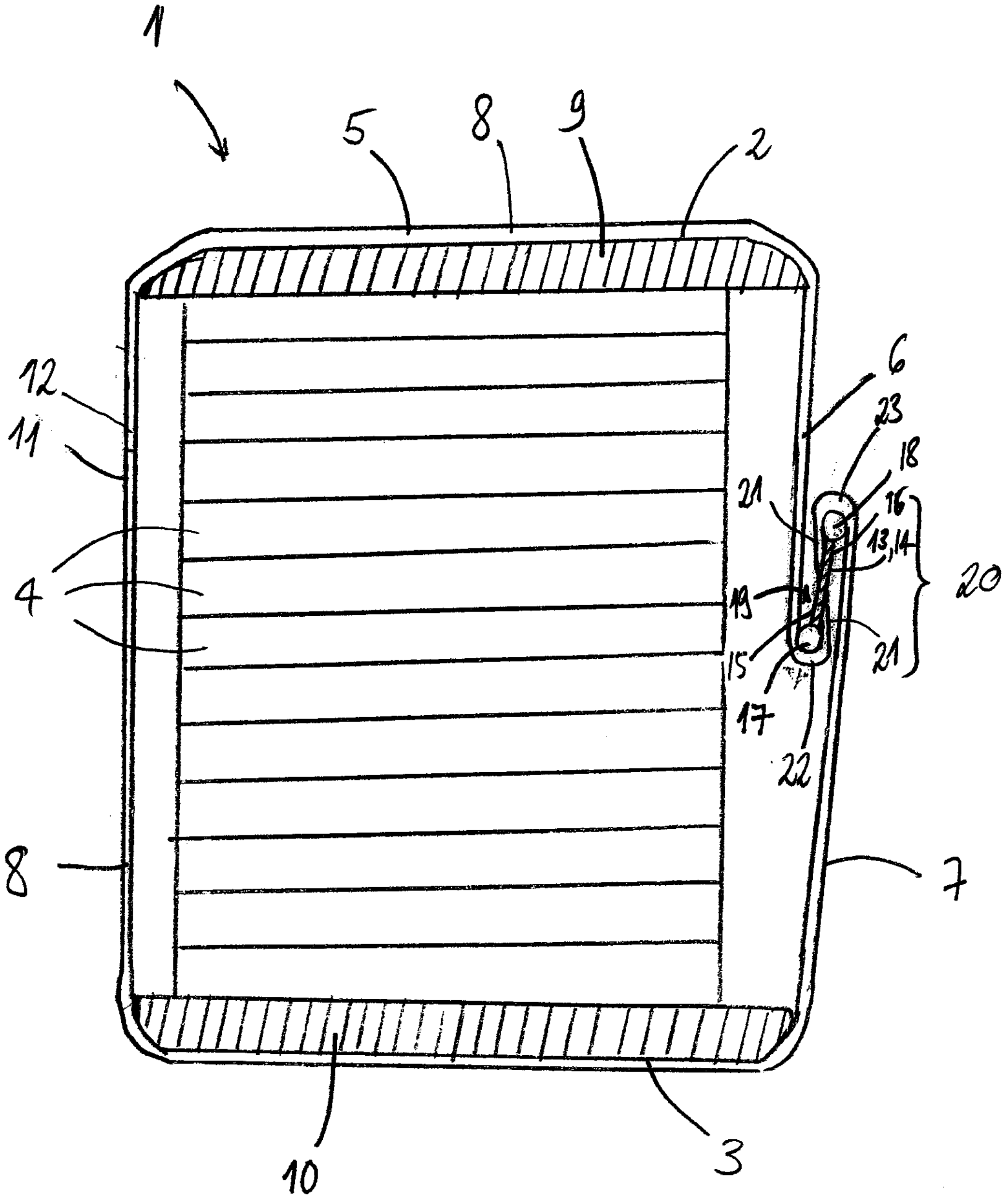

Fig. 1

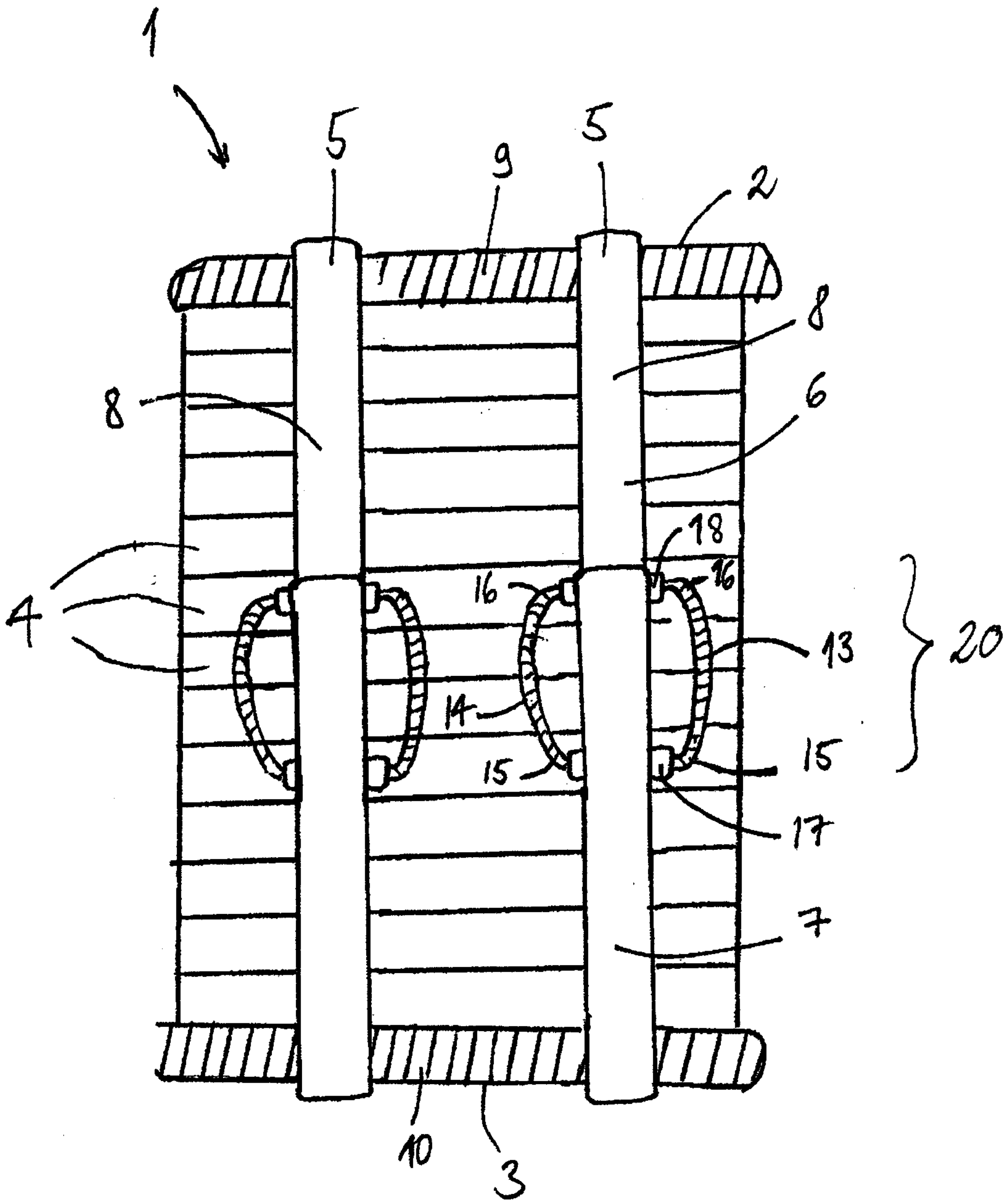

Fig. 2

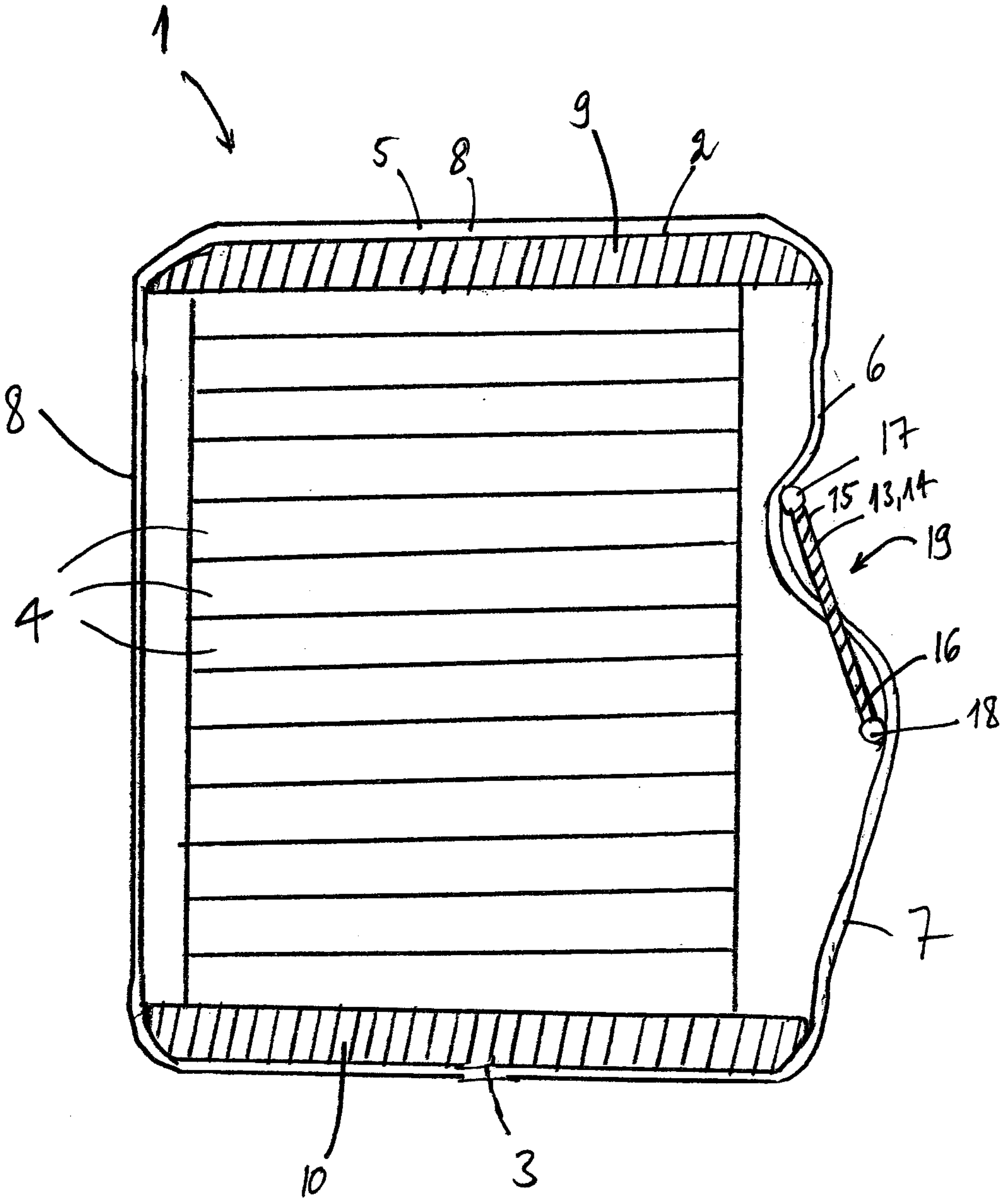

Fig. 3

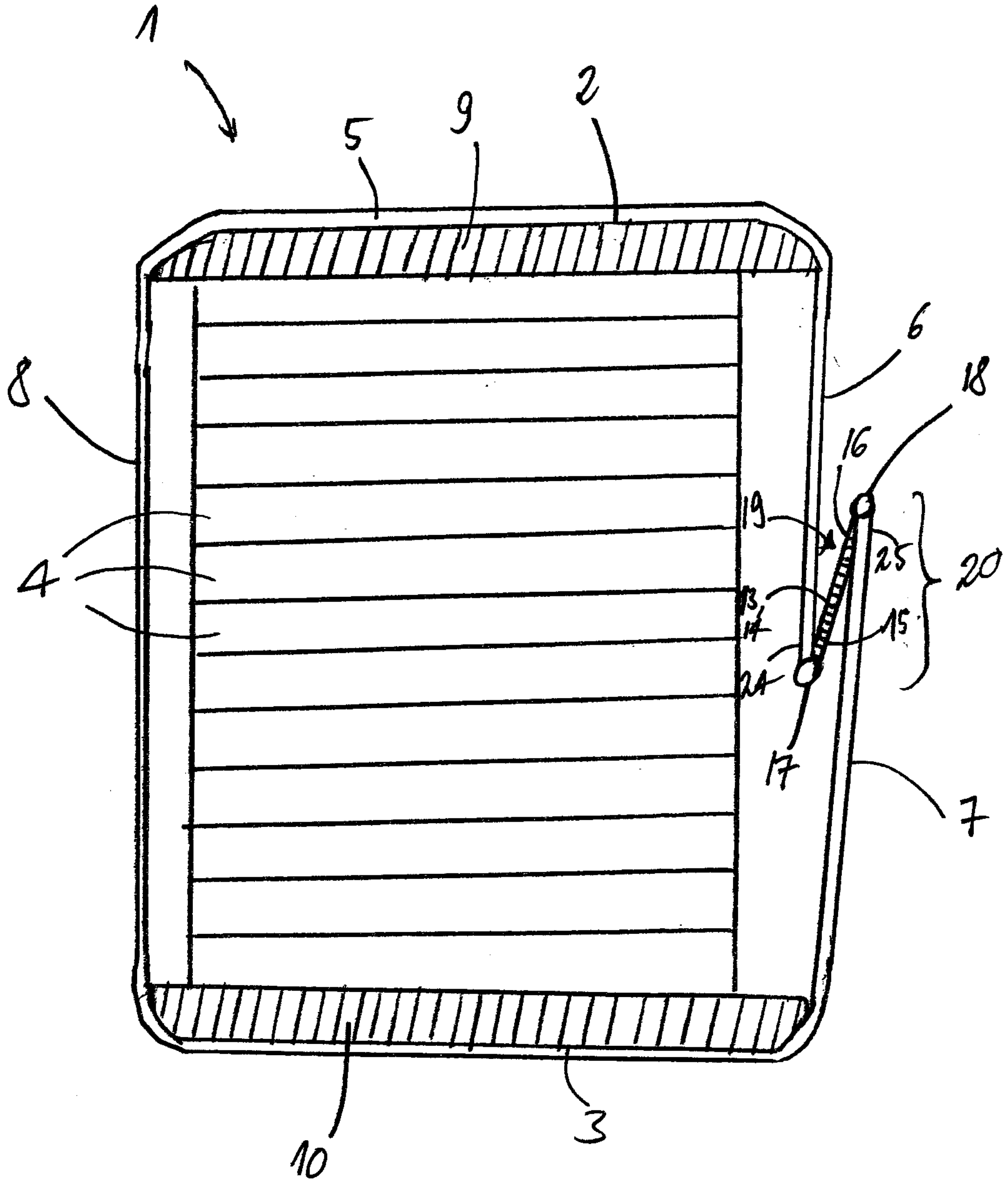

Fig. 4

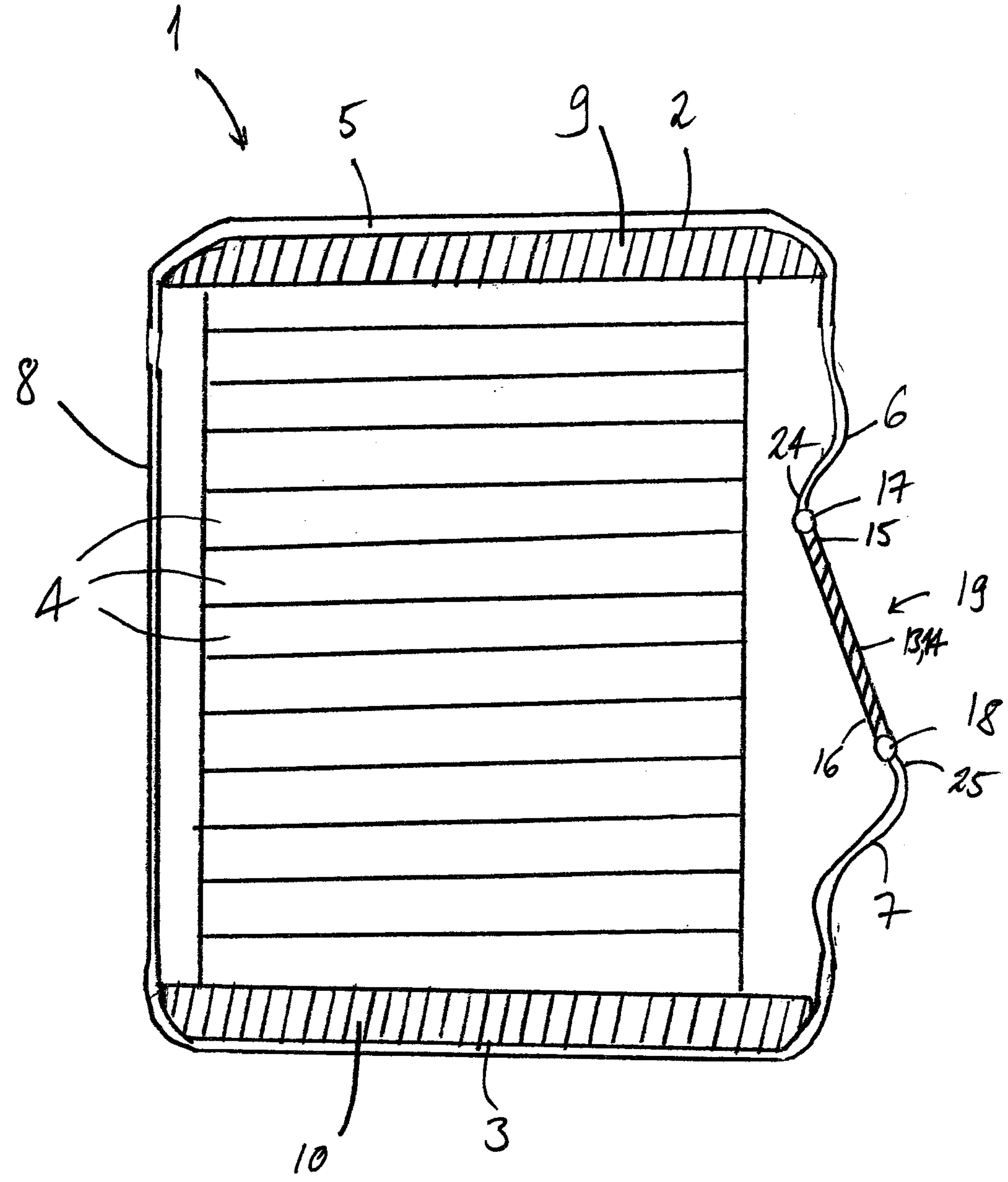

Fig. 5

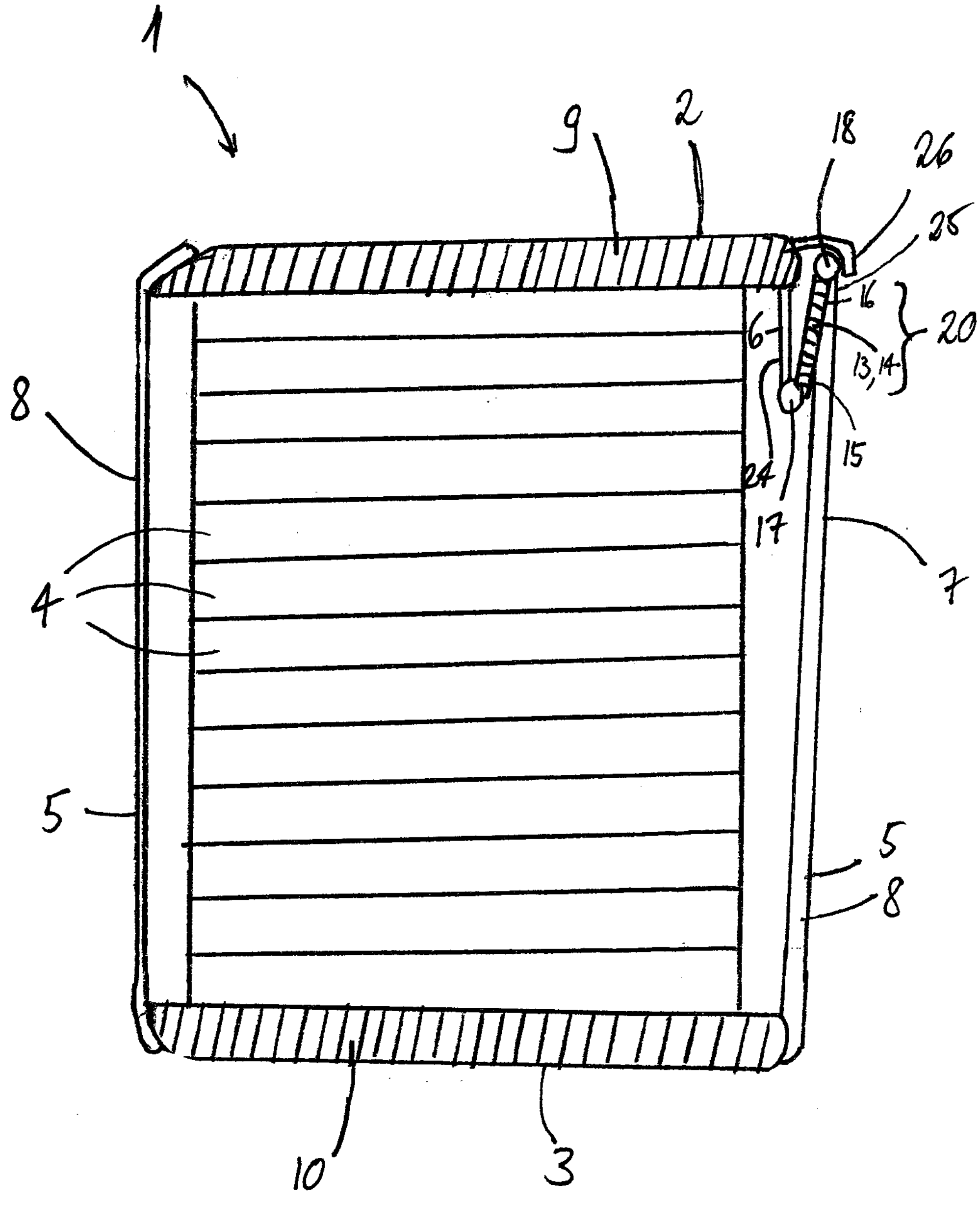

Fig. 6

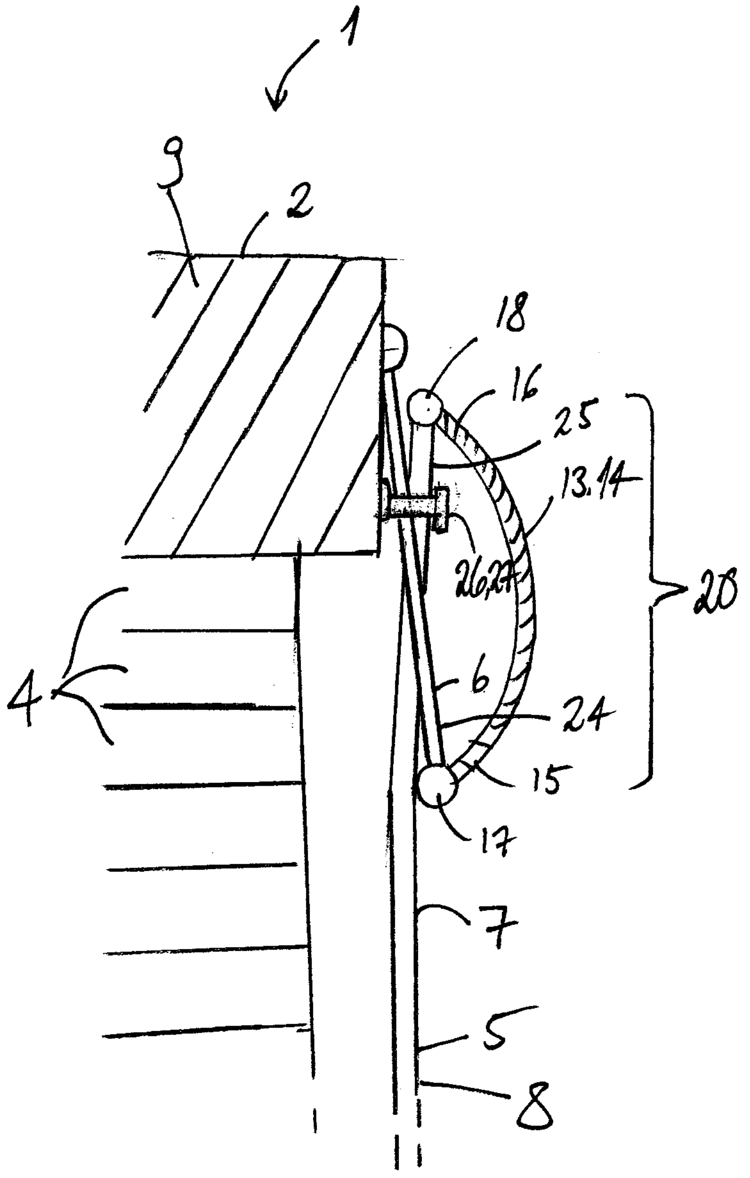

Fig. 7

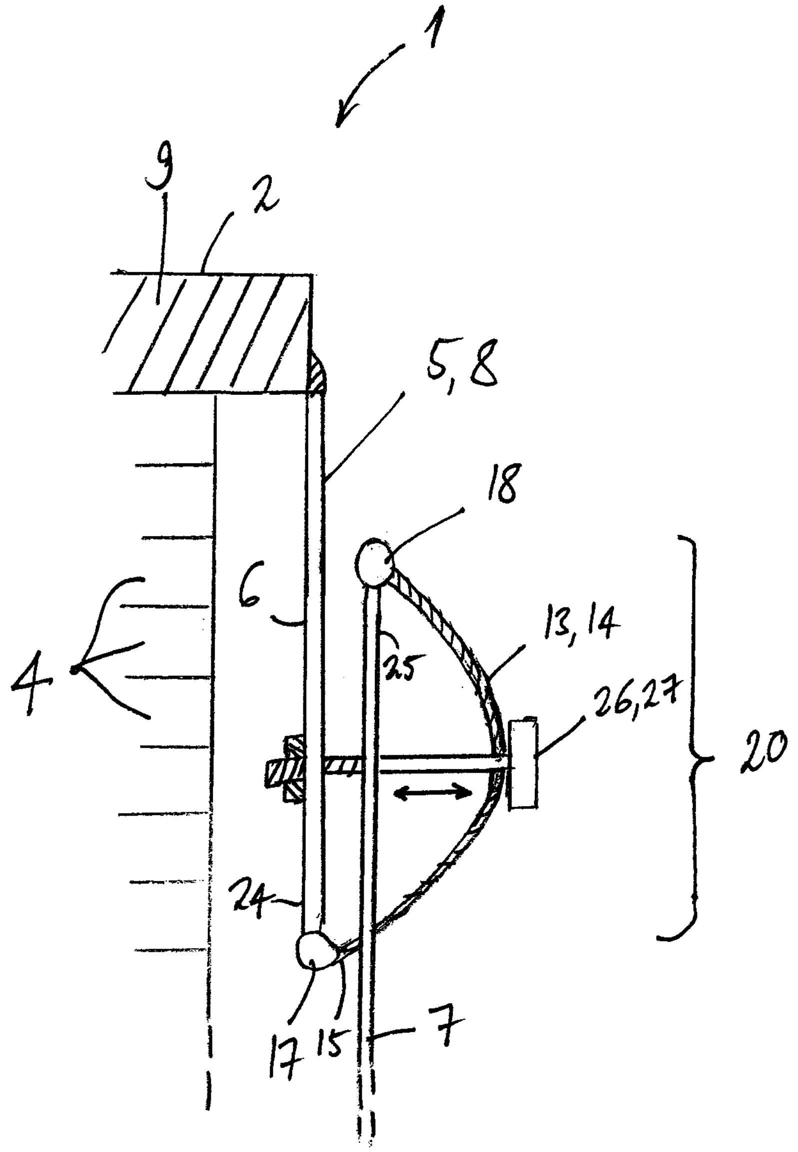

Fig. 8

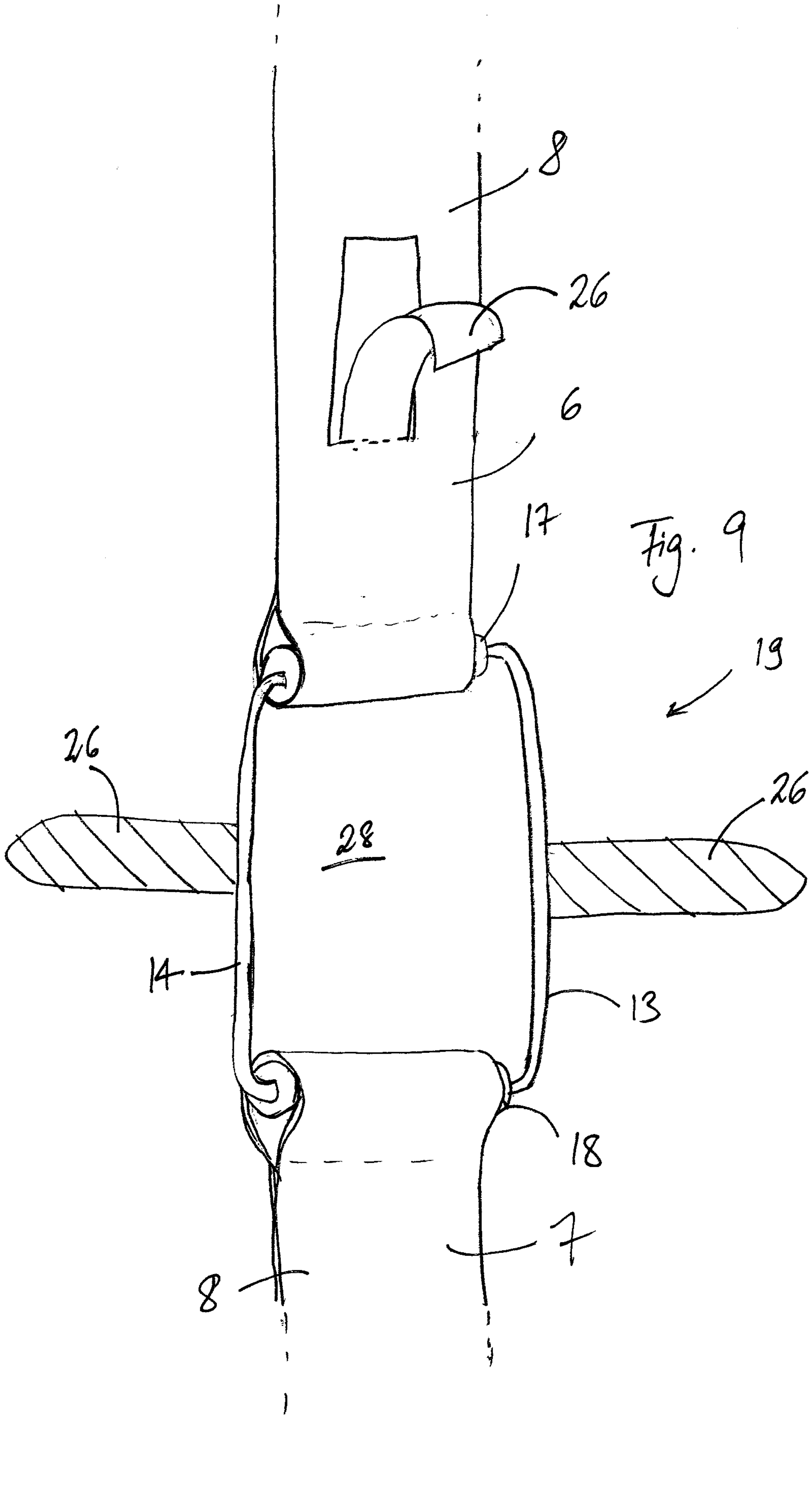

Fig. 9

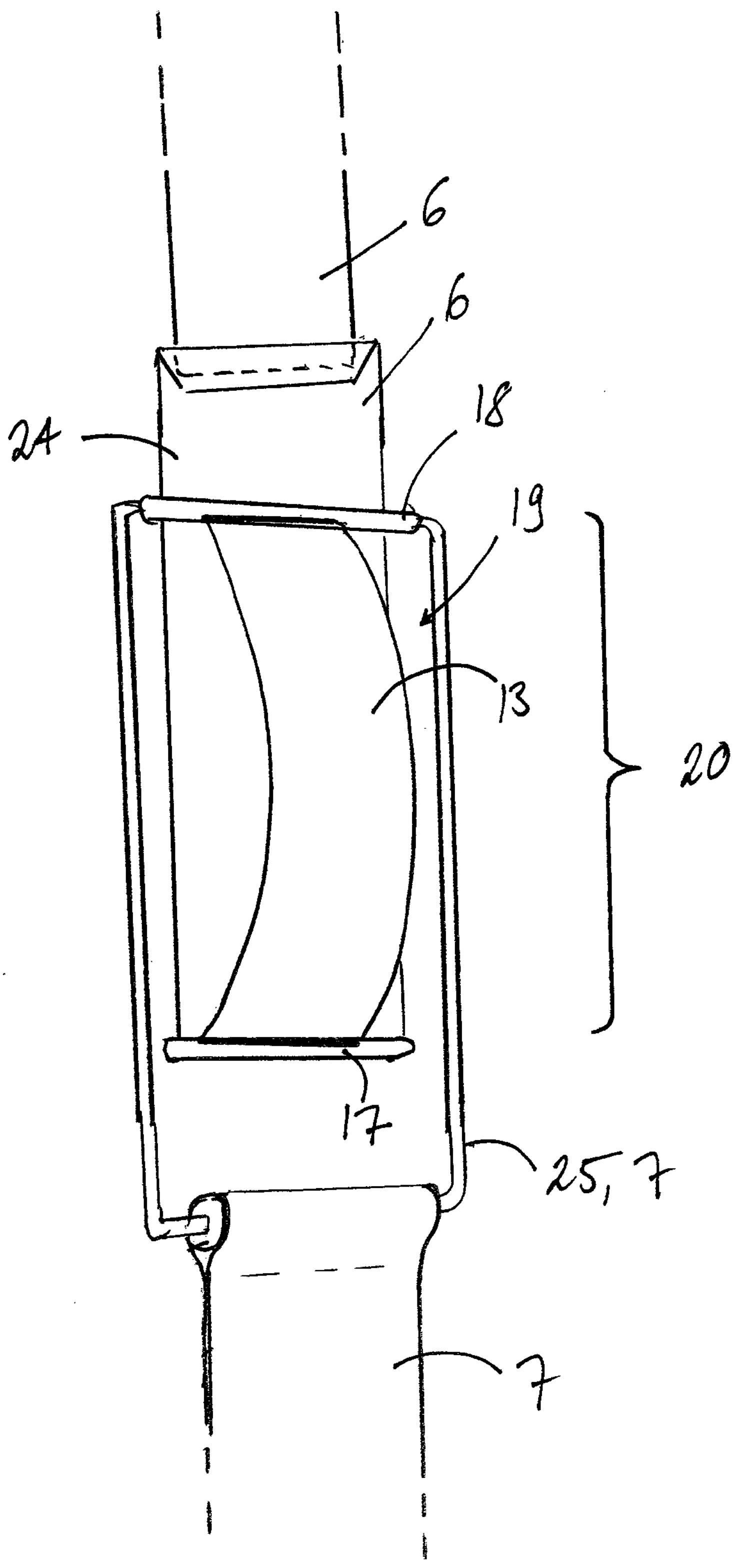

Fig. 10

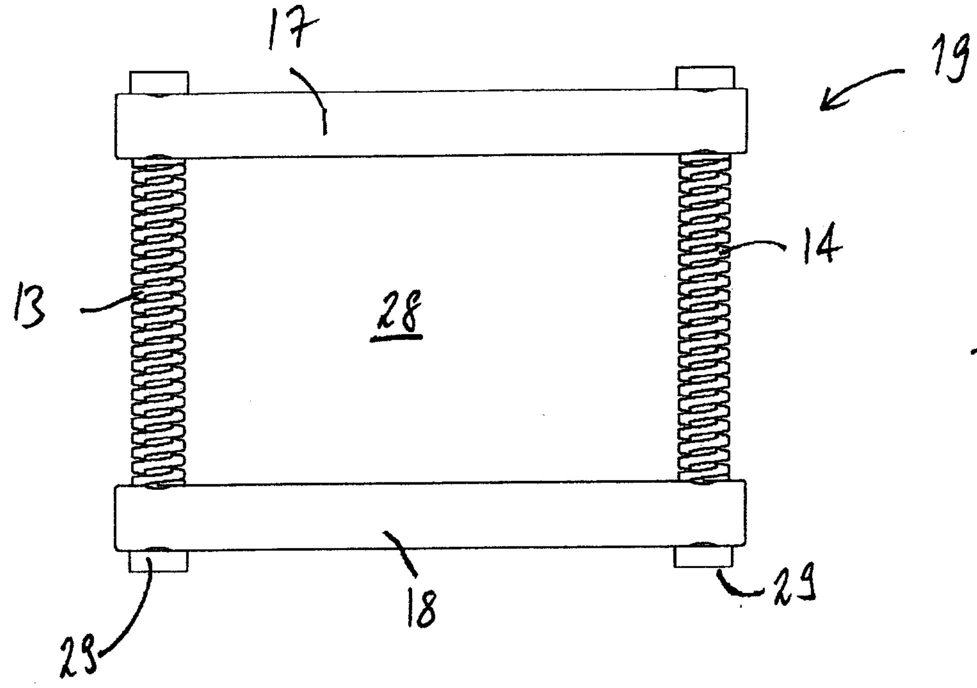

Fig. 11

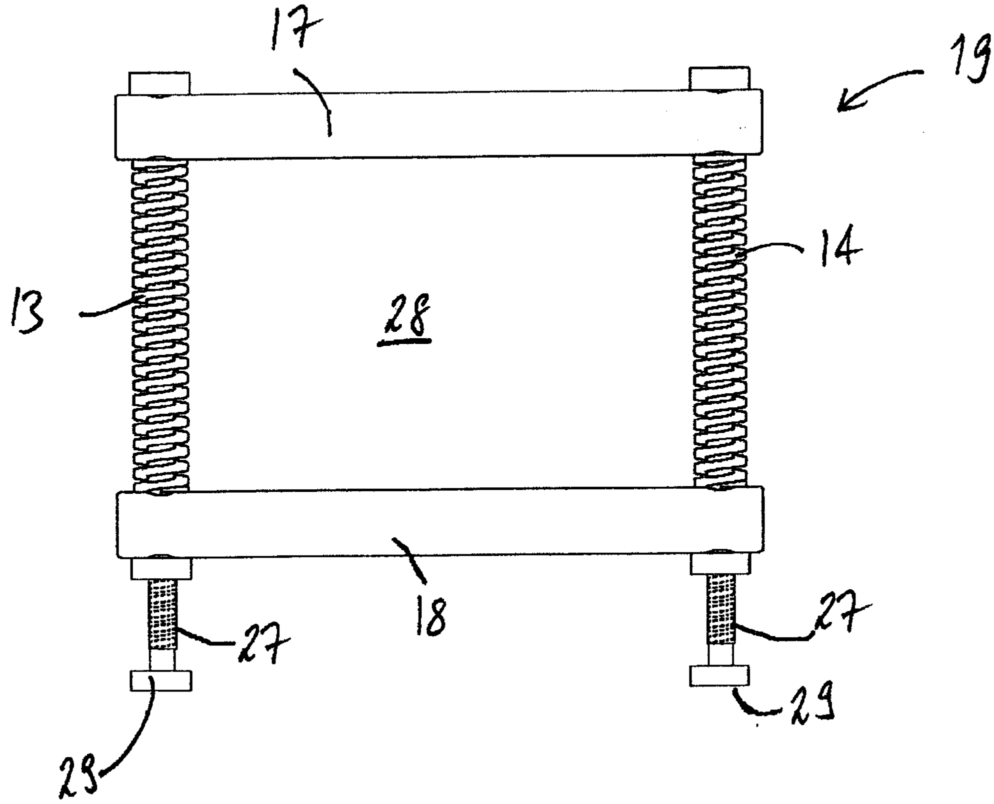

Fig. 12

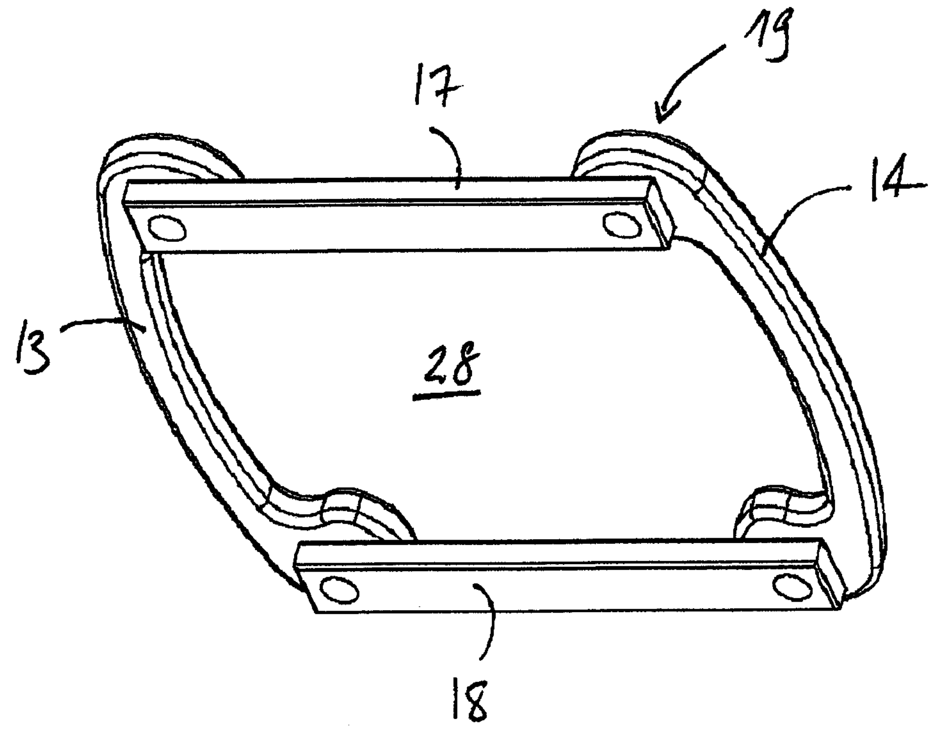

Fig. 13

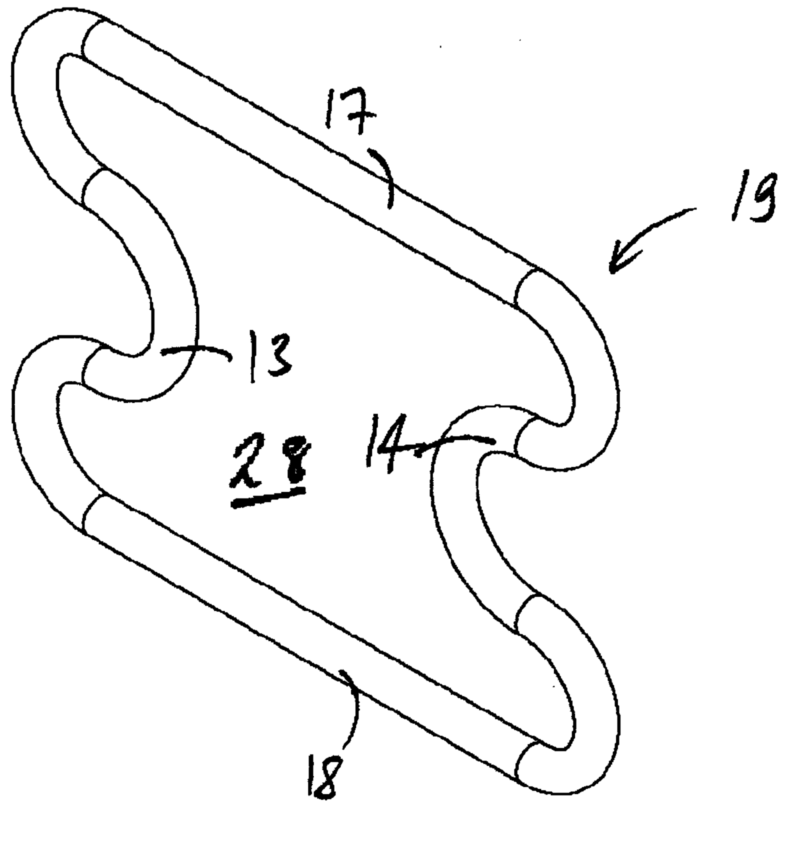

Fig. 14

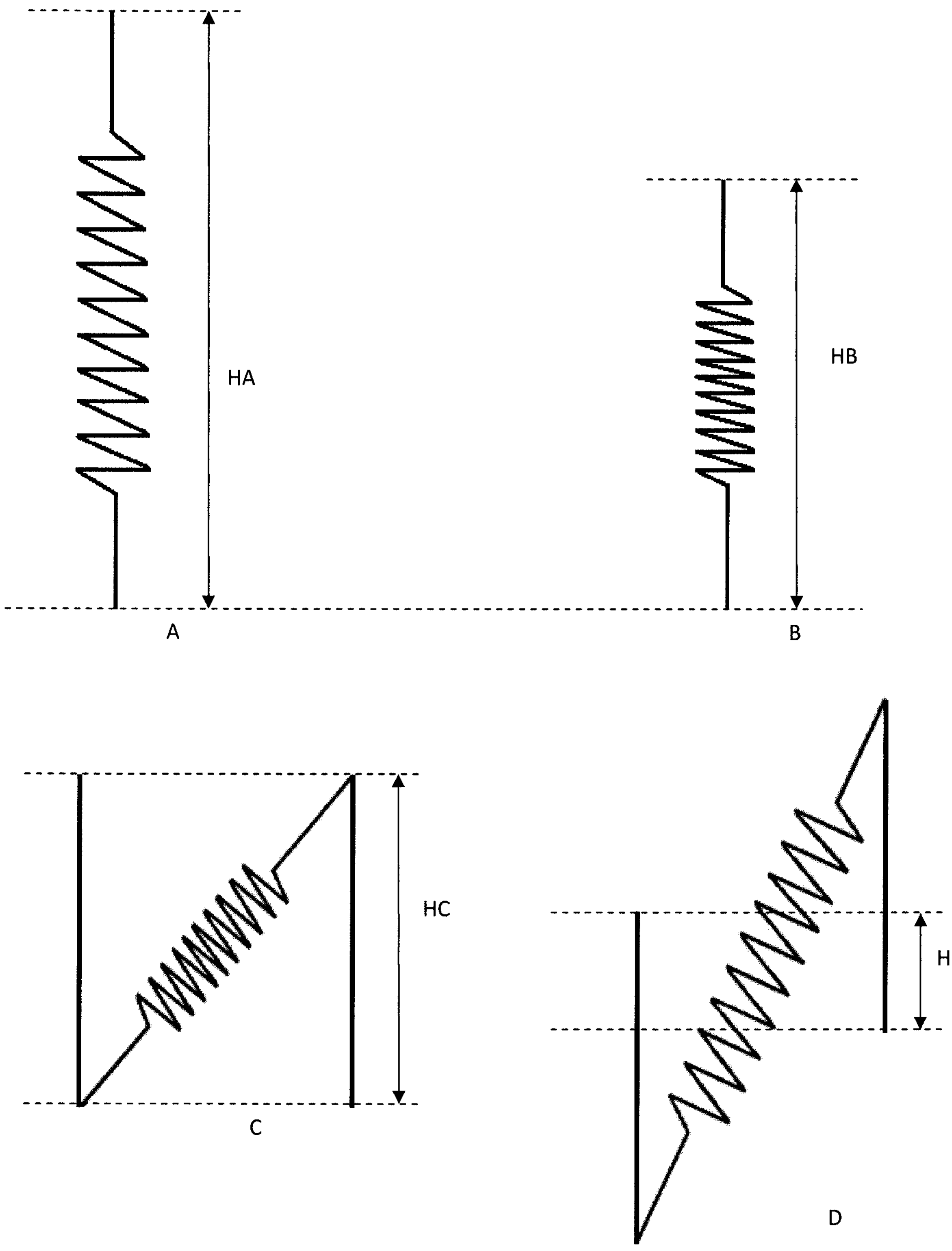

Fig. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/057192

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01M8/24
ADD.

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)
H01M A44B B60P B65D

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 2006/093890 A1 (STEINBRONER MATTHEW P [US]) 4 May 2006 (2006-05-04) abstract; figures 6,18-22 paragraphs [0047], [0050], [0057] - [0061]	1-8, 20-24 9-13,15 14,16-19
Y	US 3 860 998 A (SCHNURMACHER GERALD L) 21 January 1975 (1975-01-21) abstract; figures 1-6 column 2, lines 1-20	9-13,15
A	FR 2 562 972 A1 (CHEVRIER GERARD [FR]) 18 October 1985 (1985-10-18) abstract; figures 1-9	1-24

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

☒ See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

"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

"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

"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 July 2014	30/07/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Chmela, Emil

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/057192

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