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Description

TECHNICAL FIELD OF THE INVENTION

The invention relates to a fibre compound component, wherein, in a region extending along a main area, a plurality of fibre layers extending in parallel to the main area and a plurality of intermediate layers extending in parallel to the main area are embedded in a resin matrix, and to a method for producing such a fibre compound component. Particularly, the invention relates to a fibre compound component comprising the features of the preamble of independent claim 1, and to a method comprising the features of the preamble of independent claim 11.

PRIOR ART

Often, glued connections and/or bolted connections, i. e. material and/or mechanical joining techniques, are used for joining multilayered fibre compound components. Mechanical joining techniques with bolted connections are favoured as they are very secure. However, in mechanical joining techniques, a reduction of the connection quality may result from a low hole bearing stability of fibre compound materials. With fibre compound components increasing in size, the connection quality may only be achieved by integration of further fibre layers and/or of intermediate layers made of reinforcing materials. Both approaches result in a structural increase of the thickness and thus in a considerable increase of the mass of the fibre compound component. The infusion or injection of matrix resin for forming the resin matrix of fibre compound component with two-dimensional intermediate layers requires a special feed management or flow concept for the matrix resins. The two-dimensional intermediate layers constitute barrier layers for the resin flow. Thus, those injection technologies, which are extremely cost efficient from a production point of view, which are also designated as wet technologies, and which include the known methods RTM and VARI, may not be used, particularly not for large-area structures.

Besides simple cross bolt connections, anti-fatigue bolt connections are known for structurally highly stressed fibre compound components from Hau, E. Windkraftanlagen: Grundlagen, Technik, Einsatz, Wirtschaftlichkeit. Berlin, Heidelberg: Springer-Verlag, 2008. Whereas, in case of cross bolt connections, holes for fixing bolts extend through the respective fibre compound component in cross direction, connection holes for anti-fatigue bolts in anti-fatigue bolt connections extend through the fibre compound component from one face side along the fibre layers up to cross bolts inserted in cross holes.

For avoiding a local increase of thickness of a fibre compound component reinforced with intermediate layers made of metal, it is known from Fink, A. Lokale Metall-Hybridisierung zur Effizientsteigerung von Hochlastfügestellen in Fasberverbundstrukturen. Köln: Deutsches Zentrum für Luft- und Raumfahrt e. V., 2014 to arrange a fibre layer and a metal intermediate layer of a same thickness face to face such that a fibre layer termination edge of the fibre layer and an intermediate layer termination edge of the intermediate layer run in parallel to each other. Neighbouring fibre layers run through over the region of these abutting edges. This known concept is only suitable for comparatively thick intermediate layers made of metal which are correspondingly poorly malleable in the production of the fibre compound component.

A compound material made of a plurality of fibre compound layers and a reinforcing region with reinforcing layers made of a material reinforcing the fibre compound layers is known from EP 2 363 282 A2. Perforations are provided in the reinforcing layers. In the region in which the fibre compound layers are provided with the reinforcing layers, several bores are directed through the compound material. In a region around the bores, the reinforcing layers are formed homogenously and without perforations. The reinforcing layers are reinforcing metal sheets which replace individual fibre compound layers. The replaced fibre compound layers are interrupted and abut against the reinforcing metal layers at their rim. Here, a uniform component thickness over the region is realized in that the metal layers replace the fibre compound layers. Alternatively, the reinforcement with the metal layers is effected by addition of layers, i. e.

reinforcing metal layers are placed between the fibre compound layers. This results in deflections of the fibre compound layers at the edges of the reinforcing metal sheets, and the component thickness increases step by step due to the additional layers.

A fibre compound component comprising the features of the preamble of independent claim 1 is known from EP 2 492 087 A1. The fibre compound component has an angle in which the fibre layers are curved. After running through the curve, two inner fibre layers coming out of a first direction terminate at fibre layer termination edges. An intermediate layer termination edge of an intermediate layer coming out of a second direction opposite to the first direction faces one of the fibre layer termination edges, the intermediate layer also being a fibre layer. Due to the second inner fibre layer whose fibre layer termination edge is not facing an intermediate layer termination edge, the component thickness varies in the region in which the two inner fibre layers end.

PROBLEM OF THE INVENTION

It is the problem of the invention to provide a fibre compound component with enhanced hole bearing properties and a method for its production.

SOLUTION

The problem of the invention is solved by a fibre compound component comprising the features of independent claim 1 and by a method for its production comprising the features of independent claim 11. The dependent claims relate to preferred embodiments of the fibre compound component according to the invention and of the method according to the invention for its production.

DESCRIPTION OF THE INVENTION

In a fibre compound component according to the invention, in a region extending along a main area, a plurality of fibre layers extending in parallel to the main area and a plurality of intermediate layers also extending in parallel to the main area are embedded in a resin matrix. A first one of the fibre layers ends coming out of a first direction, within the region, with a first fibre layer termination edge, and between two fibre layers being neighbours of the first fibre layer and running through over the region in the first direction. A first one of the intermediate layers ends coming out of a second direction opposite to the first direction, within the region, with a first intermediate layer termination edge running in parallel to the first fibre layer termination edge, in front of the first fibre layer termination edge, and between two fibre layers which are neighbours of the first intermediate layer and run through over the region in the first direction, wherein at least one of the two fibre layers being neighbours of the first intermediate layer is also one of the fibre layers being neighbours of the first fibre layer. In other words, the first intermediate layer either ends between the same fibre layers running through as the first fibre layer, or there is a fibre layer which runs through between the first intermediate layer and the first fibre layer, and which belongs both to the two fibre layers running through and being neighbours of the first fibre layer and the fibre layers running through and being neighbours of the first intermediate layer.

In the fibre compound component according to the invention, at least a further one of the intermediate layers ends coming out of the second direction, within the region, with a further intermediate layer termination edge running in parallel to the first intermediate layer termination edge, between two fibre layers being neighbours of the further intermediate layer and running through over the region in the first direction, between which neither one of the fibre layers nor another one of the intermediate layers ends in the region, and in front of the first fibre layer termination edge. In other words, the second intermediate layer ends neither between the same fibre layers running through as the first fibre layer nor between the same fibre layers running through as the first or any other of the intermediate layers. Thus, at least this second intermediate layer ends between other fibre layers running through than the first fibre layer, wherein, however, one of the fibre layers running through and being a neighbour of the second intermediate layer may also be a fibre layer running through and being a neighbour of the first intermediate layer.

Further, in the fibre compound component according to the invention, an average intermediate layer thickness of those of the intermediate layers which end in the region is at maximum half as thick as an average fibre layer thickness of those of the fibre layers which end in the region. This difference in thickness compensates for the higher number of the intermediate layers ending in the region as compared to the number of the fibre layers ending in the region. Thus, the fibre compound component, despite of the higher number of the intermediate layers being added in the first direction does not get thicker over the region. The fact that the fibre compound component preferably has a uniform component thickness perpendicular to the main area over the region, does, however, not exclude that smaller changes of this component thickness appear over the region even though these are not intended.

As a general rule, it is a fact in the fibre compound component according to the invention that, on each side of the two fibre layers being neighbours of the first intermediate layer and running through over the region in the first direction, at least one of the intermediate layers ends in the region between two fibre layers running through over the region in the first direction, between which none of the fibre layers ends in the region. Thus, the smaller average intermediate layer thickness of the intermediate layers ending in the region is compensated for on both sides of the first fibre layer ending in the region.

For optimally integrating the intermediate layers in the fibre compound component of the invention, preferably not more than one of the intermediate layers ends with its intermediate layer termination edge between the two fibre layers of each pair of neighbouring fibre layers of the fibre layers running through over the region. With a plurality of continuous intermediate layers arranged between two neighbouring fibre layers it would become difficult to embed them at all sides in the matrix resin in the production of the fibre compound component according to the invention in a wet process.

Generally, however, the fibre compound component according to the invention may not only be produced in a wet process but only based on prepregs or in a hybrid process.

In the fibre compound component according to the invention, a second one of the fibre layers may also end coming out of the first direction, within the region, with a second fibre layer termination edge running in parallel to the first fibre layer termination edge, and between two fibre layers running through over the region in the first direction. Generally, there is no limitation in the fibre compound component of the invention that only a single one of the fibre layers ends within the region. Particularly, if a higher number of intermediate layers shall begin in the region when viewed in the first direction, generally also a plurality of fibre layers has to end in the region. Herein, each of the fibre layers ending in the region may be individually assigned to a plurality of intermediate layers ending in the region. Further, a plurality of fibre layers may end within the region with fibre layer termination edges not running in parallel to each other and/or with fibre layer termination edges which are not on a same level. Particularly, however, two fibre layers may end side by side, i. e. with parallel fibre layer termination edges on a same level in the first direction, wherein the fibre layers omitted at the fibre layer termination edges are compensated for with regard to the sum of their fibre layer thicknesses by at least three intermediate layers ending in the region and following in the first direction. Even with two fibre layers ending side by side in the first region it may be done without an intermediate layer also ending between the respective neighbouring fibre layers running through.

However, it is generally preferred to also let one of the intermediate layers coming out of the second direction end with an intermediate layer termination edge running in parallel to the respective fibre layer termination edge in front of the respective fibre layer termination edge between the two fibre layers which run through in the first direction over the region and between which one of the fibre layers ends with its fibre layer termination edge.

Further, it is preferred, if the arrangement of the intermediate layers is mirror-symmetric with regard to a middle plane between the first fibre layer and the second fibre layer. In this way, there is a symmetric distribution of forces when forces are distributed over the fibre layers and the intermediate layers over the region.

The first intermediate layer, with its first intermediate layer termination edge, and the further intermediate layers, with their further intermediate layer termination edges, may end in the region of the fibre compound component according to the invention in the second direction on a same level in front of the first fibre layer termination edge. Then, all intermediate layers run into the region up to the same level in the second direction. Alternatively, the first intermediate layer, with its first intermediate layer termination edge, and the further intermediate layers, with their further intermediate layer termination edges, may end in the second direction in a >- or <-shaped, i. e. more general in a V-, arrow- or migratory bird flight-shaped formation in front of the first fibre layer termination edge. A >-shaped formation designates a V-shaped formation in which the first intermediate layer runs farthest into the region in the second direction, and the further intermediate layers ending in the region run less far into the region with increasing distance to the first intermediate layer. A <-shaped formation designates a V-shaped formation in which the first intermediate layer runs to the smallest extend into the region in the second direction, and the further intermediate layers ending in the region run farther and farther into the region in the second direction with increasing distance to the first intermediate layer. Even in the latter case, the further intermediate layers, as a rule, still end in front of the first fibre layer termination edge in the second direction to avoid an increase of thickness of the fibre compound component according to the invention in the region.

If several fibre layers end in the region coming out of the first direction and are each individually compensated for by several intermediate layers ending in the region coming out of the second direction with regard to their respective fibre layer thickness, these several fibre layers may also end in a >- or >-shaped formation in the region.

With regard to the intermediate layers, it should be mentioned that none of them has to run through over the region in the second direction in the fibre compound component according to the invention, but that this is also not excluded. Thus, one or more intermediate layers may readily run through over the region in the second direction such that, viewing in the first direction, the number of the intermediate layers does not increase over the region starting from zero but starting from another value.

For locally levelling-out the difference in thickness between the fibre layer thickness of the fibre layers ending in the first region and the intermediate layer thickness of the intermediate layers ending in the region locally, a filler may be embedded in the resin matrix in the second direction in front of the intermediate layer termination edge of at least one of the intermediate layers ending in the region. If a fibre layer ends in front of the respective intermediate layer, the filler compensates for the difference in thickness between the intermediate layer and the fibre layer. If, however, no fibre layer ends between the same fibre layers running through in the second direction in front of the respective intermediate layer, the filler compensates for the intermediate layer thickness of the intermediate layer. The filler may be a separate shaped body embedded in the matrix resin. Further, it may be constituted by fibres embedded in the matrix resin which may run through along the respective intermediate layer termination edge. In any case, the filler avoids both the formation of areas of the matrix resin in front of the respective intermediate layer termination edge with an only low level of reinforcement and a strong change in direction of the adjoining fibre layers running through over the intermediate layer termination edge. Both areas of the matrix resin with low reinforcement level and strong changes of direction of the fibre layers over the intermediate layer termination edge are disadvantages with regard to the mass-related performance of the fibre compound component according to the invention.

In the fibre compound component according to the invention, a limited number of intermediate layers ending in the region, which is typically not two-digit, is allotted to each of the fibre layers ending in the region. The ratio of the intermediate layers ending in the region to the fibre layers ending in the region is at least 2:1. Often, it is at 3:1 or higher. As a general rule it does not exceed 9:1. The ration of 3:1 results, if three intermediate layers end in front of one fibre layer.

The intermediate layers ending in the region may have same intermediate layer thicknesses, and the fibre layers ending in the region may also have same fibre layer thicknesses. However, particularly the intermediate layers ending in the region may as well have different intermediate layer thicknesses. For example, an intermediate layer which ends between the same fibre layers running through in the first direction as one fibre layer may be thicker than intermediate layers which end between fibre layers running through over the region, between which no fibre layer ends in the region.

Often, the resin matrix of the fibre compound component according to the invention is thermosetting. This means that the fibre compound component is produced with chemical or reactive curing of the matrix resin and thus acquires a permanent shape.

Each of the intermediate layers ending in the region may run through in the second direction up to its intermediate layer termination edge and transverse to the second direction, i. e., up to the termination edge, it may be a continuous intermediate layer. Each of the intermediate layers may be selected independently of the others from a group of intermediate layers which particularly includes plastic foils, metal foils, metal sheets, organo sheets, fibre compounds, semi-finished fibre products, hybrid materials and laminates of the aforementioned materials. Intermediate layers of plastic foils, metal foils, metal sheets and organo sheets or of laminates which include such foils or sheets are of particular interest.

Typically, in the fibre compound component according to the invention, at least one of the intermediate layers ending in the region has another composition than any of the fibre layers ending in the region. Mostly, it will even be the case that none of the intermediate layers ending in the region coming out of the second direction has the same composition as any of the fibre layers ending in the region coming out of the first direction. The main application of the fibre compound component according to the invention is to provide intermediate layers only over a part of the fibre compound component and to let these intermediate layers end in the region.

With the mentioned preferred intermediate layers made of or made using foils or sheets, it may prove to be difficult to completely embed them into the matrix resin, particularly when applying a wet technology for producing the fibre compound component. These problems may be reduced or even be avoided in that at least one of the intermediate layers ending in the region has openings and/or a surface structuring. Further, these openings and/or the surface structuring provide for an enlarged contact surface for a positive substance jointing of the respective intermediate layer to the matrix resin and, with openings, also for an additional form-locked embedding of the respective intermediate layer into the matrix resin.

For jointing with bolt connections, the fibre compound component according to the invention may be provided with cross holes. As a rule, these cross holes extend through the intermediate layers or at least directly adjoin these intermediate layers to increase the hole bearing resistance by means of the intermediate layers as compared to common fibre compound components.

If the intermediate layers of the fibre compound component according to the invention are provided with openings and/or a surface structuring, these openings or this surface structuring, respectively, may be provided locally adjoining the cross holes. Particularly in this case, the cross holes may effectively be used as feeding channels in the production of the fibre compound component from which the areas of the intermediate layers with the openings and/or the surface structuring branch off.

Further, connection holes may extend starting from the cross holes along the main area through the fibre compound component. Preferably, however, these connection holes do not extend through the intermediate layers, because such loophole intermediate layers would have no function in the sense of an enhancement of the hole bearing stiffness, at least adjacent to the respective cross hole.

In a method according to the invention for producing a fibre compound component having a region extending along a main area, in which a plurality of fibres running in parallel to the main area and a plurality of intermediate layers extending in parallel to the main area and not consisting of fibres are embedded in a resin matrix, that is particularly suited for producing a fibre compound component according to the invention, a stack is formed of the fibre layers and the intermediate layers, this stack is infiltrated with matrix resin, and the matrix resin is cured into the resin matrix. This means that the method according to the invention belongs to wet technology. The method according to the invention is characterized in that holes in the intermediate layers running transversely to the main area in the stack fall in line with each other in such a way that at least one matrix resin supply channel is formed, which leads into the stack from the outside through the aligned holes in several of the intermediate layers, and that matrix resin is injected into the stack via the at least one matrix resin supply channel. In this procedure, the blocking effect of the intermediate layers not consisting of fibres is compensated for by means of the at least one matrix resin supply channel.

The at least one matrix resin supply channel may also extend through holes in the fibre layers communicating with the holes in the intermediate layers. Like the holes in the intermediate layers, these holes in the fibre layers are uncritical, particularly if the at least one matrix resin supply channel is bored out for forming a cross hole after curing the matrix resin.

If, after forming the cross hole, a connecting hole extending along the main area up to the cross hole is worked into the fibre compound component, it is particularly preferred that a free space overlapping with the later worked connection hole is left in the stack by means of openings in the fibre layers to form an off-branch from the at least one matrix resin supply channel. However, like the connection hole, this free space does preferably not extend into the intermediate layers.

The infiltration of the stack with matrix resin via the matrix resin supply channel and/or its off-branch is further enhanced, if at least one of the intermediate layers, adjacent to the matrix resin supply channel and/or its off-branch, is provided with a surface structuring. Particularly, this surface structuring is formed by three dimensionally deforming and/or by locally removing material from the at least one intermediate layer.

Advantageous developments of the invention result from the claims, the description and the drawings. The advantages of features and of combinations of a plurality of features mentioned at the beginning of the description only serve as examples and may be used alternatively or cumulatively without the necessity of embodiments according to the invention having to obtain these advantages. Without changing the scope of protection as defined by the enclosed claims, the following applies with respect to the disclosure of the original application and the patent: further features may be taken from the drawings, in particular from the illustrated designs and the dimensions of a plurality of components with respect to one another as well as from their relative arrangement and their operative connection. The combination of features of different embodiments of the invention or of features of different claims independent of the chosen references of the claims is also possible, and it is motivated herewith. This also relates to features which are illustrated in separate drawings, or which are mentioned when describing them. These features may also be combined with features of different claims. Furthermore, it is possible that further embodiments of the invention do not have the features mentioned in the claims.

The number of the features mentioned in the claims and in the description is to be understood to cover this exact number and a greater number than the mentioned number without having to explicitly use the adverb "at least". For example, if one cross hole is mentioned, this is to be understood such that there is exactly one cross holes or there are two cross holes or more cross holes.

Additional features may be added to the features mentioned in the claims, or these features may be the only features of the respective product or method.

The reference signs contained in the claims are not limiting the extent of the matter protected by the claims. Their sole function is to make the claims easier to understand.

SHORT DESCRIPTION OF THE FIGURES

In the following, the invention is further explained and described by means of preferred embodiment examples depicted in the figures.

Fig. 1 shows a region of a fibre compound component according to the invention, in which fibre layers, coming out of a first direction, and intermediate layers, coming out of a second direction opposite to the first direction, end.

Fig. 2, at a scale enlarged as compared to Fig. 1, shows a first one of the fibre layers ending in the region of the fibre compound component and a plurality of the intermediate layers ending in front of the first one of the fibre layers.

Fig. 3 illustrates the thickness relationships of the first fibre layer ending in the region and the intermediate layers ending in front of the first fibre layer, in an embodiment example modified vis-à-vis Fig. 2.

Fig. 4 illustrates a further modification with regard to the thickness relationships of the ending first fibre layer and the intermediate layers ending in front of the first fibre layer.

Fig. 5 illustrates even a further embodiment of the fibre compound component according to the invention with regard to the arrangement of the intermediate layers which end in front of the first fibre layer.

Fig. 6 illustrates a variant of the embodiment according to Fig. 5.

Fig. 7 illustrates two fibre layers ending in the region of the fibre compound component and intermediate layers ending in front of the two fibre layers in a further embodiment of the fibre compound component according to the invention.

Fig. 8 shows a cross hole and a connection hole in a fibre compound component according to the invention in a perspective view (the depictions of the Figs. 1 to 7 are sectional views orthogonal to a main area and along the first and the second directions of the fibre compound component according the invention).

Fig. 9 is a top view of a surface of the fibre compound component with the cross hole according to Fig. 8.

Fig. 10 is a section through a detail of an embodiment of the fibre compound component according to the invention, which runs orthogonal to the main area and the first and the second directions.

Fig. 11 is a flow chart of the method according to the invention by which the fibre compound component may be produced.

DESCRIPTION OF THE FIGURES

The fibre compound component 1 of which a region 2 is depicted in **Fig. 1** extends along a main area 3. Although the main area 3 is depicted as being plane here, it may be curved in one or more directions. The fibre compound component 1 includes a plurality of fibre layers 4 and a plurality of intermediate layers 5 which extend along the main area 3 and which are embedded in a resin matrix 6. In the region 2, some fibre layers 7 of the fibre layers 5 end, coming out of a first direction 8, with a fibre layer termination edge 9. Particularly, both in the upper part and in the lower part of the region 2 three fibre layers 7 end, with one fibre layer termination edge 9 each. The six fibre layer termination edges 9 are arranged in a <-shaped formation, i. e. the respective outer fibre layers 7 are shorter and thus end earlier in the direction 8 than the inner fibre layers 7. In front of each of the fibre layer termination edges 9, several of the intermediate layers 5 end coming out of a second direction 10 opposite to the first direction 8, with an intermediate layer termination edge 11. The thickness relationships of the ending fibre layers 7 and the intermediate layers 5 ending in front of the fibre layers 7 are selected such that a component thickness 12 does not vary over the region 2 along the main area 3. Thus, despite the intermediate layers 5 beginning in the region 2, the fibre compound component 1 is not getting thicker in the region 2. The intermediate layers 5 are particularly provided for increasing a hole bearing stiffness of the fibre compound component 1 as it will be explained in more detail in context of Figs. 8 and 10.

Fig. 2 illustrates a detail of an embodiment example of the fibre compound component 1, in which, in front of the fibre layer termination edge 9 of the ending fibre layer 7, three intermediate layers 5 end with their intermediate layer termination edges 11 in the region 2. A first intermediate layer 13 ends between the same fibre layers 4 running through in the first direction 8, between which the fibre layer 7 also ends, whereas further intermediate layers 14 of the intermediate layers 5 end on both sides of this intermediate layer 13 between fibre layers 4 running through in the first direction 8, between which no fibre layer 7 ends. The intermediate layer termination edges 11 run in parallel to the fibre layer termination edge 9 at a small distance in the first direction 8 and the second direction 10. The equal intermediate layer thickness of the three ending intermediate layers 5 is about a third of the fibre layer thickness of the ending fibre layer 7. In other words, the fibre layer thickness of the ending fibre layer 7 is distributed over three intermediate layers 5 ending in front of the fibre layer 7. A gore filler 34 may be arranged in a gore 33 formed in front of the fibre layer termination edge 9. Otherwise, the gore 14 will be filled by the resin matrix 6 in which the fibre layers 4 and the intermediate layers 5 are embedded.

Fig. 3 depicts the thickness relationships which result, if in the fibre compound component 1 in the region 2 one fibre layer 7 ending with its fibre layer termination edge 9 passes over into an entirety of seven intermediate layers 5 of equal thickness, of which the intermediate layer 13 ends with its intermediate layer termination edge 11 between the same running through fibre layers 4 as the fibre layer 7.

Fig. 4 shows that the intermediate layers which end in front of the fibre layer 7 do not need to be all of a same intermediate layer thickness. Particularly, the two outer ones of a total of five intermediate layers 5 are thicker than the three inner intermediate layers 16. Here, the average intermediate layer thickness of the intermediate layers 5 ending in front of the fibre layer 7 is a fifth of the fibre layer thickness of the fibre layer 7. in Fig. 3, this average intermediate layer thickness is a seventh, and in Fig. 2 it is a third of the fibre layer thickness.

In the embodiment of the fibre compound component 1 according to **Fig. 5**, none of the intermediate layers 5 ends between the same running through fibre layers 4 as the fibre layer 7 ending in the region 2. Instead, one intermediate layer 5 ends between each running through fibre layer 4 which is also neighbour of the fibre layer 7 and a further fibre layer 4. These two intermediate layers 5 each have an intermediate layer thickness 5 which is half as thick as the fibre layer thickness of the fibre layer 7.

In the embodiment of the fibre compound component 1 according to **Fig. 6**, also none of the intermediate layers ends between the same running through fibre layers 4 as the fibre layer 7 ending in the region 2. Here, two inner thinner intermediate layers 16 and two outer thicker intermediate layers 15 end on both sides in front of the fibre layer termination edge 9 at an offset of one and two fibre layers, respectively.

Fig. 7 illustrates an embodiment of the fibre compound component 1 in which two fibre layers 7 end with their fibre layer termination edges 9 in the region 2. Here, an entirety of eight intermediate layers 5 of equal intermediate layer thickness end in front of them, wherein two first intermediate layers 13 end between the same running through fibre layers 4 as the fibre layers 7, and further intermediate layers 14 end between other fibre layers 4. Here, the average intermediate layer thickness is also a quarter of the average fibre layer thickness of the fibre layers 7.

In all embodiments of the fibre compound component according the invention depicted in Figs. 1 to 7, the arrangement of the intermediate layers 5 with regard to the fibre layer(s) 7 compensating their thickness is symmetric. In the embodiments of Figs. 1 to 6, the symmetry is present with regard to the respective one ending fibre layer 7 itself. In the embodiment according to Fig. 7, the symmetry is existing with regard to a middle plane between the two ending fibre layers 7. Whereas all Figs. 1 to 7 indicate, that the fibre layer termination edges are on one level in the second direction 10, the fibre layer termination edges 11 may also be arranged in a V-shaped formation in front of the fibre layer termination edge 9 as it has already been explained in the description of the invention.

Fig. 8 is a perspective view on a surface 17 of a fibre compound component 1 according to the invention. A cross hole 19 extending up to the opposite surface 18 is worked in the surface 17. The cross hole 19 extends through cover tiers 20 and a middle tier 21 as well as through intermediate tiers 22 of the fibre compound component arranged in between. In the cover tiers 20 and the middle tier 21, only fibre layers are embedded in the resin matrix, whereas in the intermediate tiers 22 intermediate layers are also provided. In this way, the hole bearing stiffness of the cross hole 19 is increased. A connection hole 23, via which a pulling element may engage a cross bolt inserted into the cross hole 19, extends through the middle tier 21 and, thus, not through the intermediate layers.

Fig. 9 shows the position of such a cross bolt 24 in the cross hole 19 and an adapted course of the fibre layer termination edges 9 and intermediate layer termination edges 11 for efficiently increasing the hole bearing stiffness of the cross hole 19 for a load in the direction of an arrow 25. The reaction force supporting the load 25 is indicated by arrows 35 which are distributed over the entire width of the fibre compound component 1. The fibre layer termination edges 9 and the intermediate layer termination edges 11 do not run through linearly at right angles to the directions 8 and 20 over the entire width of the fibre compound component 1; instead, they are angled towards the rim of the fibre compound component 1.

Fig. 10 illustrates intermediate layers 5 having a surface structuring. Particularly, the intermediate layers 5 are profiled wave-shaped. Correspondingly, the adjoining fibre layers 4 are also deformed wave-shaped upon compressing a stack of the intermediate layers 5 and the fibre layers 4. However, free spaces, which continuously extend in the directions 8 and 10 and which ease the infiltration of the stack of the intermediate layers 5 and the fibre layers 4 in production of the fibre compound component 1 in wet technology, remain in the surface structure of the intermediate layers 5. This production is particularly eased, if the area of a later cross hole 19 is used as an additional matrix resin supply channel in infiltrating the stack with matrix resin. The area of a future connection hole 23 may be used similarly. In addition to the surface structuring of the intermediate layers 5 as it is depicted in Fig. 10, the often generally continuous intermediate layers 5 may be provided with local openings for the passage of matrix resin.

The method of production according to the invention which is depicted in **Fig. 11** in form of a flow chart and by which the fibre compound components according to the invention may be produced, starts with a surface structuring 26 of the intermediate layers 5. Herein, openings may additionally be worked in the intermediate layers 5. In any case, in a following step 27, holes which correspond to the later cross hole 19 are worked in the intermediate layers 5 and preferably also in the fibre layers 4. Then, a stacking 28 of the fibre layers 4 and the intermediate layers 5 takes place with aligned holes in the area of the future cross holes 19 and also with arranging, according to the invention, the intermediate layer termination edges 11 of ending intermediate layers 5 in front of fibre layer termination edges 9 of ending fibre layers 4. A following infiltrating 29 with matrix resin takes place inter alia via matrix resin supply channels which are formed by the aligned holes in the fibre layers 4 and intermediate layers 5. A boring-out 31 of the matrix resin supply channels which are formed by the aligned holes for forming the cross holes 19, and finally a working-in 31 of the connecting holes 23 leading to the cross holes 19 follow to a curing 30 of the matrix resin. Here, as already mentioned, the connection holes 23 preferably do not extend through the intermediate layers 5.

LIST OF REFERENCE NUMERALS

1	Fibre compound components
2	Region
3	Main area
4	Fibre layer
5	Intermediate layer
6	Resin matrix
7	Ending (first or second) fibre layer
8	First direction
9	Fibre layer termination edge
10	Second direction
11	Intermediate layer termination edge
12	Component thickness
13	(First) intermediate layer
14	Further intermediate layer
15	Outer intermediate layer
16	Inner intermediate layer
17	Surface
18	Opposite surface
19	Cross hole
20	Cover tier
21	Middle tier
22	Intermediate tier
23	Connection hole
24	Cross bolt
25	Arrow, load
26	Surface structuring
27	Step
28	Stacking
29	Infiltrating
30	Curing
31	Boring-out

32 Working-in

33 Gore

34 Gore filler

35 Arrow, reaction force

P a t e n t k r a v

1. Fiberkompositkomponent (1),
- hvor der i et område (2), der strækker sig langs med en hovedflade (3), er indlejret
- flere fiberlag (4), der forløber parallelt med hovedfladen (3), og
- flere mellemlag (5), der forløber parallelt med hovedfladen (3), i en harpiks-matrix (6),
- hvor et første (7) af fiberlagene (4) ender
- kommende fra en første retning (8),
- inden for området (2),
- med en første fiberlagsafslutningskant (9) og
- mellem to fiberlag (4) af fiberlagene (4) der grænser op til de første (7) af fiberlagene (4) og går igennem ud over området (2) i den første retning (8), og
- hvor et første (13) af mellemlagene (5) ender
- kommende fra en anden retning (10), der er modsat den første retning (8),
- inden for området (2),
- med en parallelt med den første fiberlagsafslutningskant (9) forløbende første mellemlagsafslutningskant (11),
- foran den første fiberlagsafslutningskant (9) og
- mellem to fiberlag (4) af fiberlagene (4), der grænser op til de første (13) af mellemlagene (5) og går igennem ud over området (2) i den første retning (8), hvor mindst et af de to fiberlag (4), der grænser op til det første mellemlag (13), er et af de to fiberlag (4), der grænser op til det første fiberlag (4),
- hvor mindst et yderligere (14) af mellemlagene (5) ender
- kommende fra den anden retning (10),
- inden for området (2),
- med en parallelt med den første mellemlagsafslutningskant (11) forløbende yderligere mellemlagsafslutningskant (11),
- mellem to fiberlag (4) af fiberlagene (4), der grænser op til de yderligere (14) af mellemlagene (5) og går igennem ud over området (2) i den første retning (8), mellem hvilke hverken et af fiberlagene (4) eller et andet af mellemlagene (5) ender i området (2), og
- foran den første fiberlagsafslutningskant (9),

kendetegnet ved,

- **at** en midterste mellemlagstykkelse af de af mellemlagene (5), der ender i området (2), er makismalt halvt så stor som en midterste fiberlagstykkelse af de af fiberlagene (4), som ender i området (2), og
- **at** fiberkompositkomponenten (1) ud over området (2) har en ensartet komponenttykkelse vinkelret på hovedfladen (3).

2. Fiberkompositkomponent (1) ifølge krav 1, **kendetegnet ved, at** på hver side af de to fiberlag (4), der grænser op til de første (13) af mellemlagene (5) og går igennem ud over området (2) i den første retning (8), mindst et af mellemlagene (5) ender i det område (2) mellem to fiberlag (4) af fiberlagene (4), der går igennem ud over området (2) i den første retning (8), mellem hvilke ingen af fiberlagene (4) ender i området (2).

3. Fiberkompositkomponent (1) ifølge krav 2, **kendetegnet ved, at** ikke flere end et af mellemlagene (5) ender med deres mellemlagsafslutningskant (11) mellem de to fiberlag (4) af hvert par af tilgrænsende fiberlag (4) af fiberlagene (4), som går igennem ud over området (2), .

4. Fiberkompositkomponent (1) ifølge et af de foregående krav, **kendetegnet ved, at** et andet (7) af fiberlagene (4) ender
- kommende fra den første retning (8),
- inden for området (2),
- med en parallelt med den første fiberlagsafslutningskant (9) forløbende anden fiberlagsafslutningskant (9),
- i den første retning (8) på højde med den første fiberlagsafslutningskant (9)
- mellem to fiberlag (4) af fiberlagene (4), der grænser op til det andet fiberlag (7) og går igennem ud over området (2) i den første retning (8).

5. Fiberkompositkomponent (1) ifølge et af de foregående krav, **kendetegnet ved, at** mellem de to fiberlag (4), som forløber ud over området (2) i den første retning (8), og mellem hvilke det første (7) eller det andet (7) af fiberlagene (4) ender med deres fiberlagsafslutningskant (9), hver især et (13) af mellemlagene (5) ender kommende fra den anden retning (10), inden for området (2), med en parallelt med den pågældende fiberlagsafslutningskant (9) forløbende mellemlagsafslutningskant (11), foran den pågældende fiberlagsafslutningskant (9).

6. Fiberkompositkomponent (1) ifølge et af de foregående krav, **kendetegnet ved, at** placeringen af de mellemlag (5), der ender i området (2), er spejlsymmetrisk med et midterplan af de første (7) af fiberlagene (4) eller med et midterplan mellem det første (7) af fiberlagene (4) og det andet (7) af fiberlagene (4).

7. Fiberkompositkomponent (1) ifølge et af de foregående krav, **kendetegnet ved, at** det første (13) af mellemlagene (5) med dets første mellemlagsafslutningskant (11) og de yderligere (14) af mellemlagene (5) med deres yderligere mellemlagsafslutningskanter (11) i den anden retning (10) ender
- i en højde foran den første fiberlagsafslutningskant (9) eller
- foran den første fiberlagsafslutningskant (9) i en V-formet formation i området (2).

8. Fiberkompositkomponent (1) ifølge et af de foregående krav, **kendetegnet ved, at** en fyldning (34) er indlejret i harpiksmatrixen (6) i den anden retning (10) foran mellemlagsafslutningskanten (11) af mindst et af de mellemlag (5), der ender i området (2).

9. Fiberkompositkomponent (1) ifølge et af de foregående krav, **kendetegnet ved,**
- **at** mindst et af mellemlagene (5) har gennembrydninger og/eller en overfladestrukturering og
- **at** tværhuller (19), der strækker sig på tværs af hovedfladen (3) gennem fiberkompositkomponenten (1), strækker sig ind igennem mellemlagene (5) eller grænser umiddelbart op til disse,
- hvor gennembrydningerne og/eller overfladestruktureringen af det mindst ene af mellemlagene (5) er tilvejebragt lokalt grænsende op til tværhullerne (19).

10. Fiberkompositkomponent (1) ifølge krav 10, **kendetegnet ved, at** tilslutningshuller (23), der strækker sig ud fra tværhullerne (19) langs med hovedfladen (3), ikke strækker sig ind igennem mellemlagene (5).

11. Fremgangsmåde til fremstilling af en fiberkompositkomponent med et område (2), der strækker sig langs med en hovedflade (3), i hvilket flere parallelt med hovedfladen (3) forløbende fiberlag (4) og flere parallelt med hovedfladen (3) forløbende, ikke af fibre bestående mellemlag (5), er indlejret i en harpiksmatrix (6), især af en fiberkompositkomponent (1) ifølge et af de foregående krav,
- hvor der ud fra fiberlagene (4) og mellemlagene (5) udformes en stabel,
- hvor stablen infiltreres med matriksharpiks og
- hvor matriksharpiksen hærdes til harpiksmatrixen (6),
kendetegnet ved,
- **at** huller i mellemlagene (5), der forløber på tværs af hovedfladen (3), flugter med hinanden på en sådan måde, at der udformes mindst en matrixharpikstilførselskanal, der fører udefra gennem de flugtende huller i flere af mellemlagene (5) ind i stablen, og
- **at** der via den mindst ene matriksharpikstilførselskanal injiceres matriksharpiks ind i stablen.

12. Fremgangsmåde ifølge krav 11, **kendetegnet ved,**
- **at** mindst et af mellemlagene (5), der grænser op til matriksharpikstilførselskanalen og/eller dens afgrening forsynes med en overfladestrukturering (26), hvor, eventuelt, overfladestruktureringen (26) udformes ved hjælp af tredimensionel deformering af og/eller ved hjælp af materialefjernelse af det mindst ene mellemlag (5), og/eller
- **at** den mindst ene matriksharpikstilførselskanal også strækker sig igennem huller i fiberlagene (4), der passer til hullerne i mellemlagene (5).

13. Fremgangsmåde ifølge krav 11 eller 12, **kendetegnet ved, at** den mindst ene matrixharpikstilførselskanal efter hærdningen af matrixharpiksen udbores med henblik på udformning af et tværhul (19).

14. Fremgangsmåde ifølge krav 13, **kendetegnet ved, at** der efter udformningen af tværhullet (19) indføres et tilslutningshul (23) i fiberkompositkomponenten (1), der strækker sig langs med hovedfladen (3) frem til tværhullet (19).

15. Fremgangsmåde ifølge krav 14, **kendetegnet ved,**
- **at** der overlappende med det senere indførte tilslutningshul (23) ved hjælp af udsparinger i fiberlagene (4) efterlades et frirum i stablen med henblik på at udforme en forgrening af den mindst ene matrixharpikstilførselskanal,
- hvor, eventuelt, tilslutningshullet (23) ikke indføres i mellemlagene (5).

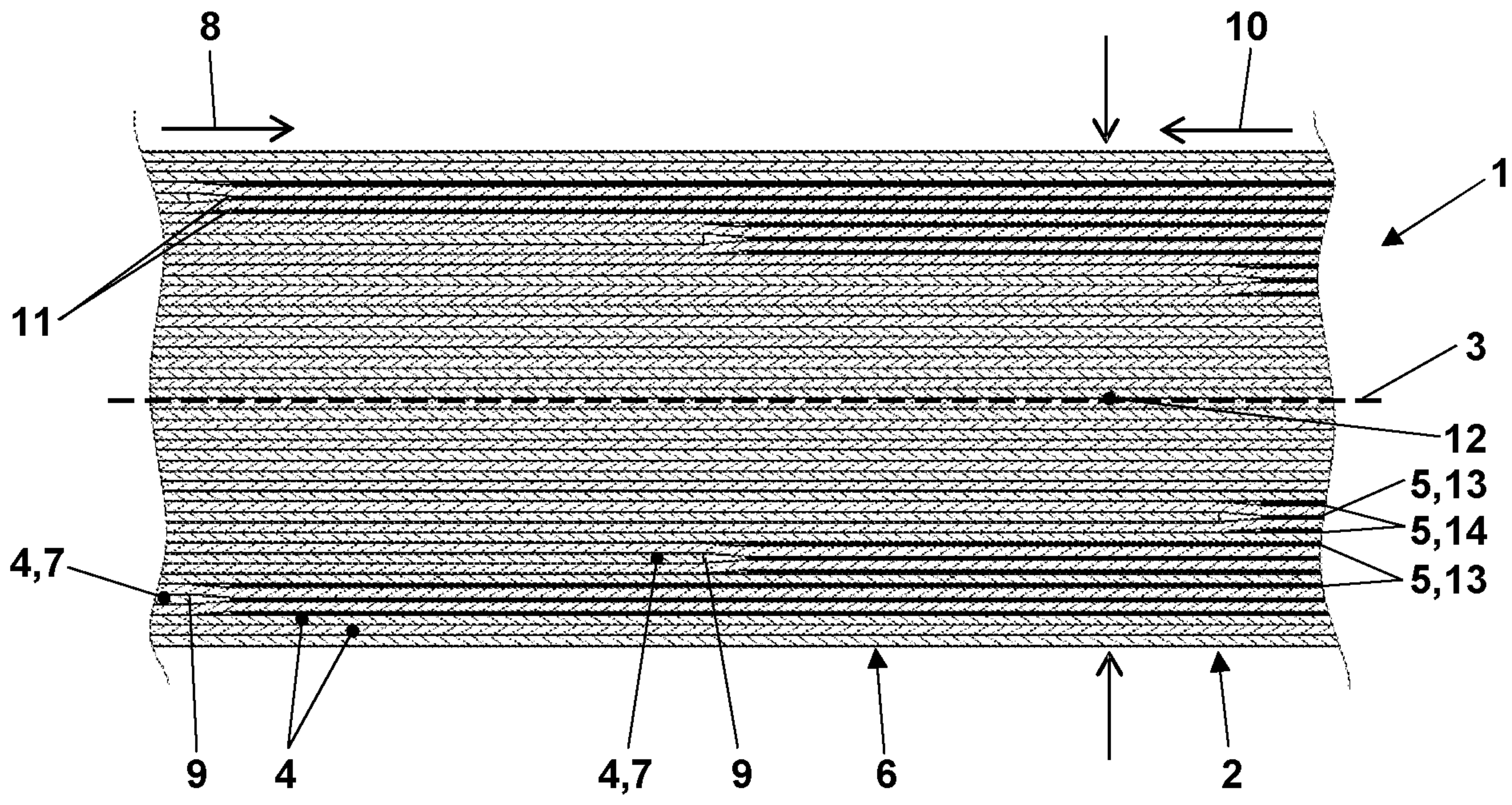

8
10
1
11
3
12
5,13
5,14
5,13
4,7
9
4
4,7
9
6
2

Fig. 1

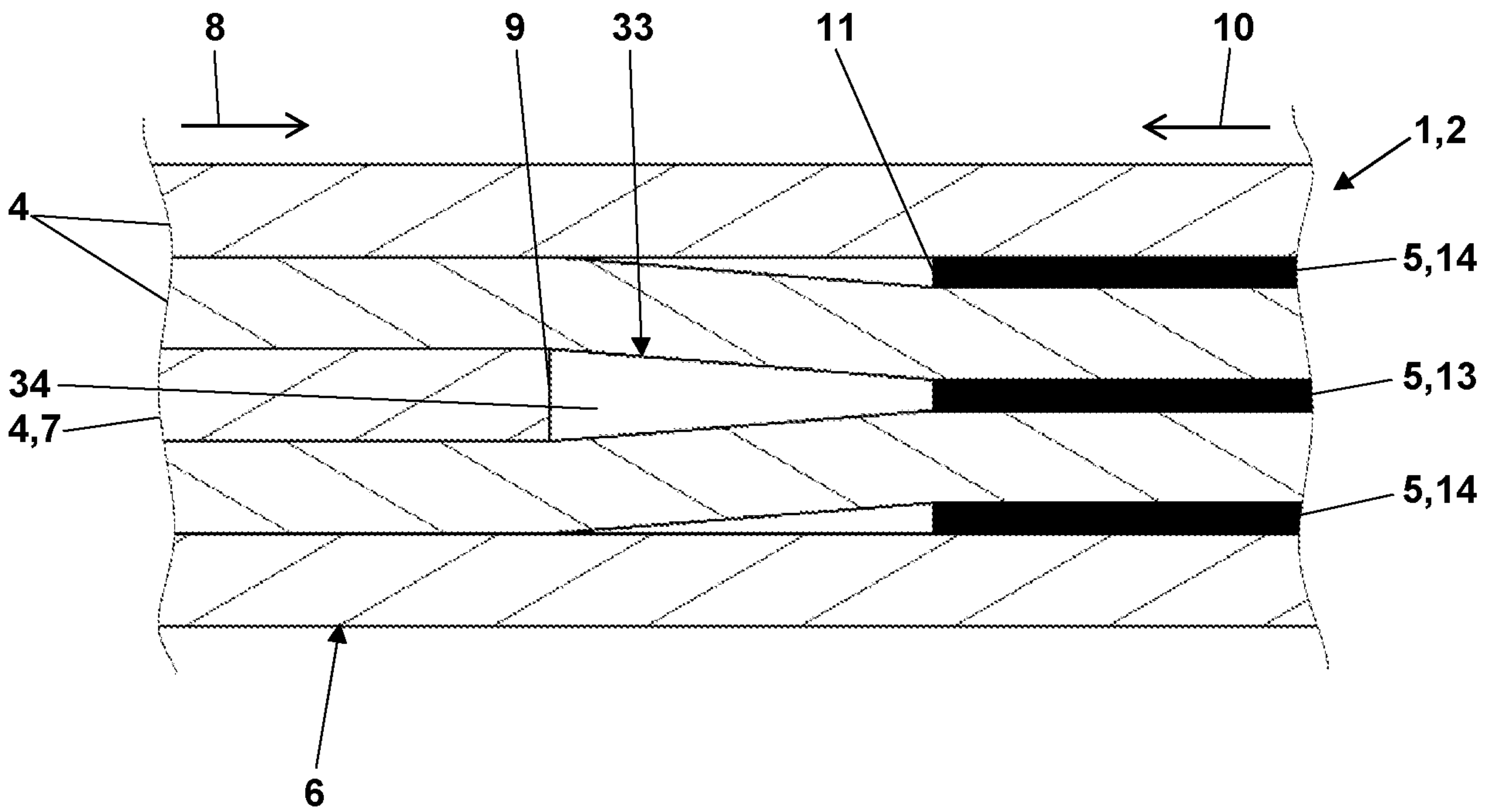

8
9
33
11
10
1,2
4
5,14
34
4,7
5,13
5,14
6

Fig. 2

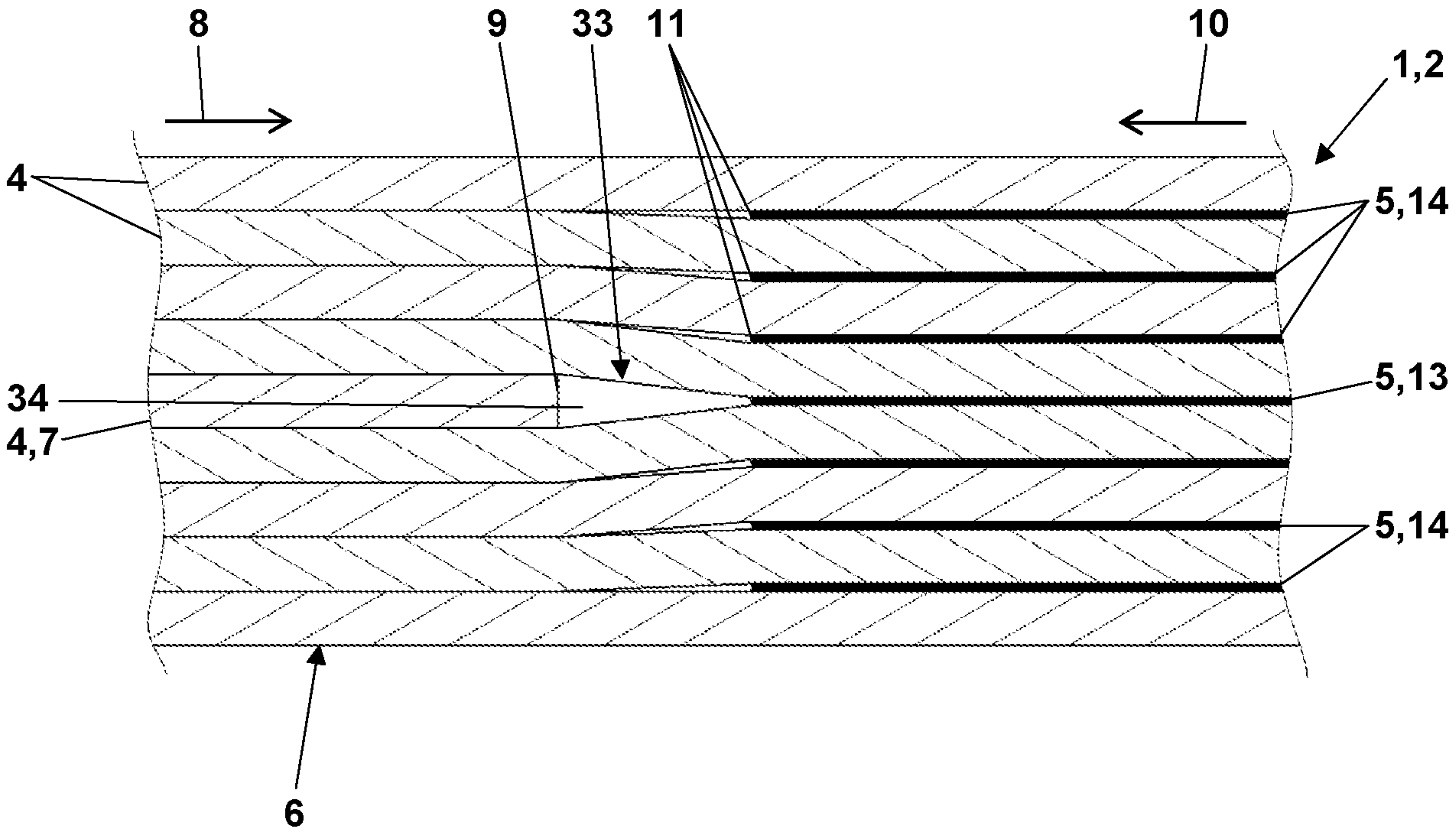

8
9
33
11
10
1,2
4
5,14
34
4,7
5,13
5,14
6

Fig. 3

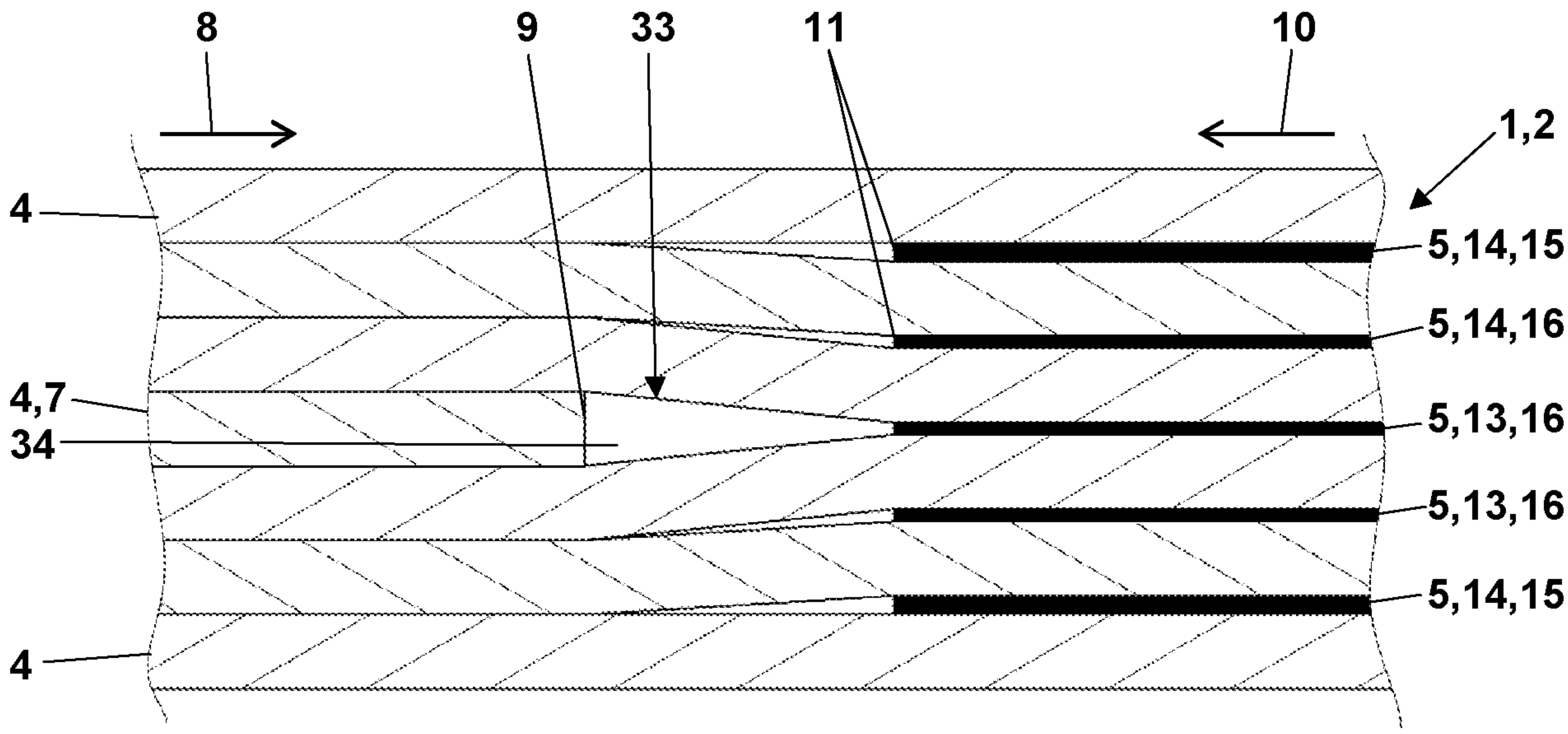

8
9
33
11
10
1,2
4
5,14,15
5,14,16
4,7
34
5,13,16
5,13,16
5,14,15
4

Fig. 4

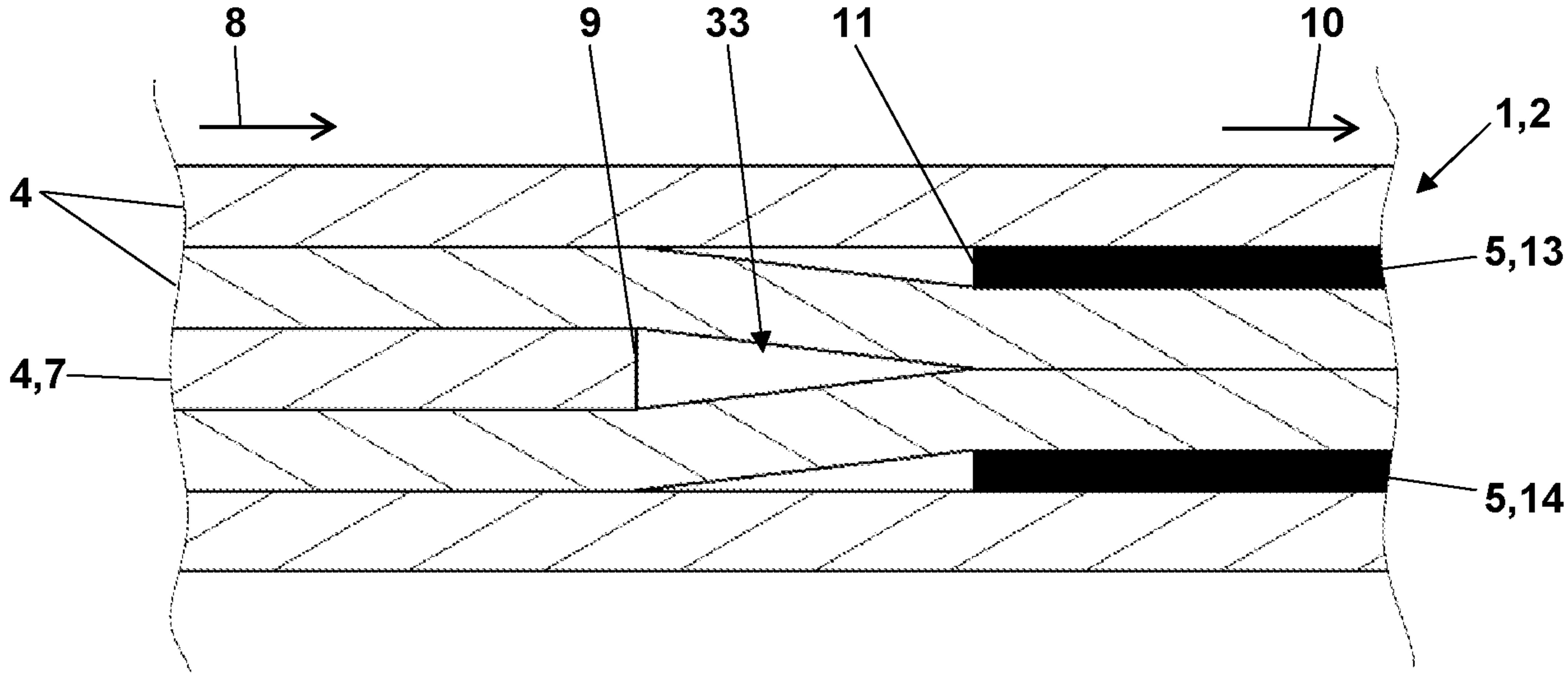

8
9
33
11
10
1,2
4
5,13
4,7
5,14

Fig. 5

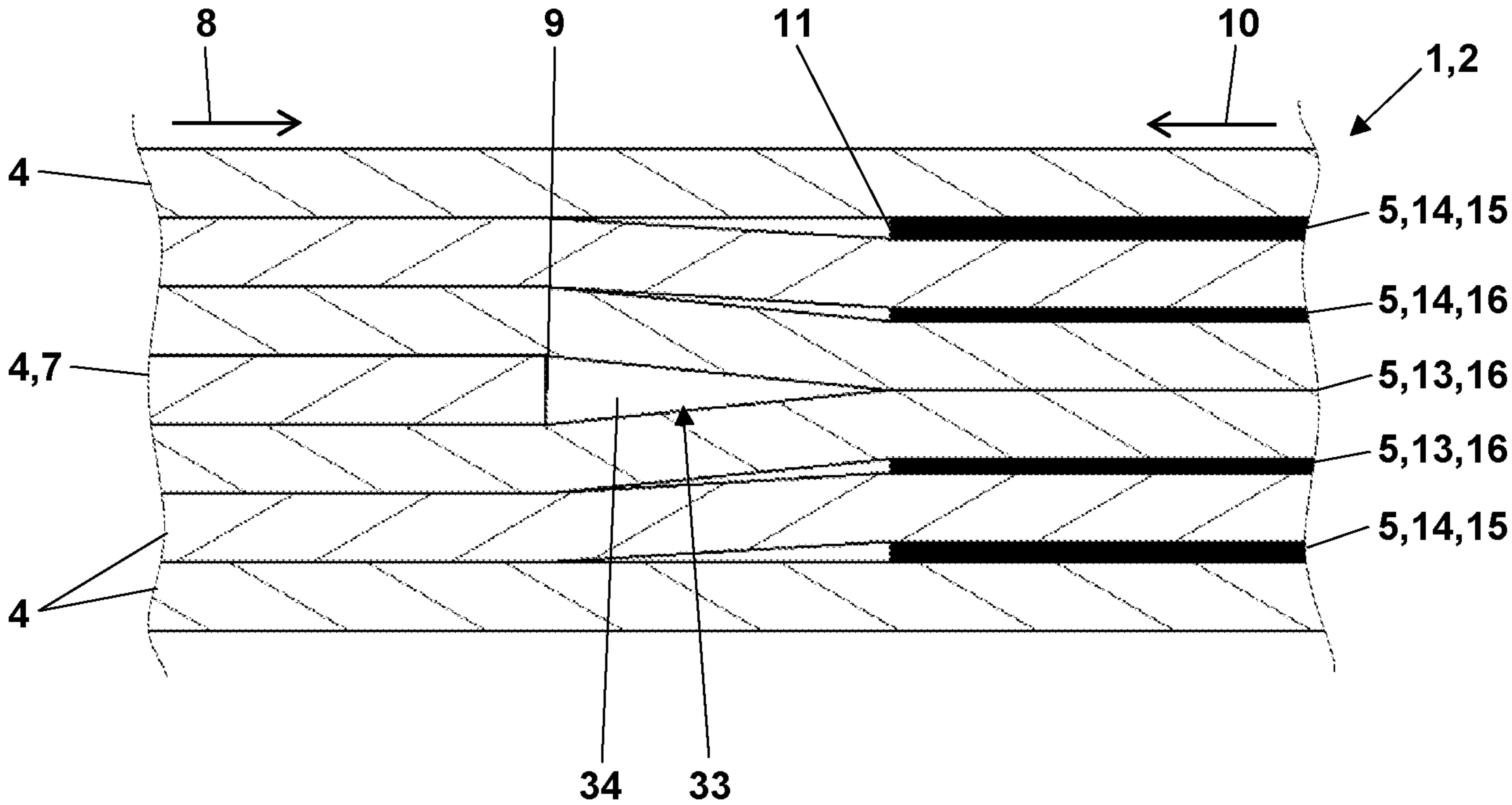
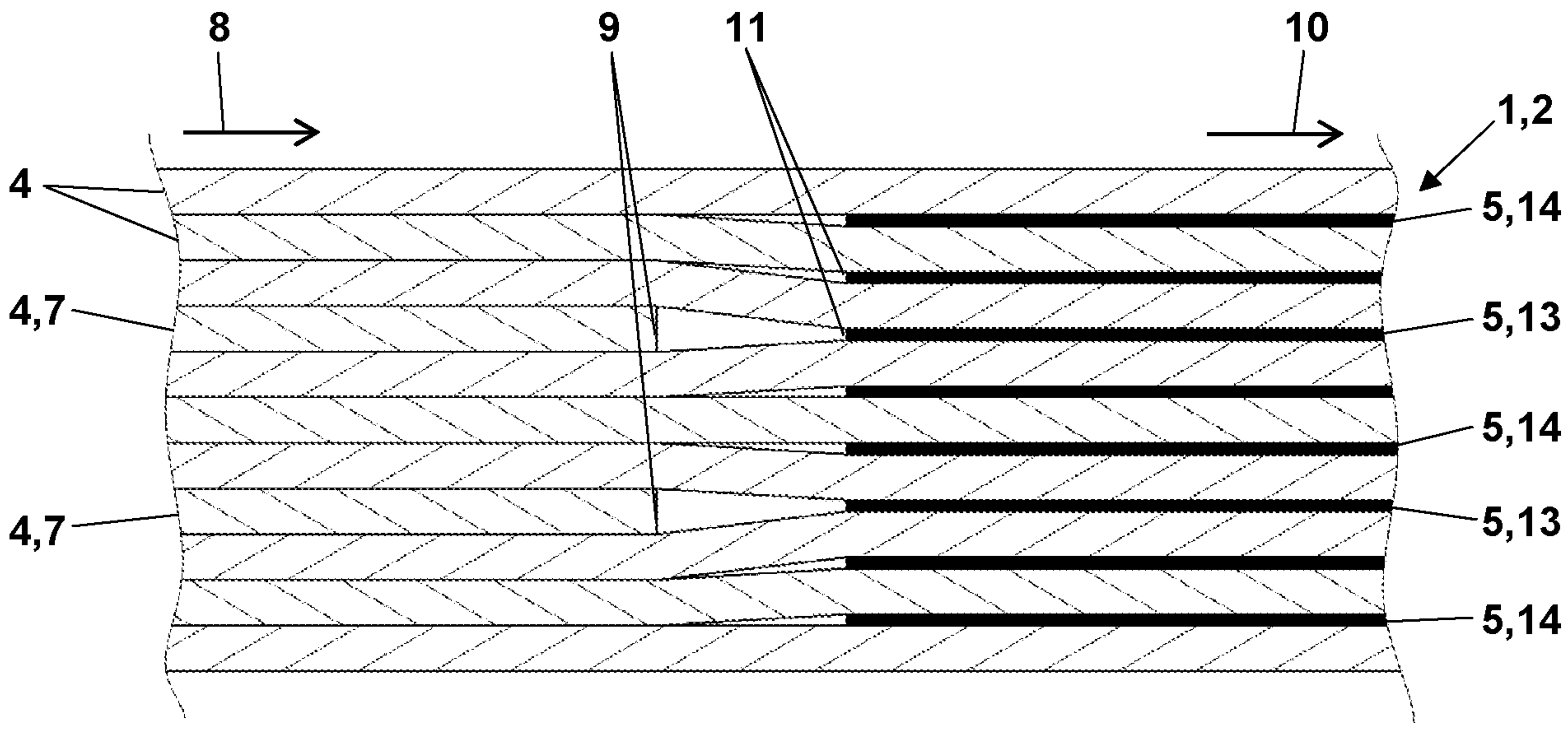

8
9
11
10
1,2
4
5,14,15
5,14,16
4,7
5,13,16
5,13,16
5,14,15
4
34
33

Fig. 6


8
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1,2
4
5,14
4,7
5,13
5,14
4,7
5,13
5,14

Fig. 7

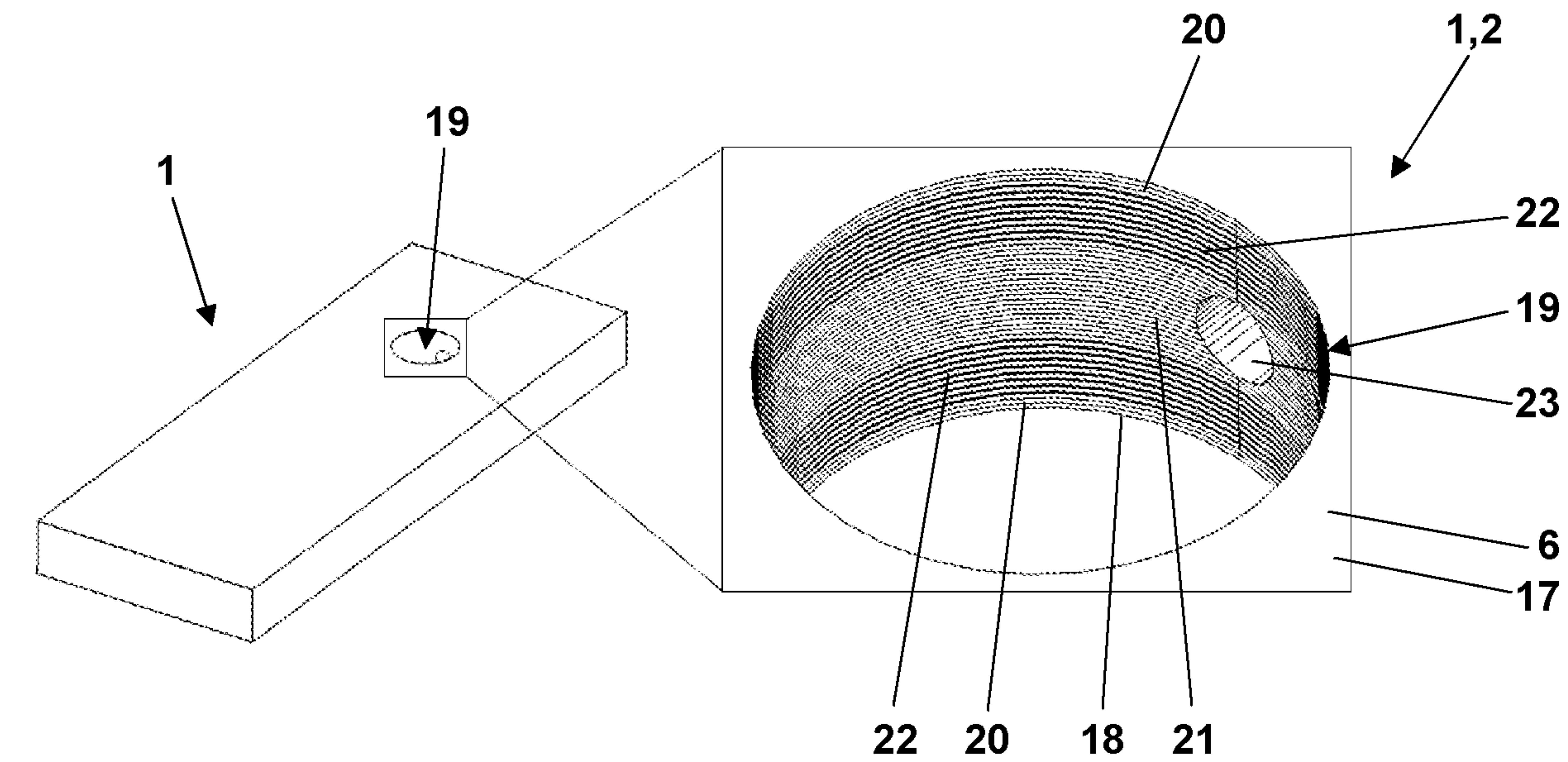
20
1,2
19
1
22
19
23
6
17
22
20
18
21

Fig. 8

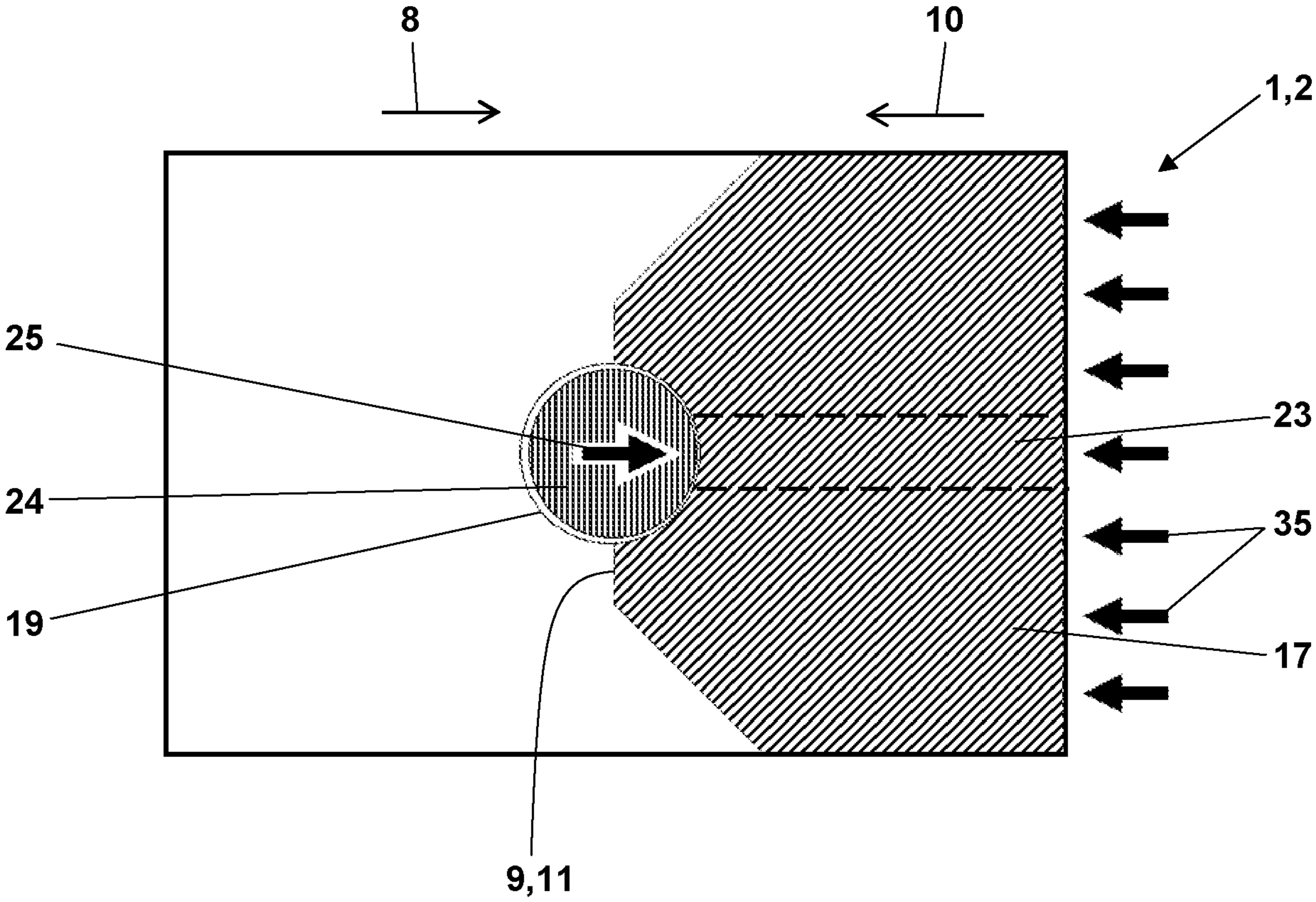

Fig. 9

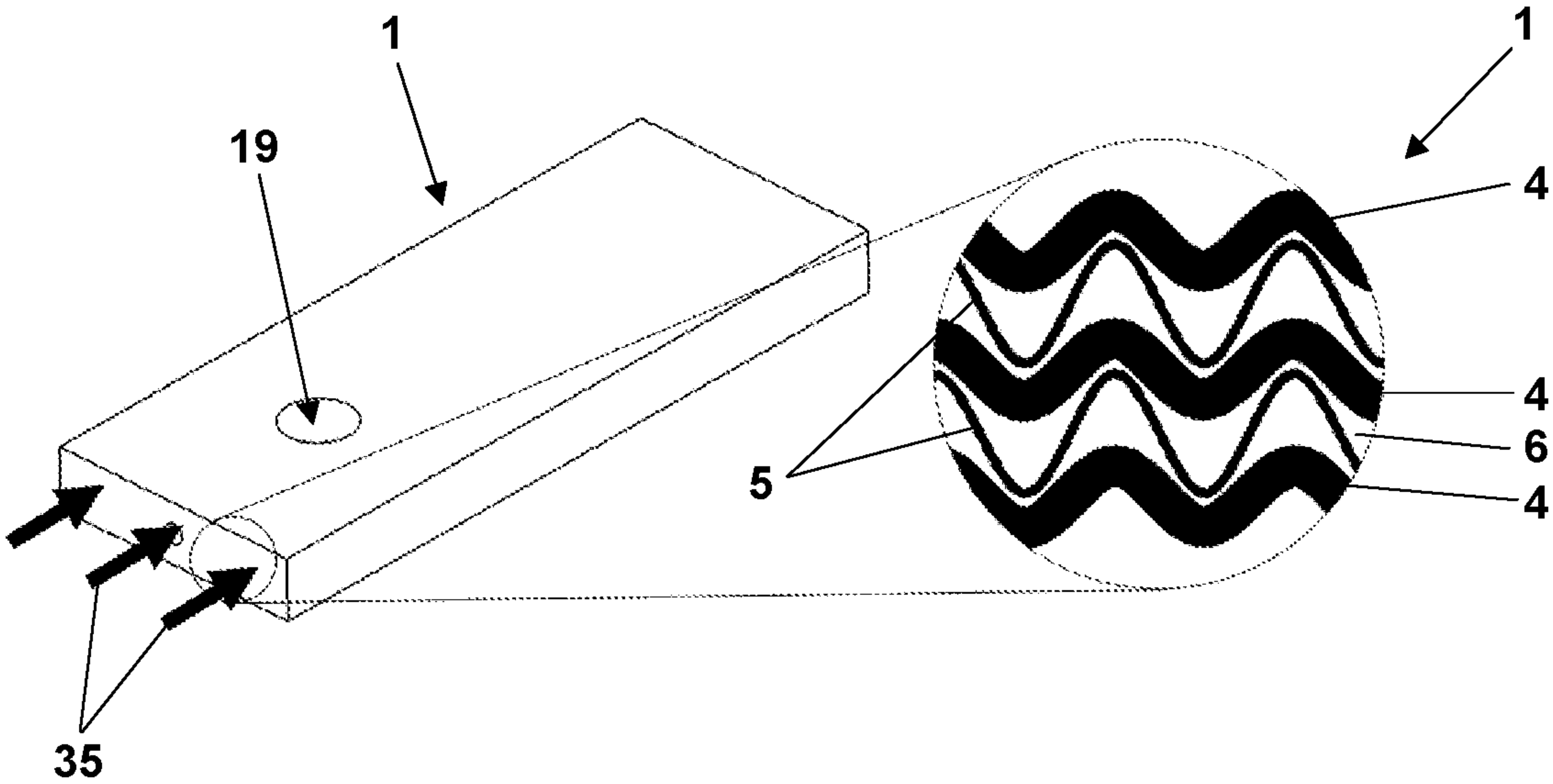

Fig. 10

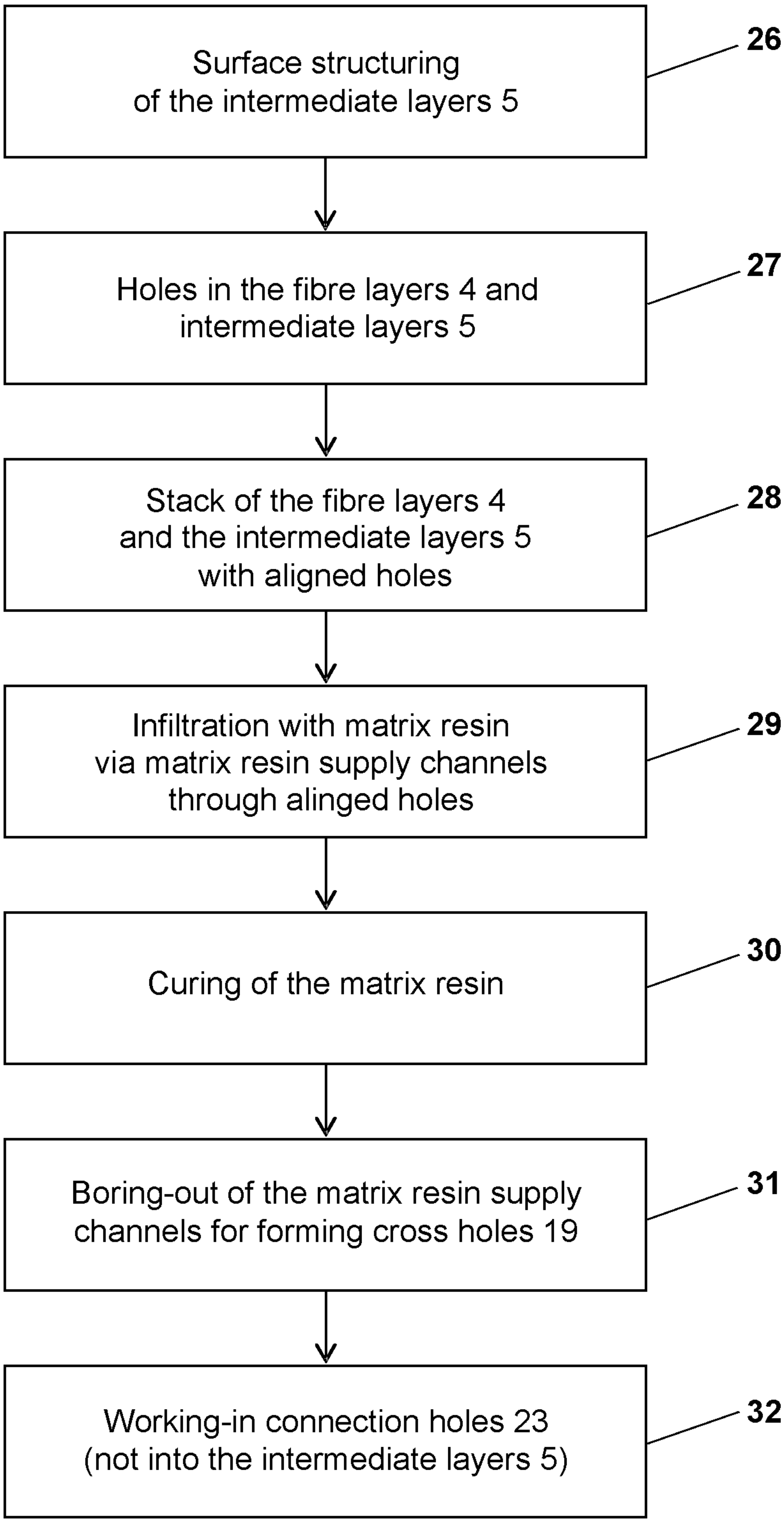
Surface structuring
of the intermediate layers 5
26
Holes in the fibre layers 4 and
intermediate layers 5
27
Stack of the fibre layers 4
and the intermediate layers 5
with aligned holes
28
Infiltration with matrix resin
via matrix resin supply channels
through alinged holes
29
Curing of the matrix resin
30
Boring-out of the matrix resin supply
channels for forming cross holes 19
31
Working-in connection holes 23
(not into the intermediate layers 5)
32

Fig. 11