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(54) **APPARATUS FOR NON-IMMERSIVE WET-CHEMICAL TREATMENT OF A PLANAR SUBSTRATE, DEVICE FOR HOLDING THE SUBSTRATE AND SYSTEM FOR TRANSPORTING THE SUBSTRATE**

(57) A device for holding a planar substrate (2) in an apparatus for non-immersive wet-chemical treatment of the substrate (2) comprises a support structure (4) comprising at least one part (5a,b,6) for engaging a support such as to hold the support structure (4) in the apparatus and at least one clamping device (10), supported by the support structure (4), for holding the substrate (2) in a plane (3). The at least one clamping devices (10) comprise at least one laterally progressing series of projections (12a-s) for engaging a major surface of a substrate (2) located in the plane (3) proximal an upper edge of the substrate (2). The device further comprises: at least one inner flow guidance part (21), having an outward-facing surface facing outwards with respect to the plane (3) and comprising a wettable surface section (25) wettable by a stream of liquid directed onto the wettable surface section (25); and at least one outer flow guidance part (23), having an inward-facing surface, wherein the inward-facing surface faces inwards with respect to the plane (3) and comprises a sloping surface section (35). The inward-facing surface of the outer flow guidance part (23) is spaced apart from the outward-facing surface of the inner flow guidance part (21) to enable liquid directed onto the wettable surface section (25) to flow onto at least the sloping section (35) of the inward-facing surface of the outer flow guidance part (23). Seen looking onto the plane (3), an edge (29) of the inner flow guidance part (21)

proximal the series of projections (12a-s) and extending at least predominantly in the lateral direction is located between the series of projections (12a-s) and the wettable surface section (25), and the sloping section (35) of the inward-facing surface of the outer flow guidance (23) part slopes towards the plane (3) in a direction (-z) transverse to the lateral direction (x) and towards the series of projections (12a-s).

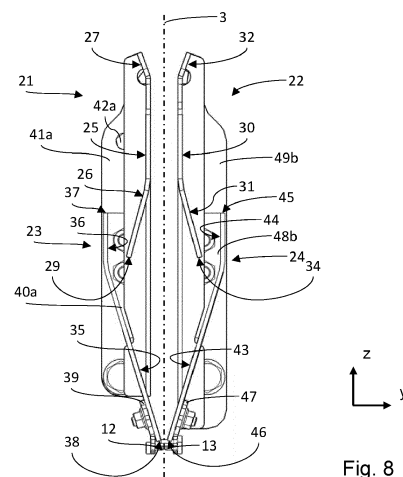


Fig. 8

Description

Technical Field

[0001] The invention relates to a device for holding a planar substrate in an apparatus for non-immersive wet-chemical treatment of the substrate, comprising:

a support structure comprising at least one part for engaging a support such as to hold the support structure with a particular orientation in the apparatus;

at least one clamping device, supported by the support structure, for holding the substrate in a plane, wherein the at least one clamping devices comprise at least one laterally progressing series of projections for engaging a major surface of a substrate located in the plane proximal an, in oriented condition upper, edge of the substrate;

at least one inner flow guidance part, having an outward-facing surface facing outwards with respect to the plane and comprising a wettable surface section wettable by a stream of liquid directed onto the wettable surface section; and

at least one outer flow guidance part having an inward-facing surface, wherein the inward-facing surface faces inwards with respect to the plane and comprises a sloping surface section, wherein the inward-facing surface of the outer flow guidance part is spaced apart from the outward-facing surface of the inner flow guidance part to enable liquid directed onto the wettable surface section to flow onto at least the sloping section of the inward-facing surface of the outer flow guidance part.

[0002] The invention also relates to a system for transporting a planar substrate through an apparatus for non-immersive wet-chemical treatment of the substrate.

[0003] The invention also relates to an apparatus for non-immersive wet-chemical treatment of the substrate.

[0004] The invention also relates to a method of non-immersive wet-chemical treatment of the substrate.

Background Art

[0005] US 2018/0100237 A1 discloses a surface treating system in which a substrate held by clips of a hanger undergoes surface treatment. The substrate is pinched and held at an upper end by the clips of the hanger. Pipes as treatment solution releasing sections are provided on both sides of the substrate held by the hanger. Each clip is biased by a spring in such a direction that tips of the clips are closed. Treatment solution receiving members extending along the entire width of the hanger are provided across the tips of the clips. Each treatment solution receiving member has a flat plate forming a proximal portion thereof and a projected section raised in a

semi-circular shape to form a distal portion thereof. Gripping projections for pinching and grasping the substrate are provided along an inner lower end of each projected section. Treatment solution is discharged obliquely upwards from the pipes and reaches the clips. The treatment solution contacts the flat plates of the treatment solution receiving members and flows downwards. The treatment solution having flowed down the surfaces of the flat plates flows down the surfaces of the projected sections with a semi-circular cross-sectional shape. The treatment solution having reached a lower end of the projected sections flows down the substrate. The projected sections are formed to have a round shape to ensure that the treatment solution flows around the projected sections onto the surfaces of the substrate at an angle close to a right angle. Further, flow guides may be provided to ensure that the treatment solution flows towards the substrate. Because the treatment solution flowing onto the substrate also slightly spreads upwards in the vicinity of the lower ends of the projected sections, the treatment solution reaches up to the upper end of the substrate.

[0006] A problem of the known device is that the treatment solution only flows upwards towards the edge of the substrate if the flow does not detach itself from the projected sections and the gripping projections hold the substrate very close to the edge of the substrate. This may not be desirable if the substrate is very thin or otherwise fragile.

Summary of Invention

[0007] It is an object of the invention to provide a device, system, apparatus and method of the types mentioned above in the opening paragraphs that allow the treatment liquid to contact the substrate up to the upper edge thereof even if the clamping devices engage the substrate at some distance from the upper edge.

[0008] This object is achieved according to a first aspect by the device according to the invention, which is characterised in that, seen looking onto the plane, an edge of the inner flow guidance part proximal the series of projections and extending at least predominantly in the lateral direction is located between the series of projections and the wettable surface section, and in that the sloping section of the inward-facing surface of the outer flow guidance part slopes towards the plane in a direction transverse to the lateral direction and towards the series of projections.

[0009] Because, seen looking onto the plane, an edge of the inner flow guidance part proximal the series of projections and extending at least predominantly in the lateral direction is located between the series of the projections and the wettable surface section, this edge is, in the particular orientation, located above where the projections contact the major surface of the substrate. This edge is the lower edge of a projection of the inner flow guidance part onto the plane, and thus marks the

lower boundary of the inner flow guidance part. The inner flow guidance part therefore shields the major surface to a level above the level at which the projections contact the major surface of the substrate. In an embodiment, the edge may be above the upper edge of the substrate, so that the substrate is exposed up to the upper edge of the substrate, except for where the projections contact the substrate. Because the sloping section of the inward-facing surface of the outer flow guidance part slopes towards the plane in a direction transverse to the lateral direction (parallel to the plane) and towards the series of projections, liquid falling or flowing onto this sloping section is directed towards the major surface of the substrate at a level above the level of the series of projections. It is therefore possible to clamp the substrate proximal to the upper edge and still direct liquid onto that upper edge. This is achieved without relying on the liquid to flow upwards over the major surface of the substrate. The liquid can, indeed will, become detached from the outward-facing surface of the inner flow guidance part.

[0010] The device is suitable for holding a planar substrate in an apparatus for non-immersive wet-chemical treatment of the substrate during the treatment. In this type of treatment, the substrate is not immersed in a bath of processing liquid, but held in the apparatus and wetted by means of a free-flowing liquid stream, in this case directed onto the wettable surface section of the inner flow guidance part. From there, the liquid flows onto the inward-facing surface of the outer flow guidance part. The liquid is then directed towards the major surface of the substrate that is to be treated. The liquid flows down the major surface, optionally over a lower flow guidance part and then drops onto the bottom of a basin or tank comprised in the apparatus.

[0011] The planar substrate may be flexible, so that the substrate is only planar when mounted in or to the device.

[0012] Examples of wet-chemical treatment include etching and plating, including electrodeless plating. The apparatus may further include stations for rinsing, de-smearing, swelling or reduction.

[0013] The device includes a support structure comprising at least one part for engaging a support such as to hold the support structure with a particular orientation in the apparatus. The support may be mobile or stationary. The at least one part for engaging a support may in particular enable the support structure to be suspended. As an example, the support structure may comprise a hanger allowing the device to be picked up by a transporter arranged to transport the device through one or more stations of the apparatus for wet-chemical processing.

[0014] The at least one clamping devices comprise at least one laterally progressing series of projections for engaging a major surface of a substrate located in the plane proximal an, in the particular orientation upper, edge of the substrate.

[0015] The configuration of the part for engaging a support allows one to determine the particular orienta-

tion, so that it is apparent from the device which way is up, in use. Correspondingly, the position and orientation of the at least one clamping devices determine which edge of a substrate held by the clamping devices is the upper edge and which edge is the lower edge. They also determine the location and orientation of the plane, which is occupied by a planar substrate when held by the clamping devices. In the particular orientation, the plane of the substrate will generally be parallel or at an acute angle to the vertical, e.g. within 5° to the vertical, to allow the processing liquid to flow down the major surface to be treated.

[0016] Because there is a series of projections for engaging the major surface of a substrate, processing liquid can pass between the projections. The lateral direction is the lateral direction seen looking onto the plane. Where the upper edge of the substrate is a straight edge, the lateral direction corresponds to within a few degrees (e.g. 10° or even 5°) to the direction in which the upper edge extends, depending on how accurately the substrate is mounted in the device. Thus, progressing in the lateral direction means that the projections are spaced apart in that direction and, if not aligned, at least located in a band extending in the lateral direction. In the oriented condition, the orientation being determined by the parts for engaging a support such as to hold the support structure with a particular orientation, the lateral direction is a horizontal direction to within a few degrees (e.g. 10° or even 5°).

[0017] The device comprises at least one inner flow guidance part having an outward-facing surface facing outwards with respect to the plane and comprising a wettable surface section wettable by a stream of liquid directed onto the wettable surface section. This wettable section need not be the only wettable section of the outward-facing surface, but is the section onto which the stream of liquid is directed. Thus, this section is exposed such as to allow a free-flowing stream of liquid directly to impinge on that surface section. In use, this stream will generally be in the shape of a sheet having a curved, e.g. parabolic shape. The outward-facing surface extends in the lateral direction over at least the lateral extent of a space for accommodating the substrate.

[0018] The device further comprises at least one outer flow guidance part having an inward-facing surface, wherein the inward-facing surface faces inwards with respect to the plane and comprises the sloping surface section. Here, inner and outer refer to the distance to the plane in which the planar substrate lies, in use.

[0019] The above description has been limited to a device suitable for treatment of one major surface of the planar substrate. Embodiments for treating both major surfaces will comprise the same features again, but in mirror image with respect to the plane.

[0020] The device is particularly suited to substrates of quadrilateral shape, seen looking onto the plane, but embodiments adapted to other shapes are possible. The upper edge need not therefore be straight. The

series of projections need not be arranged in a straight line.

[0021] Seen looking onto the plane, an edge of the inner flow guidance part proximal the series of projections and extending at least predominantly in the lateral direction is located between the series of the projections and the wettable surface section. Seen looking onto the plane with the support structure held with the particular orientation, the edge of the inner flow guidance part referred to is the lower edge. The edge results from a projection onto the plane and thus corresponds to the underside of the inner flow guidance part, the lowest part of the outer bounds of the inner flow guidance part. The direction transverse to the lateral direction and towards the series of projections is parallel to the plane. In the oriented condition this corresponds to the vertically downward direction to within a few degrees. The sloping surface section and the major surface of the substrate thus converge in downwards direction.

[0022] In an embodiment of the device, the outer flow guidance part is one of comprised in the at least one clamping devices and mounted to a respective arm of at least one of the at least one clamping devices.

[0023] The outer flow guidance part is thus comprised in one or several of the at least one clamping devices, mounted to an arm of one of the clamping devices or the respective arms of several of the clamping devices, or both. In each case, the number of component parts of the device for holding the planar substrate is kept relatively low. Moreover, in embodiments, the outer flow guidance part may be arranged to move with the arm or another part of the clamping device to which the outer flow guidance part is mounted or in which the outer flow guidance parts is comprised. The outer flow guidance part is thus automatically moved out of the way of the substrate when the clamping device or devices is or are opened to release or receive the substrate. The outer flow guidance part is moved closer when the substrate is clamped. In any embodiment, the outer flow guidance part may be arranged in fixed position and orientation relative to the part of the at least one clamping devices to which the outer flow guidance part is mounted or in which the outer flow guidance part is comprised, or the outer flow guidance part may be movable, e.g. pivotable.

[0024] In an embodiment of the device, the series of projections project from at least one of the inward-facing surface of the outer flow guidance part and an inward facing surface of a part fixed to the outer flow guidance part.

[0025] In this embodiment, there are relatively few parts that interfere with the flow of liquid from the outer flow guidance part onto the edge or edge region of the substrate. Basically, the processing liquid need only flow around the projections.

[0026] In an embodiment of the device, the inward-facing surface of the outer flow guidance part comprises a further section on an opposite side of the sloping section to a side proximal to the series of projections, and the

further section of the inward-facing surface is at a smaller angle to the plane than the sloping section of the inward-facing surface.

[0027] The further section confines processing liquid to the space between the inner flow guidance part and the outer flow guidance part. This is the case even if there is a certain amount of spray from liquid impinging on the sloping section of the inward-facing surface of the outer flow guidance part. It remains the case that the wettable surface section of the outward-facing surface of the inner flow guidance part is wettable by the stream of liquid directed onto this wettable section. That is to say that the further section is not so high as to obscure the wettable surface section.

[0028] In an example of this embodiment, the further section faces at least a section of the outward-facing surface of the inner flow guidance part located between the plane and the further section.

[0029] Seen looking onto the plane, at right angles, at least a section of the outward-facing surface of the inner flow guidance part is located between the plane and the further section. The stream of liquid will flow onto the wettable surface section from above, e.g. on the downward section of a parabolic trajectory. This allows the stream of liquid to enter the space between the further section and the outward-facing surface of the inner flow guidance part. Droplets due to impact onto the wettable surface section are caught by the further section of the inward-facing surface of the outer flow guidance part. In this embodiment, it is ensured that the stream of liquid imping on the inner flow guidance part flows further onto the outer flow guidance part.

[0030] In an embodiment of the device, the outward-facing surface of the inner flow guidance part comprises a sloping section sloping away from the plane in a direction transverse to the lateral direction and towards the series of projections.

[0031] The sloping section of the outward-facing surface slopes away from the plane in a direction transverse to the lateral direction, parallel to the plane and towards the series of projections. In the state in which the support structure is held in the apparatus in the oriented condition dictated by the part for engaging a support, the direction transverse to the lateral direction parallel to the plane and towards the series of projections will correspond to within a few degrees to the vertically downward direction. Thus, the sloping section slopes outwards in the vertically downward direction. Liquid flowing down the wettable surface section as a film flow, in use, will be re-directed somewhat away from the plane. The flow will thus be directed onto the inward-facing surface of the outer flow guidance part at an angle to the vertical. In embodiments, this flow may continue as a film flow down the inward-facing surface of the outer flow guidance part. It is in any case avoided that the liquid forms a curtain in front of the major surface of the substrate. Instead, the liquid is first directed away from the plane by the inner flow guidance part, then back towards the plane at a position at or

slightly above the upper edge of the substrate.

[0032] In an example of this embodiment in which also the inward-facing surface of the outer flow guidance part comprises a further section on an opposite side of the sloping section to a side proximal to the series of projections, the further section of the inward-facing surface is at a smaller angle to the plane than the sloping section of the inward-facing surface, and the further section faces at least a section of the outward-facing surface of the inner flow guidance part located between the plane and the further section, at least a sub-section proximal to the series of projections of the sloping section of the outward-facing surface of the inner flow guidance part is located between the plane and the further section of the inward-facing surface of the outer flow guidance part.

[0033] Seen looking onto the plane, the sub-section of the sloping section of the outward-facing surface of the inner flow guidance part is located between the plane and the further section of the inward-facing surface of the outer flow guidance part. This ensures that the flow from the outward-facing surface of the inner flow guidance part reaches (only) the inward-facing surface of the outer flow guidance part.

[0034] In an example of this embodiment, the sub-section extends to the edge of the inner flow guidance part.

[0035] Here the edge is that resulting from a projection of the inner flow guidance part onto the plane, i.e. the sub-section extends to the edge of the inner flow guidance part, seen looking onto the plane. This edge is the lower boundary of the inner flow guidance part.

[0036] In an embodiment of the device, the outward-facing surface section of the inner flow guidance part comprises a further section on an opposite side of the wettable surface section to a side proximal to the series of projections.

[0037] Here, the opposite side is the opposite side when the inner flow guidance part is projected onto the plane, i.e. the opposite side seen looking onto the plane. In the state in which the support structure is held in the apparatus in the oriented condition dictated by the part for engaging a support, the side proximal to the series of projections will be the lower side and the side on which the further section is provided will be the upper side. Thus, the further surface section of the inner flow guidance part will be above the wettable surface section. The wettable surface section and the further surface section may be at different angles to the plane (but oriented parallel to the transverse direction). In particular, the further surface direction may be at a larger angle, so as to face partly downwards in the state in which the support structure is held in the apparatus in the oriented condition dictated by the part for engaging a support. Thus, some liquid directed onto the wettable surface section may flow or splash upwards, but will flow down the further surface section. It follows that the further surface section may be wettable as well, but the stream of liquid will not impinge directly onto the further surface section, in use. In the state in

which the support structure is held in the apparatus in the oriented condition dictated by the part for engaging a support, the wettable surface section may be vertically oriented to within a few degrees, since there is no danger of liquid flowing upwards and over an upper edge of the inner flow guidance part.

[0038] In an embodiment of the device, the inner flow guidance part is mounted in fixed position relative to the support structure.

[0039] It follows that the position and orientation of the wettable surface section of the outward-facing surface of the inner flow guidance part are determined only by the part or parts for engaging the support in a cell of the apparatus for non-immersive wet-chemical treatment of the substrate. Thus, the angle at which the stream of liquid impinges on the wettable surface section is determined with a relatively high degree of certainty.

[0040] On the other hand, if mounting of the substrate is to be facilitated, the inner flow guidance part may be movably, e.g. pivotably mounted to the support structure, e.g. by means of at least one pivotably mounted arm of at least one of the at least one clamping devices.

[0041] In an embodiment of the device, the outer flow guidance part is pivotably mounted at opposite lateral edges of the outer flow guidance part for pivotable movement about an axis extending at least predominantly in the lateral direction.

[0042] It is thereby possible to change the angle of the sloping section of the inward-facing surface of the outer flow guidance part. The pivotable mounting may be to the support structure or to one or more parts of the at least one clamping devices, e.g. parts movable with respect to the support structure.

[0043] In an example of this embodiment, the outer flow guidance part is pivotable to bring the inward-facing surface into contact with a further device part along at least a line of contact extending in the lateral direction.

[0044] Thus, pivoting the outer flow guidance part can block the flow of liquid downwards onto the substrate (in the state in which the support structure is held in the apparatus in the oriented condition dictated by the at least one part for engaging a support). This allows a subsequent processing step to commence sooner. It is in particular possible to interrupt the flow of processing liquid (electrolyte, etching solution etc.) onto the substrate and commence rinsing, e.g. with water, almost immediately. The contact with a further device part along at least a line of contact will generally be contact over a surface, e.g. an elongated surface section extending longitudinally in the transverse direction. This interrupts downwards flow, but processing liquid may still flow away in the lateral direction(s) after the inward-facing surface has been brought into contact with a further device part. The further device part may be the inner flow guidance part or a further outer flow guidance part, for example, as will be explained.

[0045] In an embodiment of the device, the at least one clamping devices comprise at least a second laterally

progressing series of projections for engaging a second major surface of a substrate located in the plane proximal an upper edge of the substrate, the at least one inner flow guidance parts comprise an inner flow guidance part having a second outward-facing surface facing outwards with respect to the plane and comprising a wettable surface section wettable by a stream of liquid directed onto the wettable surface section, the outward-facing surfaces are located on opposite sides of the plane, the at least one outer flow guidance parts comprise at least a second outer flow guidance part having an inward-facing surface, the inward-facing surface faces inwards with respect to the plane and comprises a sloping surface section, the inward-facing surface of the second outer flow guidance part is spaced apart from the second outward-facing surface to enable liquid directed onto the wettable surface section of the second outward-facing surface to flow onto at least the sloping section of the inward-facing surface of the second outer flow guidance part, and the sloping section of the inward-facing surface of the second outer flow guidance part slopes towards the plane in a direction transverse to the lateral direction and towards the second series of projections.

[0046] There is thus a combination of parts forming essentially a mirror image of the inner flow guidance part and outer flow guidance part for wet-chemical treatment of a major surface of the substrate, the mirror image parts being provided for wet-chemical treatment of the opposite major surface of the substrate. In use, a second stream of liquid will be directed onto the wettable surface section of the second outward-facing surface. It is noted that the device may comprise one inner flow guidance part presenting both outward-facing surfaces (facing outwards in opposite respective directions). Alternatively, there may be separate first and second inner flow guidance parts.

[0047] In an example of any embodiment in which the outer flow guidance part is pivotably mounted at opposite lateral edges of the outer flow guidance part for pivotable movement about an axis extending at least predominantly in the lateral direction, the outer flow guidance part is pivotable to bring the inward-facing surface into contact with a further device part along at least a line of contact extending in the lateral direction, the at least one clamping devices comprise at least a second laterally progressing series of projections for engaging a second major surface of a substrate located in the plane proximal an upper edge of the substrate, the at least one inner flow guidance parts comprise an inner flow guidance part having a second outward-facing surface facing outwards with respect to the plane and comprising a wettable surface section wettable by a stream of liquid directed onto the wettable surface section, the outward-facing surfaces are located on opposite sides of the plane, wherein the at least one outer flow guidance parts comprise at least a second outer flow guidance part having an inward-facing surface, the inward-facing surface faces inwards with respect to the plane and comprises a sloping surface

section, the inward-facing surface of the second outer flow guidance part is spaced apart from the second outward-facing surface to enable liquid directed onto the wettable surface section of the second outward-facing surface to flow onto at least the sloping section of the inward-facing surface of the second outer flow guidance part, and the sloping section of the inward-facing surface of the second outer flow guidance part slopes towards the plane in a direction transverse to the lateral direction and towards the second series of projections, the further device part is the second outer flow guidance part.

[0048] Thus, the outer flow guidance part and second outer flow guidance part are pivotable into contact with each other along at least a line of contact.

[0049] In an embodiment of the device, each series of projections is arranged in a respective laterally extending array, e.g. aligned in a laterally extending row.

[0050] This ensures that the projections in the series all engage the major surface of the substrate close to the upper edge. A laterally extending array may, for example, form a zig-zag pattern extending in lateral direction. Other patterns are conceivable. Alignment in a laterally extending row means that the projections engage the major surface at approximately the same distance from a straight upper edge, depending on how accurately the substrate is positioned with respect to the device.

[0051] In an embodiment of the device, the support structure comprises at least two parts located, seen looking onto the plane, on opposite sides of a space for receiving the substrate, the device comprises at least one further clamping device for engaging the major surface of the substrate proximal an opposite edge of the substrate to the upper edge, and at least one of the further clamping devices and a part supporting the further clamping devices is connected to the two parts at ends of the two parts distal to the series of projecting parts for engaging the major surface proximal the upper edge of the substrate.

[0052] Thus, a relatively flexible substrate can be clamped at the upper edge and at the lower edge (upper and lower being with reference to the state in which the support structure is held in the apparatus in the oriented condition dictated by the at least one part for engaging a support). Projected onto the plane, the two parts of the support structure are located on either side, the left and right sides, of the substrate. They are not necessarily located in the plane and there need not be exactly one part, e.g. one elongated member, on either side of the space for receiving the substrate. In one example, the further clamping devices interconnect the distal ends of the two parts or are mounted to at least one part interconnecting the distal ends. In that case, the space for receiving the substrate is framed. In another example, there is no such frame, the further clamping devices engaging the substrate in corner regions, in use.

[0053] In an example of any embodiment in which the support structure comprises at least two parts located, seen looking onto the plane, on opposite sides of a space

for receiving the substrate, the device comprises at least one further clamping device for engaging the major surface of the substrate proximal an opposite edge of the substrate to the upper edge, and at least one of the further clamping devices and a part supporting the further clamping devices is connected to the two parts at ends of the two parts distal to the series of projecting parts for engaging the major surface proximal the upper edge of the substrate, the at least one further clamping devices comprise a series of projections for engaging the major surface of the substrate proximal an opposite edge of the substrate to the upper edge.

[0054] Thus, liquid flowing down the major surface of the substrate, in use, will flow through the at least one further clamping devices, more particularly in between the series of projections for engaging the major surface of the substrate proximal an opposite edge of the substrate to the upper edge. A relatively small basin can be provided to collect the processing liquid.

[0055] According to another aspect, the system according to the invention for transporting a planar substrate through an apparatus for non-immersive wet-chemical treatment of the substrate comprises a conveyor comprising at least one movable support and at least one device according to the invention for engaging at least one of the at least one movable supports.

[0056] The conveyor may comprise an overhead conveyor. The conveyor may comprise a chain or belt conveyor or a transporter guided on a track. In each case, the movable support is provided with one or more parts for engaging the at least one co-operating part of the support. When engaged, the device(s) according to the invention is or are held in the intended orientation, with the upper edge of the substrate at the top and the major surface oriented vertically to within a few degrees, e.g. at most 10° or even at most 5°.

[0057] According to a third aspect, the apparatus for non-immersive wet-chemical treatment of a planar substrate comprises at least one device according to the invention, at least one treatment station and at least one support for engaging the support structure of the device, wherein the apparatus includes a system for directing a stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part.

[0058] Again, when engaged, the device(s) according to the invention is or are held in the intended orientation, with the upper edge of the substrate at the top and the major surface oriented vertically to within a few degrees, e.g. at most 10° or even at most 5°. The at least one support of the apparatus may be movable, e.g. comprised in a conveying system, or stationary. In embodiments in which both major surfaces of the substrate are treated simultaneously, the system for directing a stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part will be arranged to direct a second stream of liquid onto the wettable surface section of a second outward-facing surface of either the inner flow guidance part or a second

inner flow guidance part. The system generates a free-flowing stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part. There is no guidance, and thus contact or even a risk of contact, between the system for directing the stream of liquid onto the wettable surface section on the one hand and the device for holding the substrate on the other can be avoided.

[0059] In an embodiment of the apparatus, the system for directing a stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part is configured to direct a downwardly-directed stream of liquid onto the wettable surface section.

[0060] This embodiment allows a film flow over the outward-facing surface of the inner flow guidance part to be obtained. The stream of liquid impinges on the wettable surface section of the outward-facing surface of the inner flow guidance part at an acute angle. If the path across the surface is long enough, the flow will be at least equalised, generally laminar and continue with relatively little turbulence until reaching the major surface of the substrate. This contributes to achieving uniformity of surface treatment.

[0061] In an embodiment of the apparatus, the system for directing a stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part comprises:

at least one flooding device,
wherein each flooding device comprises a vessel for holding liquid,
wherein the vessel is provided with at least one discharge passage through a side wall of the vessel, each discharge passage defining a respective inflow aperture open to an interior of the vessel,
wherein the flooding device is provided with at least one orifice in an exterior of the flooding device for delivering liquid passing through at least one of the discharge passages as the stream; and
a liquid supply system for supplying liquid to the vessel interior,
wherein the system for directing a stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part is configured to maintain a level of a free surface of liquid in the vessel interior of each flooding device above the at least one discharge passage inflow apertures.

[0062] The flooding device comprises a vessel for holding the processing liquid. In use, the liquid is present in the vessel interior, which is generally bounded by at least a bottom wall surface and a side wall surface. Thus, it is possible to determine a level, namely with respect to the bottom surface bounding the vessel interior. The vessel may be covered or closed at the top. The vessel interior may be vented. The vessel is provided with at least one discharge passage, e.g. only one discharge

passage, through a side wall of the vessel. This is the side wall on the side proximal to the substrate, in use. The discharge passage or passages may be a simple aperture or defined by a conduit extending through the side wall, for example. The or each discharge passage defines a respective inflow aperture open to the interior of the vessel, through which liquid can flow into the discharge passage from the vessel interior, in use.

[0063] The flooding device is provided with at least one orifice in an exterior of the device. The orifice may be defined by the discharge passage where the discharge passage terminates at an opposite end to the inflow aperture. In other embodiments, the discharge passage merely communicates with the orifice, e.g. via intermediate flow-conducting parts. The stream is free-flowing from the point where the stream leaves the orifice.

[0064] The system is configured to maintain a level of a free surface of liquid in the vessel interior of each flooding device above the at least one discharge passage inflow apertures. The pressure with which the liquid flows through the discharge passage or passages and then the orifice is thus the hydrostatic pressure, because there is a free liquid surface in the vessel interior, below a highest level of the vessel interior and in particular any surface forming an upper bound to the vessel interior. There is no back pressure, there would be in a spray bar for generating a stream of liquid. The pressure with which the liquid is supplied to the flooding device, in particular whether this pressure varies, is immaterial. The stream of liquid is driven only by gravity. The stream of liquid emerges from the orifice as a jet with a substantially constant velocity, determined only by the level of the (free surface of the) liquid in the vessel interior (neglecting viscosity and streamline contraction), in accordance with Toricelli's law. The direction in which the orifice points is immaterial, as is the density of the liquid.

[0065] The stream emerges from the orifice as a jet moving along a parabolic trajectory. Thus, the stream of liquid is downwardly-directed when impinging on the wettable surface section of the outward-facing surface of the inner flow guidance part.

[0066] In an example of this embodiment, at least one of the at least one flooding devices is provided with at least one overflow for conducting liquid out of the vessel interior, and the discharge passage is provided at a level between the overflow and a bottom surface bounding the vessel interior.

[0067] By supplying liquid at a sufficient rate, the level of the overflow(s) determine(s) the hydrostatic pressure and thus the velocity of the stream of liquid emerging from the orifice. As a result, the shape of the trajectory of the free-flowing stream is also determined.

[0068] In a particular example of any embodiment in which at least one of the at least one flooding devices is provided with at least one overflow for conducting liquid out of the vessel interior, and the discharge passage is provided at a level between the overflow and a bottom surface bounding the vessel interior, the vessel interior

has an elongated shape, seen from above, and overflows are provided on sides of the vessel interior at opposite longitudinal ends.

[0069] There is thus relative uniformity of pressure and concentration in longitudinal direction. Any gradients in longitudinal direction are only over half the length of the vessel interior.

[0070] In a particular example of any embodiment of the apparatus in which the system for directing a stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part comprises: at least one flooding device, wherein each flooding device comprises a vessel for holding liquid, wherein the vessel is provided with at least one discharge passage through a side wall of the vessel, each discharge passage defining a respective inflow aperture open to an interior of the vessel, wherein the flooding device is provided with at least one orifice in an exterior of the flooding device for delivering liquid passing through at least one of the discharge passages as the stream; and a liquid supply system for supplying liquid to the vessel interior, wherein the system for directing a stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part is configured to maintain a level of a free surface of liquid in the vessel interior of each flooding device above the at least one discharge passage inflow apertures, the orifice is formed by a slit.

[0071] This embodiment is suitable for providing a sheet-shaped free-flowing stream of liquid. The sheet extends in the lateral direction, as does the wettable surface section of the outward-facing surface of the inner flow guidance part. It can therefore suffice to provide one stream of liquid, instead of an array of streams. This improves the achievable uniformity of treatment over the major surface of the substrate.

[0072] In an example of this embodiment, the slit has a height, a width and a depth, seen from an outside of the flooding device, and the width decreases with increasing depth from the orifice in the direction of the vessel interior.

[0073] This has the effect of limiting contraction of the stream of liquid leaving the orifice.

[0074] In an example of any embodiment of the apparatus in which the system for directing a stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part comprises: at least one flooding device, wherein each flooding device comprises a vessel for holding liquid, wherein the vessel is provided with at least one discharge passage through a side wall of the vessel, each discharge passage defining a respective inflow aperture open to an interior of the vessel, wherein the flooding device is provided with at least one orifice in an exterior of the flooding device for delivering liquid passing through at least one of the discharge passages as the stream; and a liquid supply system for supplying liquid to the vessel interior, wherein the system for directing a stream of liquid onto the wettable surface section of the outward-facing sur-

face of the inner flow guidance part is configured to maintain a level of a free surface of liquid in the vessel interior of each flooding device above the at least one discharge passage inflow apertures, and the orifice is formed by a slit, the slit has a uniform height and a depth, seen from an outside of the flooding device, and a ratio of depth to height is between 8 and 12, e.g. between 9 and 11.

[0075] It has been found that a ratio in this range, e.g. about 10, allows one to obtain a free-flowing stream of liquid with relatively little turbulence.

[0076] In an example of any embodiment in which the system for directing a stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part comprises: at least one flooding device, wherein each flooding device comprises a vessel for holding liquid, wherein the vessel is provided with at least one discharge passage through a side wall of the vessel, each discharge passage defining a respective inflow aperture open to an interior of the vessel, wherein the flooding device is provided with at least one orifice in an exterior of the flooding device for delivering liquid passing through at least one of the discharge passages as the stream; and a liquid supply system for supplying liquid to the vessel interior, wherein the system for directing a stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part is configured to maintain a level of a free surface of liquid in the vessel interior of each flooding device above the at least one discharge passage inflow apertures, and the orifice is formed by a slit, the flooding device comprises at least a first masking part, distinct from and mounted to an exterior of a part of the flooding device at least partly bounding the vessel interior, and the slit is defined between the first masking part and one of a second masking part mounted to the exterior of the part of the flooding device at least partly bounding the vessel interior and a projecting part of the part of the flooding device at least partly bounding the vessel interior.

[0077] This embodiment is relatively easy to manufacture with the slit height, and thus the orifice size, contained within a relatively tight tolerance range. For example, manufacturing can comprise placing a gauge between the first masking part and the second masking part or projecting part of the flooding device. The first masking part is then fixed in position, e.g. by means of fasteners such as screws. Thereupon the gauge is withdrawn from the slit formed in this way. The part of the flooding device at least partly bounding the vessel interior may be a relatively large part, e.g. made in one piece. This part may be obtainable by moulding and/or machining, but without requiring dimensions contained within the same tight tolerance range as the slit height. In one example, the part of the flooding device at least partly bounding the vessel interior bound the vessel interior on a side proximal the substrate holding device, in use. The discharge passage or passages extend(s) through a side wall formed by this part of the flooding device. The first

masking part and, if present, the second masking part, are mounted externally to this side wall. In an alternative embodiment, the slit forms the discharge passage and the first, and optionally the second, masking part form(s) the side wall and thus bound(s) the vessel interior.

[0078] According to another aspect, the method according to the invention of non-immersive wet-chemical treatment of a planar substrate, comprises:

mounting the substrate to a device according to the invention, and
directing a stream of liquid onto the wettable surface section of the outward-facing surface of the inner flow guidance part.

[0079] The method may in particular comprise directing a free-flowing stream of liquid onto the wettable surface section, i.e. an unguided stream of liquid. The method allows the major surface of the substrate to be treated up to at least close to the upper edge. There is still a sufficient distance between the substrate holding device and substrate on the one hand and the device for providing the stream of liquid on the other for the risk of collision to be relatively small.

[0080] In an embodiment of the method, a downwardly-directed stream of liquid is directed onto the wettable surface section of the outward-facing surface of the inner flow guidance part.

[0081] In an embodiment of the method, the treatment is carried out in an apparatus according to the invention.

Brief Description of Drawings

[0082] The invention will be explained in further detail with reference to the accompanying drawings, in which:

- Fig. 1 is a first perspective view of a substrate holding device with the substrate mounted therein;
- Fig. 2 is a second perspective view of the substrate holding device, but without the substrate;
- Fig. 3 is a plan view of the substrate holding device with the substrate mounted therein;
- Fig. 4 is a detailed perspective view onto part of an outer flow guidance part comprised in the substrate holding device;
- Fig. 5 is a further perspective view of the substrate holding device, without the substrate and with a lower clamping device omitted;
- Fig. 6 is a detailed perspective view of an upper part of the substrate holding device;
- Fig. 7 is a further detailed perspective view of the upper part of the substrate holding device;
- Fig. 8 is a cross-sectional view of inner and outer flow guidance parts comprised in the upper part of the substrate holding device;
- Fig. 9 is detailed perspective view of one end of the upper part of the substrate holding device;

- Fig. 10 is a further detailed perspective view from another angle of the part shown in Fig. 9;
- Fig. 11 is a detailed perspective view of the lower clamping device of the substrate holding device;
- Fig. 12 is a perspective view of a flooding device for use with the substrate holding device in an apparatus for non-immersive wet-chemical treatment of the substrate;
- Fig. 13 is a top view of a lower masking part comprised in the flooding device of Fig. 12;
- Fig. 14 is a perspective view of the lower masking part shown in Fig. 13;
- Fig. 15 is a rear view of an upper masking part comprised in the flooding device of Fig. 12;
- Fig. 16 is a plan view into the flooding device of Fig. 12 with the lower and upper masking parts omitted;
- Fig. 17 is a perspective view onto the same parts of the flooding device as are shown in Fig. 16; and
- Fig. 18 is a detailed cross-sectional view through parts of the upper and lower masking parts when mounted in the flooding device.

Description of Embodiments

[0083] A substrate holding device 1 is configured for holding a planar substrate 2 in an apparatus for non-immersive treatment wet-chemical treatment of the substrate 2.

[0084] In the illustrated embodiment, the substrate 2 is quadrilateral, e.g. square. In other embodiments, the substrate may have a different polygonal outline, or even a circular or elliptical outline. The substrate 2 may be rigid so as to maintain the planar shape. Alternatively, the substrate 2 may be flexible, e.g. a foil, when not mounted in the substrate holding device 1. The apparatus is in particular suitable for such substrates as printed circuit boards, semiconductor dies or integrated circuit substrates, and the like.

[0085] Instead of being immersed in a bath of processing liquid, the substrate 2 is wetted on at least one side by processing liquid that flows across a major surface of the substrate 2 on that side in the form of a relatively thin film of liquid. This reduces the amount of processing liquid that is needed, providing environmental and economic benefits. The treatment may comprise rinsing, desmearing, etching, swelling, reduction or plating, including electrodeless plating, for example. Indeed, the apparatus may comprise multiple treatment stations, each configured in the manner to be described in more detail, but with the processing liquid differing between at least two of the stations.

[0086] It is useful to define a reference co-ordinate system (Fig. 1) with respect to a plane 3 (Fig. 8) in which the substrate 2 lies, when mounted in the substrate holding device. The description will take the viewpoint

of an observer looking onto the plane 3 in a direction y normal to the plane 3.

[0087] The substrate holding device 1 comprises a support structure comprising a frame 4. The frame 4 illustrated is made in one piece. In other embodiments, the frame 4 may comprise multiple interconnected members instead. In the illustrated embodiment, the frame 4 is provided with two arms 5a,b extending in opposite lateral directions $-x,x$. One arm 5a is provided with a claw 6 for engaging a support (not shown). The other arm 5b can be inserted into a support or rest on a support. Engagement between the arms 5a,b and the support or supports determines the orientation of the substrate holding device 1, so that the substrate 2 lies in the xz -plane 3. The substrate holding device 1 of the drawings is thus configured to be suspended in a station of the apparatus for wet-chemical processing of the substrate 2. In other embodiments, the substrate holding device 1 may additionally or alternatively be supported, e.g. by wheels, travellers or other devices mounted to the bottom of the frame 4.

[0088] The frame 4 frames a space 7 (Fig. 5) for receiving the substrate 2, and thus the substrate 2 when in place. This space 7 corresponds to a section of the plane 3. The frame 4 comprises lateral frame parts 8a,b on either side of the space 7. The frame 4 further comprises a lower interconnecting frame part 9 interconnecting the lower ends of the lateral frame parts 8a,b. In an alternative embodiment, the lower interconnecting frame part 9 may be dispensed with.

[0089] In the illustrated embodiment, the substrate holding device 1 comprises an upper clamping device 10 and a lower clamping device 11. Each of the clamping devices 10,11 comprises two respective series of projections 12a-s,13a-s, 14a-c,15a-c for engaging opposite major surfaces of the substrate 2. In the illustrated embodiment, the projections 12a-s,13a-s,14a-c,15a-c are pin-shaped. An, in this case circular, pin-head engages the surface of the substrate 2 in the closed condition of the clamping device 10,11 concerned.

[0090] In the illustrated embodiment, each series of projections 12a-s,13a-s,14a-c, 15a-c consists of a respective row of aligned projections 12a-s,13a-s,14a-c, 15a-c extending in the lateral direction x . The projections 12a-s,13a-s of the upper clamping device 10 engage the surfaces of the substrate 2 close to an upper edge of the substrate 2. The projections 14a-c,15a-c of the lower clamping device 11 engage the surfaces of the substrate 2 close to a lower edge of the substrate 2. In other embodiments, there may be further clamping devices for engaging the surfaces of the substrate 2 along the lateral edges of the substrate 2. In the illustrated embodiment, this is not required.

[0091] The number of projections 12a-s,13a-s for engaging the surfaces of the substrate 2 along the upper edge is higher than the number of projections 14a-c,15a-c for engaging the surfaces of the substrate 2 along the lower edge. In the illustrated embodiment, there are two

rows of nineteen projections 12a-s, 13a-s in the upper clamping device 10 and two rows of three projections 14a-c, 15a-c in the lower clamping device 11.

[0092] The upper clamping device 10 is biased into a closed configuration in which the projections 12a-s, 13a-s comprised therein engage the surfaces of the substrate 2. In the illustrated embodiment, the biasing means comprise a pair of springs 16a,b.

[0093] Similarly, the lower clamping device 11 is biased into a closed configuration in which the projections 14a-c, 15a-c engage the surfaces of the substrate 2. Here, the biasing means comprise two pairs of springs 17a-d. Each pair of springs 17a-d interconnects a pair of pivoting arms 18a-d mounted to ends of the lateral frame parts 8a,b. A movable interconnecting member 19a,b is provided on either side of the plane 3 (in front of the plane 3 and behind the plane 3, seen looking onto the plane 3 in the y-direction). Each series of projections 14a-c, 15a-c is mounted to a respective one of the movable interconnecting members 19a,b. Further lower interconnecting members 20a,b are provided closer to the pivot axis for reinforcement. The interconnecting members 19a,b, 20a,b have a round cross-section, in this example circular. They are not cylindrical, however, but taper towards each longitudinal end (i.e. in the -x-direction and +x-direction).

[0094] In the illustrated embodiment, the substrate holding device 1 comprises first and second inner flow guidance parts 21, 22 and first and second outer flow guidance parts 23, 24. The first inner flow guidance part 21 and the first outer flow guidance part 23 are provided on one side of the plane 3. The second inner flow guidance part 22 and the second outer flow guidance part 24 are provided on the other side of the plane 3.

[0095] The first inner flow guidance part 21 has a first outward-facing surface, facing outwards with respect to the plane 3, predominantly in the -y-direction. The second inner flow guidance part 22 has a second outward-facing surface, facing outwards with respect to the plane 3, predominantly in the +y-direction.

[0096] The first outward-facing surface comprises a wettable first surface section 25, an sloping first inner surface section 26 and an further first inner surface section 27. The sloping first inner surface section 26 slopes outwards, away from the plane 3, in the downwards direction (the -z-direction). The further first inner surface section 27 slopes outwards, away from the plane, in the upwards direction (the +z-direction). The wettable first surface section 25 is arranged vertically to within at most 10°, e.g. at most 5°, in the suspended condition of the substrate holding device 1. In use, a downwardly-directed free-flowing sheet-shaped stream of liquid is directed onto the wettable first surface section 25 and flows onto the sloping first inner surface section 26. The further first inner surface section 27 catches splashes and also prevents upwards flow of liquid across the outward-facing surface. First inner flow guidance part fins 28a,b are oriented at right angles to the outward-facing

surface and confine the liquid to that surface. A lower edge 29 of the first inner flow guidance part 21 is formed by the lower edge of the sloping first inner surface section 26. This lower edge 29 is at a distance in the z-direction to both the upper edge of the substrate 2, when present, and the projections 12a-s, 13a-s of the upper clamping device 10. The surface sections 25-27 forming the outward-facing surface of the first inner flow guidance part 21 are defined by a single plate-shaped part, bent at two locations to form folds extending in lateral direction x, which separate adjacent ones of the surface sections 25-27.

[0097] The second outward-facing surface is essentially a mirror image of the first.

[0098] Thus, the second outward-facing surface comprises a wettable second surface section 30, a sloping second inner surface section 31 and a further second inner surface section 32. The sloping second inner surface section 31 slopes outwards, away from the plane 3, along the extent thereof in the downwards direction (the -z-direction). The further second inner surface section 32 slopes outwards, away from the plane, along the extent thereof in the upwards direction (the +z-direction). The wettable second surface section 30 is arranged vertically to within at most 10°, e.g. at most 5°, in the suspended condition of the substrate holding device 1. In use, a downwardly-directed free-flowing sheet-shaped stream of liquid is directed onto the wettable second surface section 30 and flows onto the sloping second inner surface section 31. The further second inner surface section 32 catches splashes and also prevents upwards flow of liquid across the outward-facing surface. Second inner flow guidance part fins 33a,b are oriented at right angles to the outward-facing surface and confine the liquid to that surface. A lower edge 34 of the second inner flow guidance part 22 is formed by the lower edge of the sloping second inner surface section 31. This lower edge 34 is at a distance in the z-direction to both the upper edge of the substrate 2, when present, and the projections 12a-s, 13a-s of the upper clamping device 10. The surface sections 30-32 forming the outward-facing surface of the second inner flow guidance part 22 are defined by a single plate-shaped part, bent at two locations to form folds extending in lateral direction x, which separate adjacent ones of the surface sections 30-32.

[0099] The first outer flow guidance part 23 is provided with a first inward-facing surface facing towards the plane. The first inward-facing surface comprises a sloping first outer surface section 35 and a further first outer surface section 36. The sloping first outer surface section 35 slopes inwards, towards the plane 3 in the downwards direction, the -z-direction. The further first outer surface section 36 is arranged vertically to within at most 10°, e.g. at most 5°, in the suspended condition of the substrate holding device 1. An upper edge 37 of the first outer flow guidance part 23 is formed by an upper edge of the further first outer surface section 36. A lower edge 38 of the first outer flow guidance part 23 is formed by a lower edge of

the sloping first outer surface section 35. These edges 37,38 extend in lateral direction (the x-direction). In the illustrated embodiment, the series of first upper projections 12a-s are provided on a first support part 39 fixed to the first outer flow guidance part 23. In the illustrated embodiment, the first support part 39 is plate-shaped and bent to define a fold extending in the lateral direction, the x-direction. A section on one side of the fold is fixed to an outward-facing surface of the first outer flow guidance part 23. A section on the other side of the fold depends from the first outer flow guidance part 23. Thus, the series of first upper projections 12a-s are provided at a lower level than the lower edge 38 of the sloping first outer surface section 35, which in this case is also the lower edge 38 of the first outer flow guidance part 23. An inward-facing surface of the first support part 39 from which the first upper projections 12a-s project is at a smaller angle to the plane 3 than the sloping first outer surface section 35. In the illustrated embodiment, the inward-facing surface of the first support part 39 from which the first upper projections 12a-s project is parallel to the plane 3 to within at most 10°, e.g. at most 5°, at least when the upper clamping device 10 is closed to engage the substrate 2. The first upper projections 12a-s project in a direction normal to the inward-facing surface of the first support part 39.

[0100] The inward-facing surface of the first outer flow guidance part 23 is spaced apart from the outward-facing surface of the first inner flow guidance part 21 in a direction normal to the plane 3, the -y-direction. Thus, liquid impinging onto the wettable first surface section 25 can enter the space between the first outer flow guidance part 23 and the first inner flow guidance part 21 and flow onto the sloping first outer surface section 35.

[0101] At least the further first outer surface section 36 faces the outward-facing surface of the first inner flow guidance part 21 being located at the same level (in the z-direction). In the illustrated embodiment, the further first outer surface section 36 faces and is at the same level as a sub-section of the sloping first inner surface section 26. Thus, this sub-section is located between the further first outer surface section 36 and the plane 3.

[0102] At least the lower edge 38 of the first outer flow guidance part 23 is provided at a lower level than the lower edge 29 of the first inner flow guidance part 21. In the illustrated embodiment, the lower edge 29 of the first inner flow guidance part 21 is provided between the further first outer surface section 36 and the plane 3.

[0103] Fins 40a,b are provided at opposite lateral ends of the first outer flow guidance part 23. The first outer flow guidance part fins 40 a,b are plate-shaped and oriented at right angles to the inward-facing surface of the first outer flow guidance part 23, projecting towards the plane 3. In the illustrated embodiment, the first outer flow guidance part fins 40a,b are used to fix the first outer flow guidance part 23 to first pivot arms 41a,b. In this case, the first pivot arms 41a,b are made in one piece with the first inner flow guidance part 21 and are also plate-shaped.

The first pivot arms 41a,b are pivotably mounted to the frame 4, in this case via first pivots 42a,b. The pivot axis extends in lateral direction, the y-direction.

[0104] The second outer flow guidance part 24 is provided with a second inward-facing surface facing towards the plane. The second inward-facing surface comprises a sloping second outer surface section 43 and a further second outer surface section 44. The sloping second outer surface section 43 slopes inwards, towards the plane 3 in the downwards direction, the -z-direction. The further second outer surface section 44 is arranged vertically to within at most 10°, e.g. at most 5°, in the suspended condition of the substrate holding device 1. An upper edge 45 of the second outer flow guidance part 24 is formed by an upper edge of the further second outer surface section 44. A lower edge 46 of the second outer flow guidance part 24 is formed by a lower edge of the sloping second outer surface section 43. These edges 45,46 extend in lateral direction (the x-direction). In the illustrated embodiment, the series of first upper projections 13a-s are provided on a second support part 47 fixed to the second outer flow guidance part 24. In the illustrated embodiment, the second support part 47 is plate-shaped and bent to define a fold extending in the lateral direction, the x-direction. A section on one side of the fold is fixed to an outward-facing surface of the second outer flow guidance part 24. A section on the other side of the fold depends from the second outer flow guidance part 24. Thus, the series of first upper projections 13a-s are provided at a lower level than the lower edge 46 of the sloping second outer surface section 43, which in this case is also the lower edge 46 of the second outer flow guidance part 24. An inward-facing surface of the second support part 47 from which the second upper projections 13a-s project is at a smaller angle to the plane 3 than the sloping second outer surface section 43. In the illustrated embodiment, the inward-facing surface of the second support part 47 from which the second upper projections 13a-s project is parallel to the plane 3 to within at most 10°, e.g. at most 5°. The second upper projections 13a-s project in a direction normal to the inward-facing surface of the second support part 47.

[0105] The inward-facing surface of the second outer flow guidance part 24 is spaced apart from the outward-facing surface of the second inner flow guidance part 22 in a direction normal to the plane 3, the +y-direction. Thus, liquid impinging onto the wettable second surface section 30 can enter the space between the second outer flow guidance part 24 and the second inner flow guidance part 22 and flow onto the sloping second outer surface section 43.

[0106] At least the further second outer surface section 44 faces the outward-facing surface of the second inner flow guidance part 22 being located at the same level (in the z-direction). In the illustrated embodiment, the further second outer surface section 44 faces and is at the same level as a sub-section of the sloping second inner surface section 31. Thus, this sub-section is located between the

further second outer surface section 44 and the plane 3.

[0107] At least the lower edge 46 of the second outer flow guidance part 24 is provided at a lower level than the lower edge 34 of the second inner flow guidance part 22. In the illustrated embodiment, the lower edge 34 of the second inner flow guidance part 22 is provided between the further second outer surface section 44 and the plane 3.

[0108] Fins 48a,b are provided at opposite lateral ends of the second outer flow guidance part 24. The second outer flow guidance part fins 48a,b are plate-shaped and oriented at right angles to the inward-facing surface of the second outer flow guidance part 24, projecting towards the plane 3. In the illustrated embodiment, the second outer flow guidance part fins 48a,b are used to fix the second outer flow guidance part 24 to mounting fins 49a,b. In this case, the mounting fins 49a,b are made in one piece with the second inner flow guidance part 22 and are also plate-shaped. The mounting fins 49a,b are fixed in position with respect to the frame 4. Thus, the second outer flow guidance part 24 is also fixed in position with respect to the frame 4.

[0109] In an alternative embodiment, the mounting fins 49a,b may be pivotable like the first pivot arms 41a,b.

[0110] In yet another alternative embodiment, the first and second support parts 39,47 are not fixed to the first and second outer flow guidance parts 23,24. Instead, they are fixed to the first pivot arms 41a, and mounting fins 49a,b at longitudinal ends of the first and second support parts 39,47. In such an embodiment, it is possible for at least one of the first and second outer flow guidance parts 23,24 to be pivotably mounted to the first pivot arms 41a, and mounting fins 49a,b for pivotable movement about an axis extending at least predominantly in the lateral direction (the x-direction). This in turn allows the inward-facing surfaces of the first and second outer flow guidance parts 23,24 to be pivoted into contact with each other along at least a line of contact extending at least predominantly in the lateral direction (the x-direction). An actuator may be provided to effect the pivoting movement. In this way, it is possible to interrupt the downward flow of liquid onto the substrate 2 whilst the substrate 2 is still mounted in the substrate holding device 1.

[0111] The apparatus for non-immersive wet-chemical treatment of the substrate 2, comprises at least one substrate holding device 1 at least one treatment station and at least one support for engaging the frame 4. The support or supports may be comprised in a conveying system for transporting the substrate holding device 1 holding the substrate 2 through the at least one treatment station. The apparatus further includes a system for directing a first stream of liquid onto the wettable first surface section 25 of the outward-facing surface of the first inner flow guidance part 21 and a second stream of liquid onto the wettable second surface section 30. The streams are unguided, free-flowing streams. The streams are downwardly directed on reaching the wettable surface sections 25,30.

[0112] A suitable flooding device 50 for producing one of these streams is disclosed here. The other stream of liquid can be generated with a device of the same construction as the flooding device 50. An alternative suitable flooding device is disclosed in European patent application No. 22192694.2 of 29 August 2022.

[0113] The flooding device 50 comprises a body 51 forming part of a vessel for holding liquid. In the illustrated embodiment, the body 51 is made in one piece, albeit surface treatment, including coating and anodising, are possible. The body 51 may be moulded or machined and made of metal or polymer material, including polymer composite material. In a particular embodiment, the body 51 is obtainable by both moulding and machining.

[0114] A cavity 52 is formed in the body 51. The cavity 52 at least partly defines a vessel interior 53 and two overflow spaces 54,55. More particularly, the body 51 defines surfaces bounding the vessel interior 53 and overflow spaces 54,55 on five sides. These are all sides with the exception of the side on which an orifice 62 for delivering liquid as a stream of liquid is provided. On that side, the cavity 52 is closed by an upper masking part 56 and a lower masking part 57 mounted to an exterior of the body 51.

[0115] The upper masking part 56 and the lower masking part 57 thus form a side wall of the vessel.

[0116] The upper masking part 56 and the lower masking part 57 are mounted against a flat exterior surface 58 of the body 51, e.g. by means of screws or other fasteners. In the illustrated embodiment, a groove 59 for seating one or more sealing elements (not shown) is formed, e.g. machined, in the exterior surface 58.

[0117] A discharge passage is provided through the side wall of the vessel formed by the upper masking part 56 and the lower masking part 57. The discharge passage is defined between the upper masking part 56 and the lower masking part 57.

[0118] The discharge passage comprises a flaring section 60 and a slit 61. The slit 61 forms the orifice 62 for delivering liquid passing through the discharge passage as the stream of liquid for wetting one of the wettable surface sections 25,30, in use. The flaring section 60 interconnects the slit 61 and the vessel interior 53 and flares outwards in height direction towards the vessel interior 53. This is achieved by providing the upper masking part 56 and the lower masking part 57 with respective bevels 63,64.

[0119] The slit 61 has a height, a width and a depth, seen from an outside of the second flooding device 50. The height is uniform between the orifice 62 and the start of the flaring discharge passage section 60. The width decreases with increasing depth from the orifice into the direction of the vessel interior 53. The slit 61 ensures that a sheet-shaped stream of liquid is discharged, in use.

[0120] The height of the slit 61 may have a value in the range of 0.5 - 1.5 mm, e.g. in the range of 0.6 - 1.3 mm. The depth may have a value of at least 5 mm, e.g. in the range of 6 - 12 mm. The ratio of the depth to the height

may have a value in the range of 5 - 15, e.g. in the range of 9 - 11 mm, for example about 10.

[0121] In the illustrated embodiment, a flat section of a lower surface 65 of the upper masking part 56 bounds the slit 61. The slit 61 is otherwise defined by a central section 66 set back with respect to a remainder of an upper surface 67 of the lower masking part 57. This central surface section 66 extends between two lateral edges 68a,b that are at an angle to a straight front edge 69, e.g. an angle in the range of 20-40°. This helps prevent the sheet-shaped stream of liquid emerging from the orifice 62, in use, from contracting laterally. The surface section front edge 69 is relatively sharp to ensure that a well-defined jet of liquid emerges from the orifice 62.

[0122] In an alternative embodiment, the upper surface 67 may be flat and the slit 61 defined by a recessed part of the upper masking part 56.

[0123] The height of the slit 61 can be set relatively exactly by placing a gauge between the upper masking part 56 and the lower masking part 57 when mounting them to the body 51. After fixing the upper masking part 56 and the lower masking part 57 in place, the gauge is removed to open up the slit 61.

[0124] It will be appreciated that the flooding device 50 has an elongated shape, seen from above, as do the body 51 and the vessel interior 53. The orifice 62 is likewise elongated and extends in the longitudinal direction. In the illustrated embodiment, the vessel interior 53 is bounded by a bottom surface 70.

[0125] The overflow spaces 54,55 are provided on either side of the vessel interior 53, seen in longitudinal direction. There are thus two overflows 71,72 in the illustrated embodiment. The discharge passage formed by the flaring discharge passage section 60 and the slit 61 defines an inflow aperture open only to the vessel interior 53. There is no direct liquid connection between the overflow spaces 54,55 and the discharge passage.

[0126] The overflow spaces 54,55 are separated from the vessel interior 53 by respective barriers 73,74. The barriers 73,74 of the illustrated embodiment are integral parts of the body 51. The barriers 73,74 function as weirs to define overflows 71,72 extending over respective crests 75,76 of the barriers 73,74. The crests 75,76 are at a higher level (with respect to the bottom surface 70 of the vessel interior 53) than the discharge passage. The crests 75,76 are at a lower level (with respect to the bottom surface 70 bounding the vessel interior 53) than an upper edge of the side wall through which the discharge passage extends, at least where that side wall bounds the vessel interior 53. It will be recalled that, in this embodiment, that side wall is formed by the upper and lower masking parts 56,57. Thus, in use, the liquid level can have a free surface at a level higher than the crests 75,76 allowing the liquid in the vessel interior 53 to overflow into the overflow spaces 54,55.

[0127] In use, liquid is supplied to the flooding device 50 by a pump (not shown) through a supply pipe connected to a supply conduit 77 via a fitting 78. The supply

conduit 77 opens into the vessel interior 53 through a supply aperture 79 in the bottom surface 70 bounding the vessel interior 53. Thus, with the liquid overflowing via the overflows 71,72, there is a relatively steady upwards flow of liquid. Stagnant zones in the vessel interior 53 are largely avoided.

[0128] The second flooding device 50 is provided with outflow ports, each opening into one of the overflow spaces 54,55 through a respective outflow aperture 80,81. In the illustrated embodiment, the outflow ports extend through a side wall on an opposite side to the side on which the wall provided with the discharge passage is located. The outflow apertures 80,81 have at least a lower edge section at a level of a bottom surface bounding the overflow space 54,55 they are arranged to empty. When operation of the flooding device 50 ceases, the overflow spaces 54,55 can thus be emptied completely.

[0129] The outflow ports connect the overflow spaces 54,55 with outflow conduit sections (not shown in detail) connected to a return conduit 82 for returning the overflowing liquid to the pump. In use, the rate at which liquid is supplied is such that the liquid in the flooding device 50 has a free surface at an essentially constant level, slightly above the level of the lowest level of the overflows 71,72, this lowest level being determined by the positions of the crests 75,76 of the barriers 73,74.

[0130] Since there is always an empty head space above a free surface of liquid in the vessel interior 53, hydrostatic pressure at the inflow aperture to the discharge passage determines the velocity of the liquid flowing from the orifice 62. There is no back-pressure. The trajectory of the free-flowing stream of liquid is thus approximately invariant.

[0131] The invention is not limited to the embodiments described above, which may be varied within the scope of the accompanying claims. For example, other types of biasing device than the springs 16a,b,17a-d may be used. The liquid supply system may use one pump for two or more flooding devices 50.

List of reference numerals

[0132]

- | | |
|------|----------------------------|
| 1 | - Substrate holding device |
| 2 | - Substrate |
| 3 | - Plane |
| 4 | - Frame |
| 5a,b | - Arms |
| 6 | - Claw |
| 7 | - Receiving space |

27		EP 4 541 937 A1		28	
8a,b	- Lateral frame parts	37			- Upper edge of first outer flow guidance part
9	- Lower interconnecting frame part	38			- Lower edge of first outer flow guidance part
10	- Upper clamping device	5	39		- First support part
11	- Lower clamping device	40a,b			- First outer flow guidance part fins
12a-s	- First upper projections	41a,b			- First pivot arm
13a-s	- Second upper projections	10	42a,b		- First pivots
14a-c	- First lower projections	43			- Sloping second outer surface section
15a-c	- Second lower projections	15	44		- Further second outer surface section
16a,b	- Upper springs	45			- Upper edge of second outer flow guidance part
17a-d	- Lower springs				
18a-d	- Lower pivoting arms	20	46		- Lower edge of second outer flow guidance part
19a,b	- Movable lower interconnecting member	47			- Second support part
20a,b	- Further lower interconnecting member	25	48a,b		- Second outer flow guidance part fins
21	- First inner flow guidance part	49a,b			- Mounting fins
22	- Second inner flow guidance part	50			- Flooding device
23	- First outer flow guidance part	30	51		- Body
24	- Second outer flow guidance part	52			- Cavity
25	- Wettable first surface section	35	53		- Vessel interior
26	- Sloping first inner surface section	54			- First overflow space
27	- Further first inner surface section	55			- Second overflow space
28a,b	- First inner flow guidance part fins	40	56		- Upper masking part
29	- Lower edge of first inner flow guidance part	57			- Lower masking part
30	- Wettable second surface section	45	58		- Exterior body surface
31	- Sloping second inner surface section	59			- Groove
32	- Further second inner surface section	60			- Flaring discharge passage section
33a, b	- Second inner flow guidance part fins	50	61		- Slit
34	- Lower edge of second inner flow guidance part	62			- Orifice
35	- Sloping first outer surface section	55	63		- Upper masking part bevel
36	- Further first outer surface section	64			- Lower masking part bevel

65	- Lower surface of upper masking part	
66	- Central surface section	
67	- Upper surface of lower masking part	5
68a,b	- Lateral surface section edges	
69	- Front edge of surface section	
70	- Bottom surface	10
71	- First overflow	
72	- Second overflow	15
73	- First barrier	
74	- Second barrier	
75	- First crest	20
76	- Second crest	
77	- Supply conduit	25
78	- Supply fitting	
79	- Supply aperture	
80	- First outflow aperture	30
81	- Second outflow aperture	
82	- Return conduit	35

Claims

1. Device for holding a planar substrate (2) in an apparatus for non-immersive wet-chemical treatment of the substrate (2), comprising:
 - a support structure (4) comprising at least one part (5a,b,6) for engaging a support such as to hold the support structure (4) in the apparatus; at least one clamping device (10), supported by the support structure (4), for holding the substrate (2) in a plane (3),
 - wherein the at least one clamping devices (10) comprise at least one laterally progressing series of projections (12a-s) for engaging a major surface of a substrate (2) located in the plane (3) proximal an upper edge of the substrate (2);
 - at least one inner flow guidance part (21), having an outward-facing surface facing outwards with respect to the plane (3) and comprising a wettable surface section (25) wettable by a stream of liquid directed onto the wettable sur-

face section (25); and
 at least one outer flow guidance part (23), having an inward-facing surface, wherein the inward-facing surface faces inwards with respect to the plane (3) and comprises a sloping surface section (35),
 wherein the inward-facing surface of the outer flow guidance part (23) is spaced apart from the outward-facing surface of the inner flow guidance part (21) to enable liquid directed onto the wettable surface section (25) to flow onto at least the sloping section (35) of the inward-facing surface of the outer flow guidance part (23),
characterised in that
 seen looking onto the plane (3), an edge (29) of the inner flow guidance part (21) proximal the series of projections (12a-s) and extending at least predominantly in the lateral direction is located between the series of projections (12a-s) and the wettable surface section (25),
 and **in that**
 the sloping section (35) of the inward-facing surface of the outer flow guidance (23) part slopes towards the plane (3) in a direction (-z) transverse to the lateral direction (x) and towards the series of projections (12a-s).

2. Device according to claim 1,
 wherein the outer flow guidance part (23) is one of comprised in the at least one clamping devices (10) and mounted to a respective arm (41a,b) of at least one of the at least one clamping devices (10).
3. Device according to claim 1 or 2,
 wherein the series of projections (12a-s) project from at least one of the inward-facing surface of the outer flow guidance part (23) and an inward facing surface of a part (39) fixed to the outer flow guidance part (23).
4. Device according to any one of the preceding claims,
 wherein the inward-facing surface of the outer flow guidance part (23) comprises a further section (36) on an opposite side of the sloping section (35) to a side proximal to the series of projections (12a-s),
 wherein the further section (36) of the inward-facing surface is at a smaller angle to the plane (3) than the sloping section (35) of the inward-facing surface.
5. Device according to any one of the preceding claims,
 wherein the outward-facing surface of the inner flow guidance part (21) comprises a sloping section (26) sloping away from the plane (3) in a direction (-z) transverse to the lateral direction and towards the series of projections (12a-s).

6. Device according to any one of the preceding claims, wherein the outward-facing surface section of the inner flow guidance part (21) comprises a further section on an opposite side of the wettable surface section (25) to a side proximal to the series of projections (12a-s).

7. Device according to any one of the preceding claims, wherein the inner flow guidance part (21) is mounted in fixed position relative to the support structure (4).

8. Device according to any one of the preceding claims, wherein the outer flow guidance part (23) is pivotably mounted at opposite lateral edges of the outer flow guidance part (23) for pivotable movement about an axis extending at least predominantly in the lateral direction.

9. Device according to claim 8, wherein the outer flow guidance part (23) is pivotable to bring the inward-facing surface into contact with a further device part along at least a line of contact extending in the lateral direction.

10. Device according to any one of the preceding claims,

wherein the at least one clamping devices (10) comprise at least a second laterally progressing series of projections (13a-s) for engaging a second major surface of a substrate (2) located in the plane (3) proximal an upper edge of the substrate (2),

wherein the at least one inner flow guidance parts comprise an inner flow guidance part (22) having a second outward-facing surface facing outwards with respect to the plane (3) and comprising a wettable surface section wettable (30) by a stream of liquid directed onto the wettable surface section (30),

wherein the outward-facing surfaces are located on opposite sides of the plane (3), wherein the at least one outer flow guidance parts comprise at least a second outer flow guidance part (24) having an inward-facing surface,

wherein the inward-facing surface faces inwards with respect to the plane (3) and comprises a sloping surface section (43),

wherein the inward-facing surface of the second outer flow guidance part (24) is spaced apart from the second outward-facing surface to enable liquid directed onto the wettable surface section (30) of the second outward-facing surface to flow onto at least the sloping section (43) of the inward-facing surface of the second outer flow guidance part (24), and

wherein the sloping section (43) of the inward-facing surface of the second outer flow guidance part (24) slopes towards the plane (3) in a direc-

tion (-z) transverse to the lateral direction and towards the second series of projections (13a-s).

11. Device according to claim 9 and 10, wherein the further device part is the second outer flow guidance part (24).

12. System for transporting a planar substrate (2) through an apparatus for non-immersive wet-chemical treatment of the substrate (2), comprising a conveyor comprising at least one movable support and at least one device (1) according to any one of the preceding claims for engaging at least one of the at least one movable supports.

13. Apparatus for non-immersive wet-chemical treatment of a planar substrate (2), comprising at least one device (1) according to any one of claims 1-11, at least one treatment station and at least one support for engaging the support structure (4) of the device (1), wherein the apparatus includes a system for directing a stream of liquid onto the wettable surface section (25) of the outward-facing surface of the inner flow guidance part (21).

14. Apparatus according to claim 13,

wherein the system for directing a stream of liquid onto the wettable surface section (25) of the outward-facing surface of the inner flow guidance part (21) comprises:

at least one flooding device (50), wherein each flooding device (50) comprises a vessel for holding liquid,

wherein the vessel is provided with at least one discharge passage through a side wall of the vessel, each discharge passage defining a respective inflow aperture open to an interior (53) of the vessel,

wherein the flooding device (50) is provided with at least one orifice (62) in an exterior of the flooding device (50) for delivering liquid passing through at least one of the discharge passages as the stream; and

a liquid supply system for supplying liquid to the vessel interior (53),

wherein the system for directing a stream of liquid onto the wettable surface section (25) of the outward-facing surface of the inner flow guidance part (21) is configured to maintain a level of a free surface of liquid in the vessel interior (53) of each flooding device (50) above the at least one discharge passage inflow apertures.

15. Method of non-immersive wet-chemical treatment of

a planar substrate (2), comprising:

mounting the substrate (2) to a device (1) according to any one of claims 1-11, and directing a stream of liquid onto the wettable surface section (25) of the outward-facing surface of the inner flow guidance part (21).

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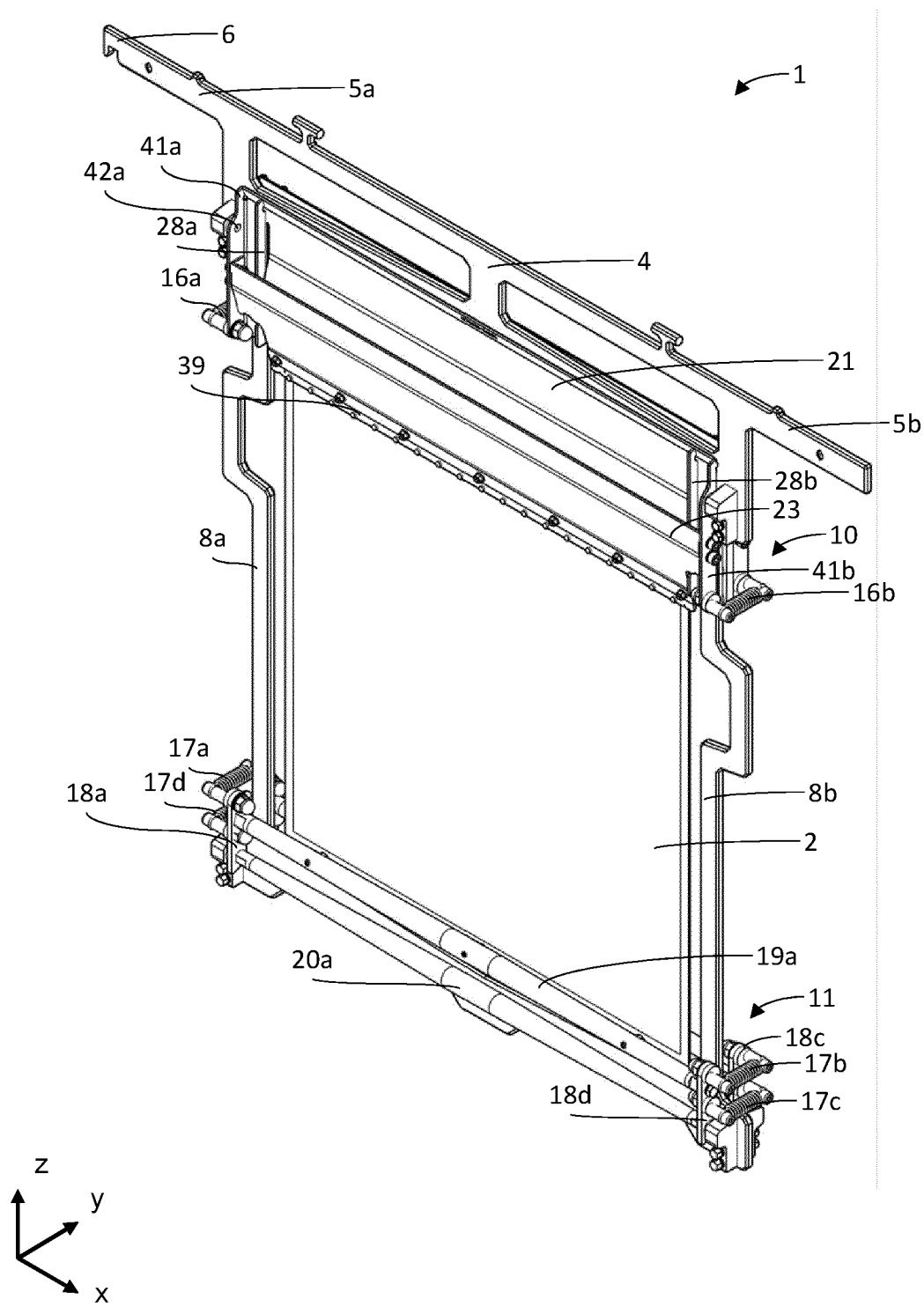


Fig. 1

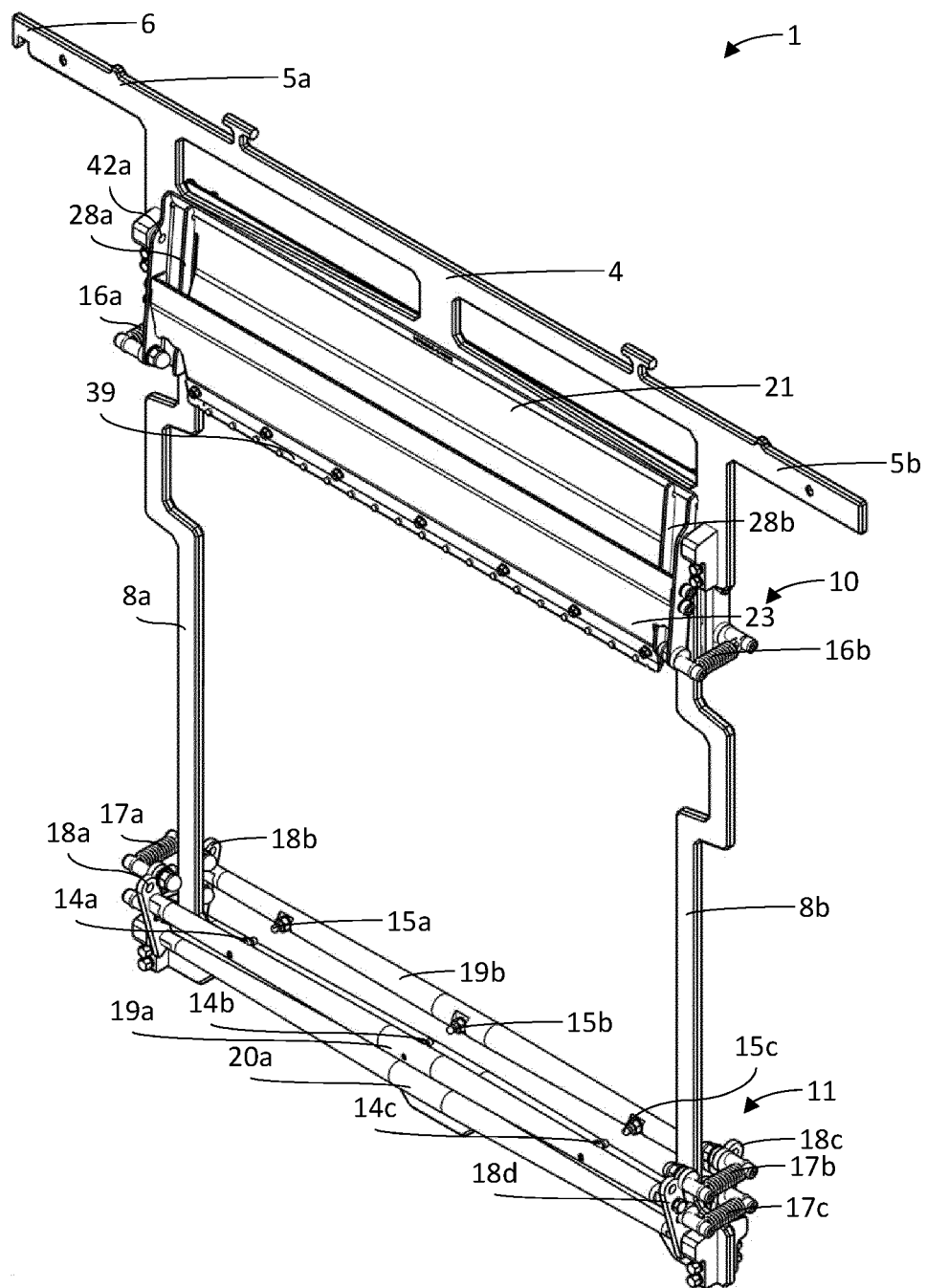


Fig. 2

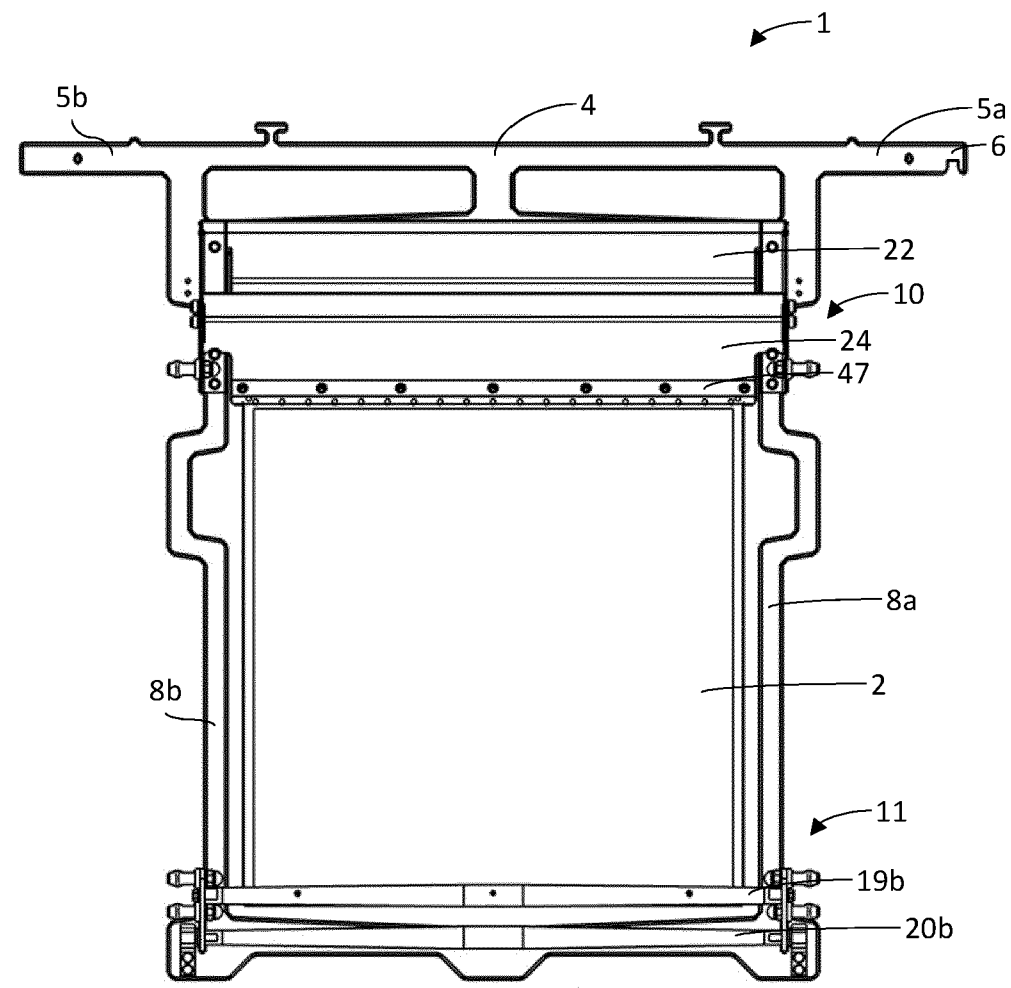


Fig. 3

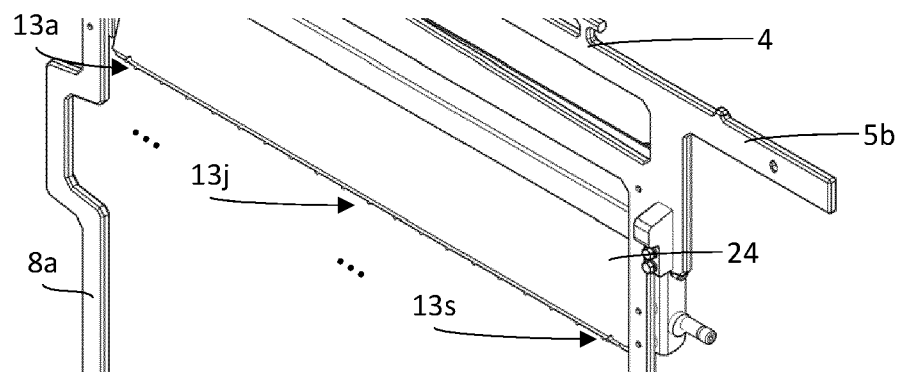


Fig. 4

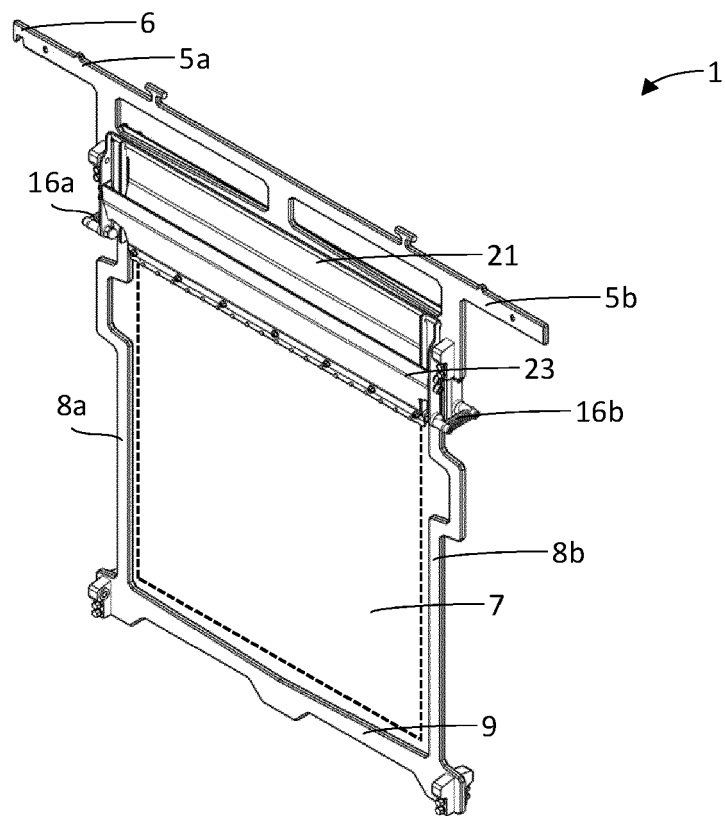


Fig. 5

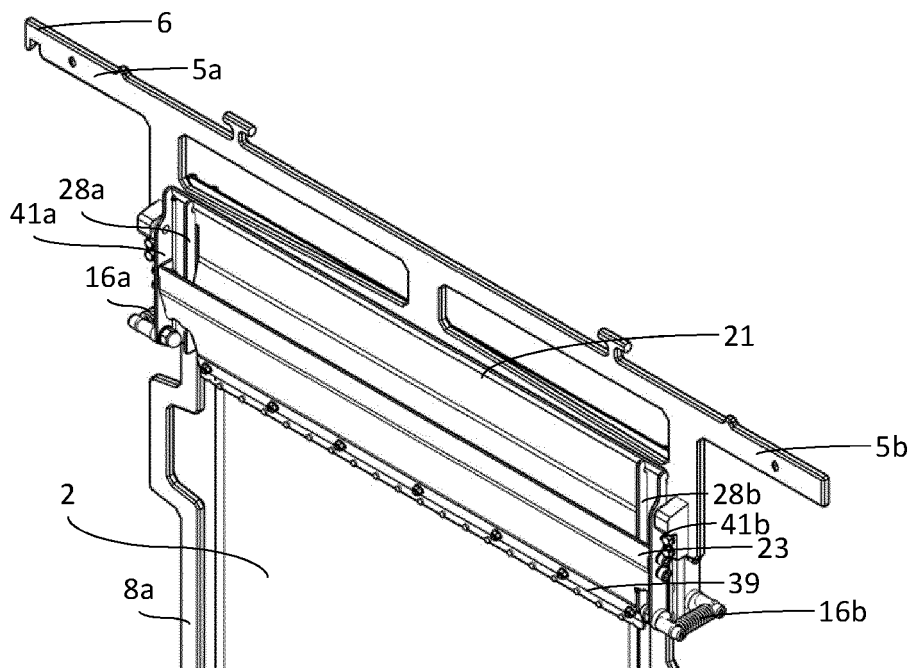


Fig. 6

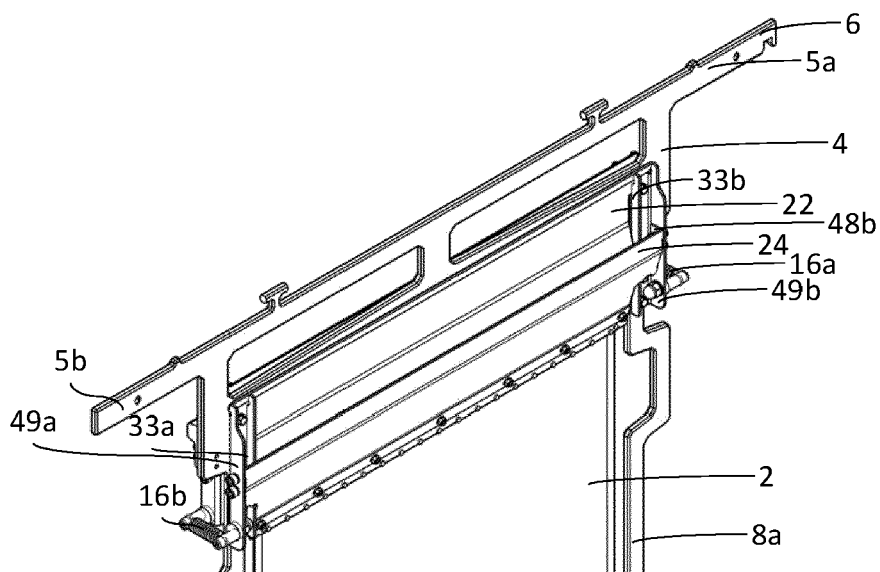


Fig. 7

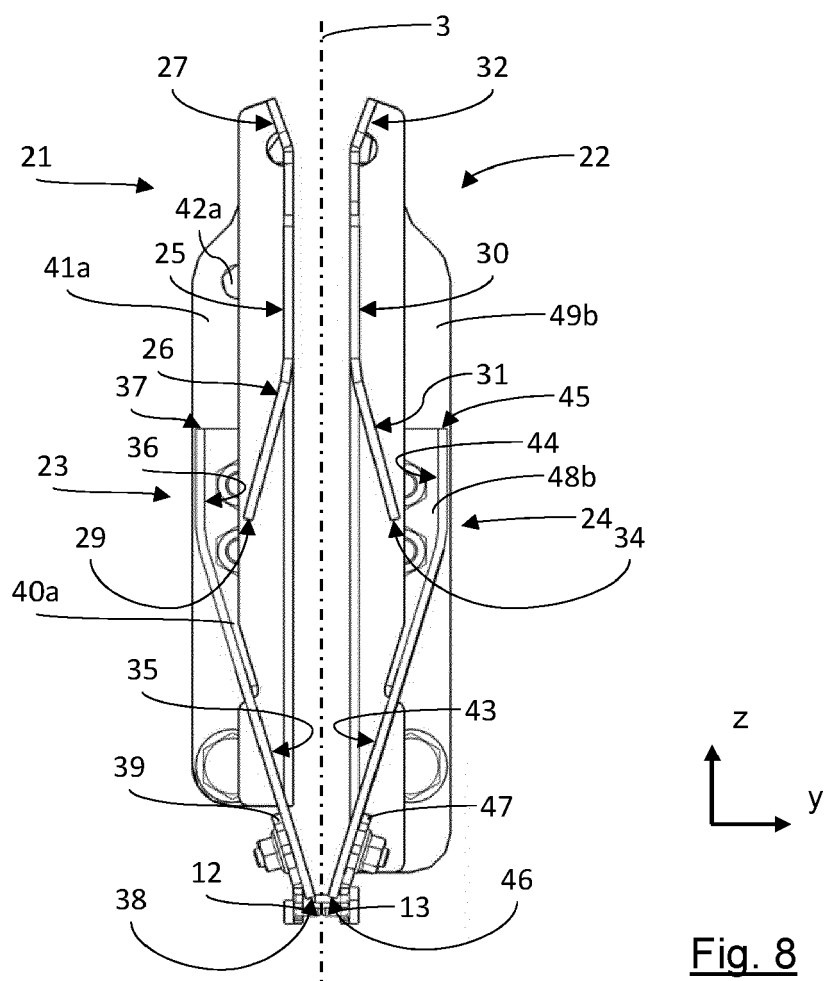


Fig. 8

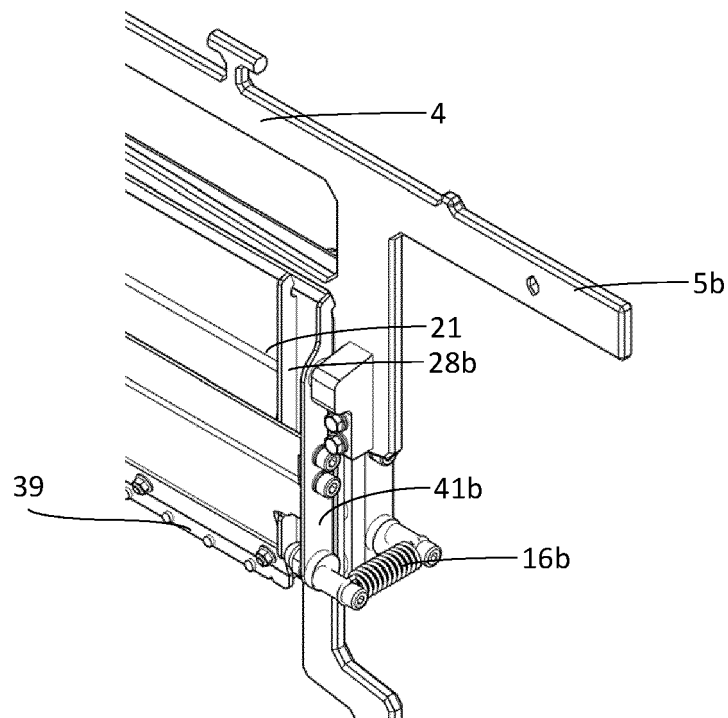


Fig. 9

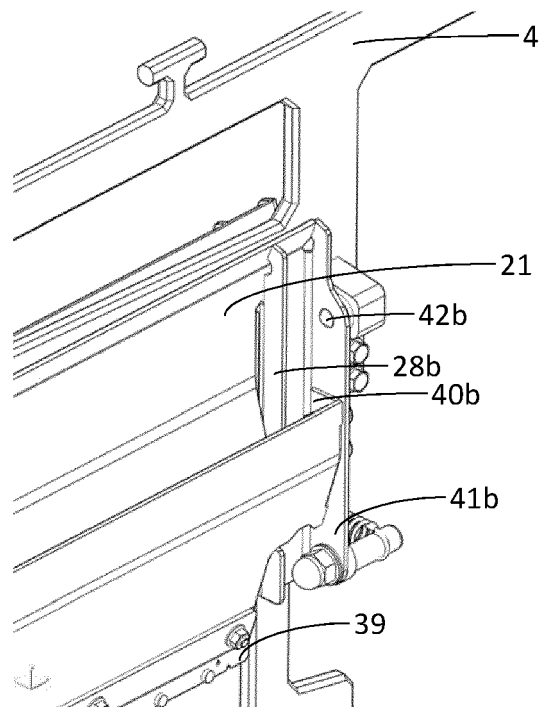


Fig. 10

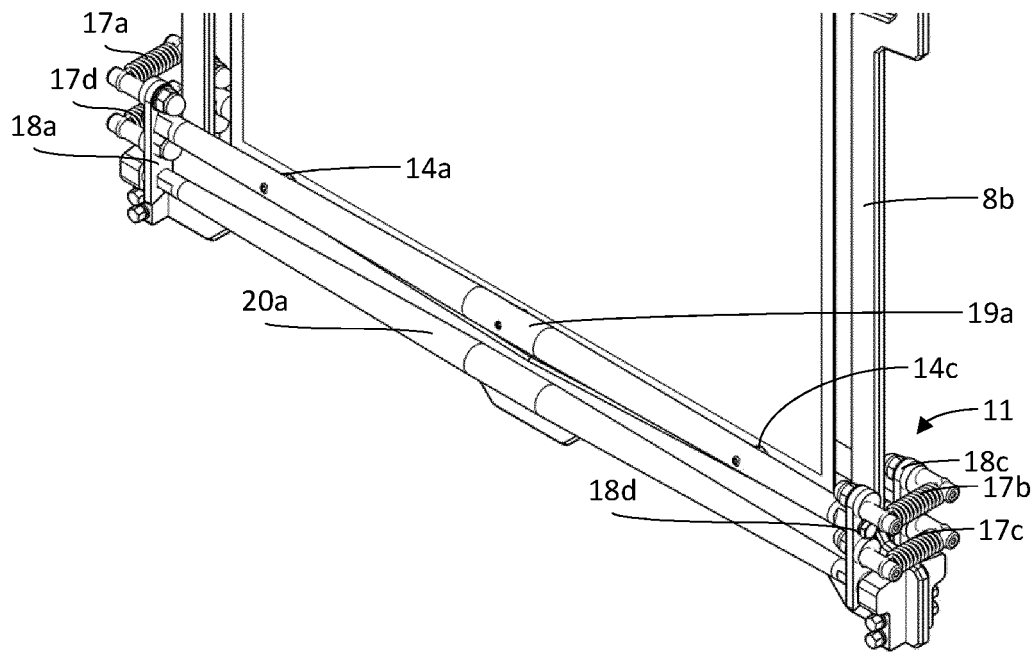


Fig. 11

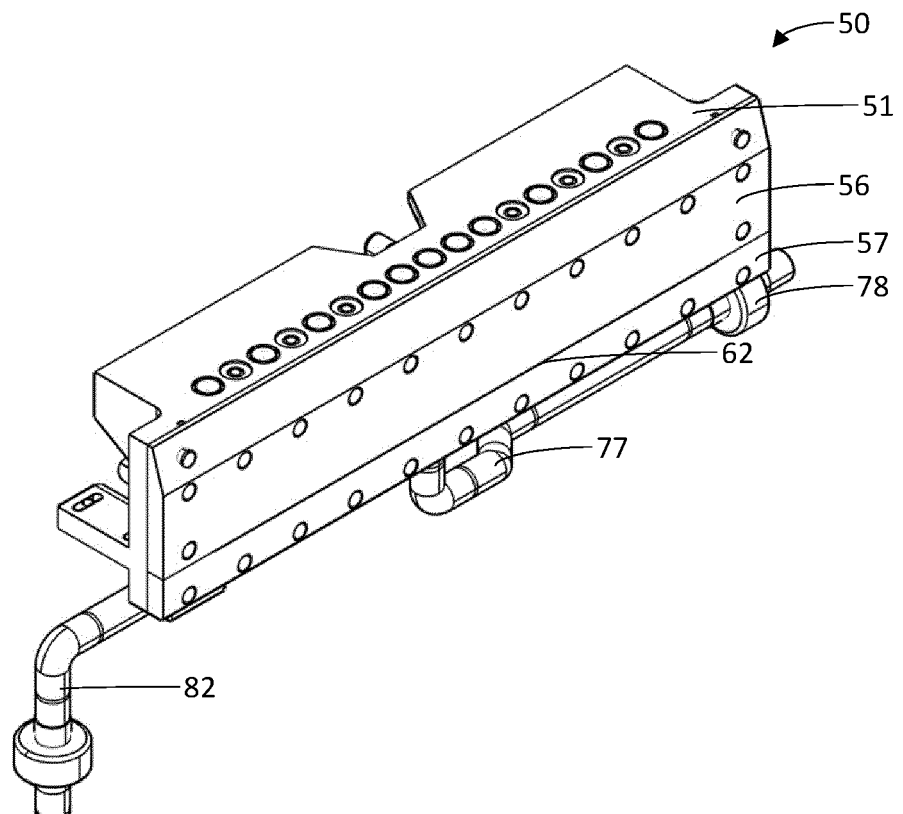


Fig. 12

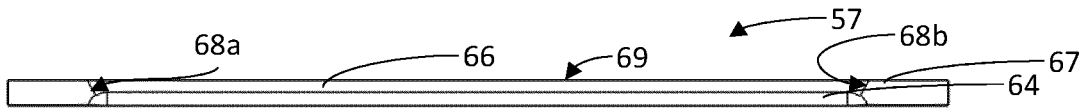


Fig. 13

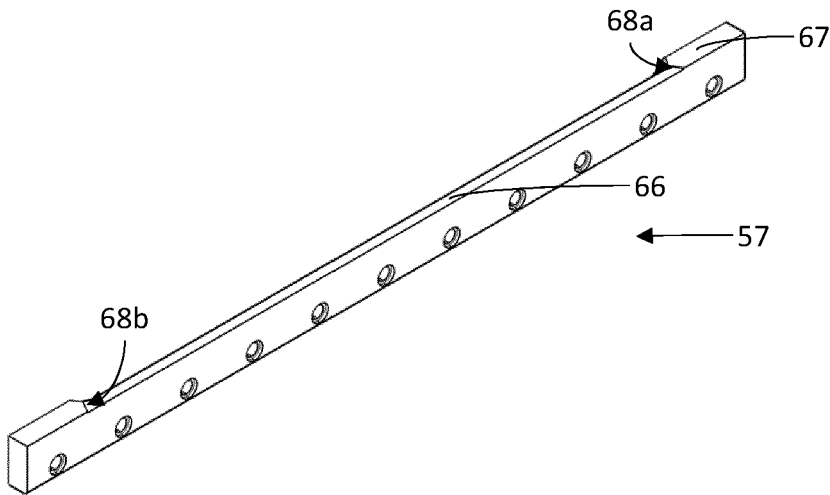


Fig. 14

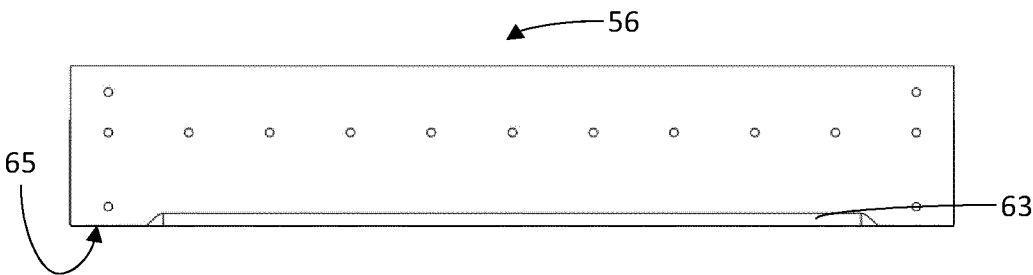


Fig. 15

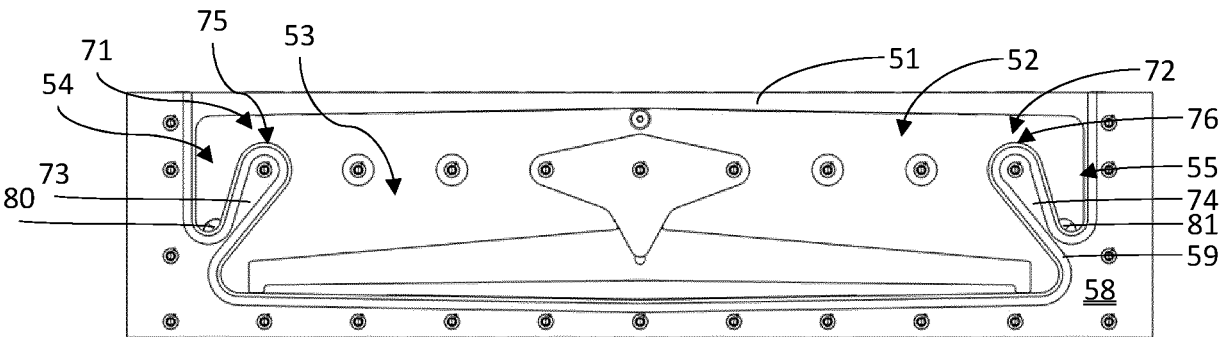


Fig. 16

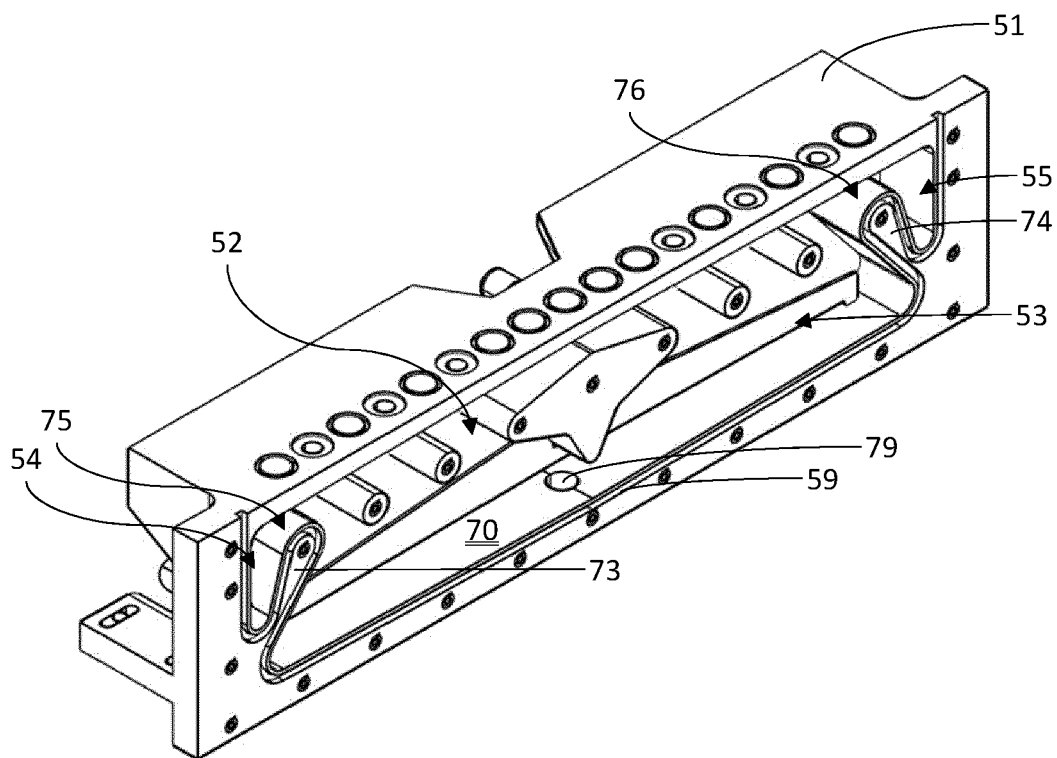


Fig. 17

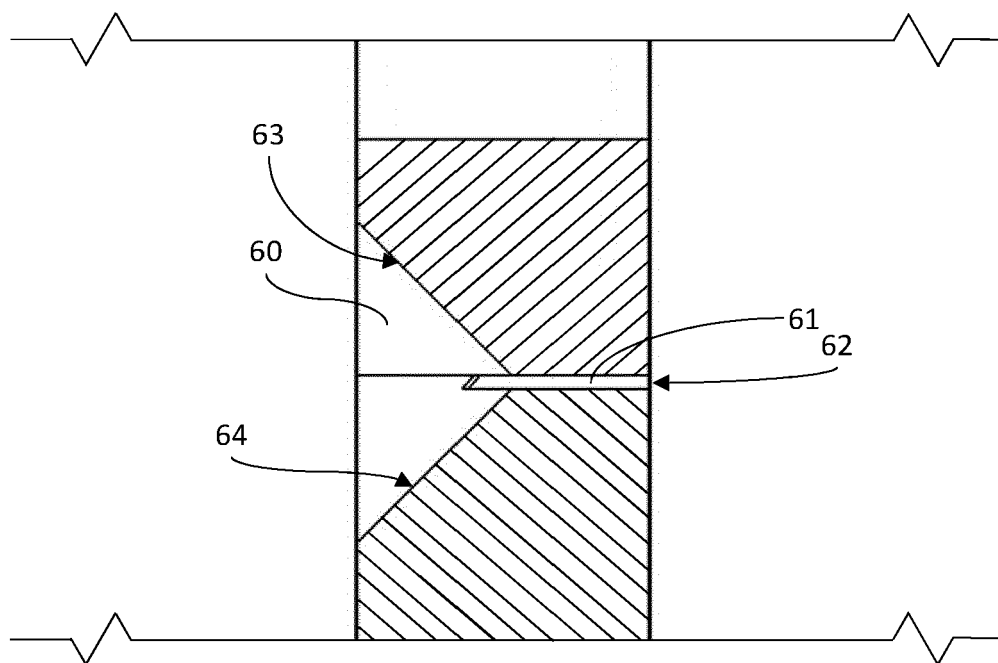


Fig. 18



EUROPEAN SEARCH REPORT

Application Number

EP 23 20 4589

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A	----- US 2022/325429 A1 (WIENER FERDINAND [DE] ET AL) 13 October 2022 (2022-10-13) * the whole document *	1-15	

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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		15 April 2024	Suárez Ramón, C
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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